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Textbook of Oral and Maxillofacial Surgery



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Neelima Anil Malik

Foreword
SG Damle

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Textbook of Oral and Maxillofacial Surgery

Textbook of Oral and Maxillofacial Surgery

Fourth Edition

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Foreword

SG Damle

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Dedicated to



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and
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and
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and
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Foreword

It is my privilege to write a few words about the *Textbook of Oral and Maxillofacial Surgery*.

Textbook of Oral and Maxillofacial Surgery is a well-orchestrated effort by the editor, Professor Dr (Mrs) Neelima Anil Malik, *Formerly*, Head, Department of Oral and Maxillofacial Surgery and Dean, Nair Hospital Dental College (NHDC), Mumbai, Maharashtra, India. She is an academician par excellence. This, coupled with her surgical skills and expertise in the field of oral and maxillofacial surgery, makes her an epitome for an ideal oral and maxillofacial surgeon and an eminent teacher.

The hallmark of the book is an extensive, point-wise coverage of the vast subject of oral and maxillofacial surgery in accordance with the syllabus of Dental Council of India and universities all over India. I am confident that the lucid, well-illustrated book with easy language and concise tables will make an interesting and informative reading for undergraduate students.

The chapters have been authored by dedicated, outstanding, experienced clinicians and eminent teachers from India and will provide guidelines to safe and sound operative techniques suitable for the Indian subcontinent. The information provided in the book is the latest, taking into account the advances in science and technology in dentistry.

The editor deserves a hearty congratulation for all the efforts and hard work, she has undertaken. I am sure that the book will guide students into gaining an insight into the vast field of oral and maxillofacial surgery.

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Preface to the Fourth Edition

My Dear Readers,

There is no better vocation than teaching, inspiring and motivating students. When the first edition of this textbook was published in 2002, my sole intention was to motivate the students, develop their interest in the subject of oral and maxillofacial surgery, and help them gain correct information to acquire and improve good surgical skills. While presenting this fourth edition of the book in 2016 and dedicating my life to teaching for nearly four decades, my aims and objectives still remain the same.

The journey so far has been very fruitful, as my students from all over the country are my inspiration who have loved and respected me unconditionally. I will always remain grateful for the constructive suggestions from the students and my learned colleagues, which has resulted in the publication of this new edition.

Hausamen JE in 2001 had said, "One has to realize that every step forward, every allegedly new development, as well as our entire knowledge and technical know-how in medicine, are only temporary; they have only a transitory character; they are certain to change" (Hausamen JE: The scientific development of M/F surgery in the 20th century and an outlook into the future. J Cranio Max. Facial Surg. 2001:29:2-21).

Our field has indeed progressed beyond imagination. This progress can be attributed to technological developments and availability of newer medicines and biomaterials, but needless to emphasize that many basic principles have stood the test of time.



Dr Neelima Anil Malik, Recipient of Lifetime Achievement Award in November 2015, Amritsar, Punjab, India

All along, whenever we have upgraded every edition, we have taken care, that the basic format is maintained, which is previously so well received. At the same time, latest knowledge is incorporated in depth for the benefit of readers. We have restructured the contents in such a manner that both students as well as practitioners can be benefitted by using comprehensive, clinically relevant information, which is provided keeping in mind the current curriculum.

This arduous task would not have been possible without constant support and timely help from my contributors—Professor Vidya Rattan, Professor MI Parkar, Associate Professor Dr Kumar Nilesh, to name a few. My special thanks to Professor Sujata Mohanty for providing me some of the clinical pictures at a short notice and Professor Sripathi Rao for encouraging me all along during each new edition. Professor Vithal Dhulkhed and his team also offered to update the General Anesthesia chapters. I also wish to convey my thanks to my earlier contributors. My opologies for any omissions of the credits, which are unintentional. My family members, my husband Dr Anil Malik, my daughter Dr Shambhvi Anil Malik, who are also contributors and are my pillars of strength in my life. My friends and well-wishers have also contributed towards the success by constant encouragement and support.

I profusely thank Shri Jitendar P Vij (Group Chairman), Mr Ankit Vij (Group President), Mr Tarun Duneja (Director-Publishing), Dr Priya Verma (Editor-in-Chief), and the entire production team of M/s Jaypee Brothers Medical Publishers (P) Ltd, New Delhi for their enthusiasm and constant efforts in bringing out this book.

I would also like to congratulate Shri Jitendar P Vij (Group Chairman) of M/s Jaypee Brothers Medical Publishers (P) Ltd, New Delhi, India for completing his successful 48 years of service in medical publishing. I wish him successful marching towards Golden Jubilee.

During his journey, he has imparted knowledge to countless students through his books all over the world and, in turn, touched so many souls. He has an amazing foresight in choosing his authors, and he personally gives the much needed support and encouragement.

I always thank God Almighty for his blessings in all my endeavors.

Neelima Anil Malik

Preface to the First Edition

This textbook is the natural outcome of having worked at one of the prime dental teaching institutes in India where there is abundance of clinical materials and excellent infrastructure with my teachers, colleagues and good friends over the past twenty-seven years in various capacities. This text also represents many years of combined clinical research and experience at our institute.

The field of oral and maxillofacial surgery has witnessed significant changes over the last two decades. These changes have improved our knowledge and understanding of the diagnosis and management of oral and maxillofacial surgical problems. The basic aim of this textbook is to incorporate this updated information and provide concise description of various oral and maxillofacial surgical procedures and current concepts and contemporary information.

The unique feature of this book is that it incorporates all of those various subjects, which are usually found in separate textbooks. We have taken efforts to present every chapter with updated text and to provide clear illustrations, wherever required.

The information given and the chapters mentioned in this book are based on the curriculum prescribed for undergraduate program for all universities in India.

We felt the need to incorporate the extensive section on anesthesiology, as this aspect is not covered adequately in the currently available standard textbooks in the subject. For the first time in the history, the anesthesiology chapters are supplemented with color illustrations.

It has been observed that the current trend of the undergraduate students is not to refer to many textbooks, may be due to either the time factor or the lack of availability of books, etc. We, therefore, desired to accommodate maximum information in one single textbook (Local anesthesia is not included, as many good books are available).

The purpose of this book is to present as lucid and simple text as possible in the point format without sacrificing the biological concepts.

The painstaking efforts are also made to create illustrations and to provide maximum clinical pictures in most of the chapters which is an essential feature of the book.

The earlier publications by our predecessors and prominent workers in the field served as a valuable source of reference material for this book.

The book is basically intended for dental undergraduates but would certainly be useful for postgraduates, general practitioners and teachers in the field.

I humbly request the teachers throughout the country to give their suggestions and contributions for its future editions.

As we begin with the first century of the new millennium, we hope that this textbook will provide the data and reference source to assist the clinician and others to face the oral and maxillofacial problems.

"Never must the physician say the disease is incurable. By that admission he denies God, our creator, he doubts Nature with her profuseness of hidden powers and mysteries."

Paracelsus

I am very happy to present this textbook to the students all over the country, in the year, when I have been selected as "President-Elect" of the Association of Oral and Maxillofacial Surgeons of India. I am grateful to all the members for giving me this opportunity to serve the fraternity.

Neelima Anil Malik

Acknowledgments

For the past many many years, I always dreamt of presenting a *Textbook of Oral and Maxillofacial Surgery* to the students all over the country.

First and foremost, I have to thank "The Supreme Power—God" for giving me energy, inspiration and courage to complete this arduous task and to make my dream come true. Without "His" blessings nothing is possible.

I acknowledge my gratitude to Professor Dr SG Damle, Dean, Nair Hospital Dental College and Director, Medical Education and Public Health, Municipal Corporation of Greater Mumbai, Maharashtra, India. I am indebted to him for providing the facilities and opportunities that made it possible to conduct the various clinical research and patient care over the years, from which the clinical material for this text has been obtained. His constant encouragement and appreciation of the good work has always given us a boost.

My acknowledgments are also due to my all undergraduate teachers who made the subject of oral and maxillofacial surgery so interesting which inspired me to join the postgraduate studies in the subject.

I am indebted to my postgraduate teachers, Professor Dr AP Chitre, Professor Dr KHC Kapadia and Professor Dr SK Dewan for their encouragement and guidance throughout my training program.

I would fail in my duty, if I do not mention late Dr Mrs Dhun Battiwala who taught me my very first dental extraction. She and Dr AD'Costa supported me and helped me to continue my postgraduate studies along with the teaching job in the subject of oral and maxillofacial surgery by exchanging their teaching posts with me. I am grateful to both of them.

A book of this magnitude was possible only with cooperation of many individuals.

I would like to express my deep appreciation to all the contributors whose untiring efforts have made this textbook possible.

My special thanks to the staff of the Anesthesiology Department of Topiwala Nair Medical College (TNMC) and Hospital, Mumbai, Maharashtra, India, who have been always supportive for many years and their contribution towards this book is also immense. Special credit goes to Professor Dr Mrs Divekar (Ex-Professor and Head of the Anesthesiology at TNMC) who developed the present 'state-of-the-art' anesthesiology department at our institute. And later on, more advances were carried forward by Professor Dr Mrs Panchal—Former Professor and Head of the Department of Anesthesiology at TNMC and Current Professor and Head of the Department, Professor Dr Mrs Kamdar. Their excellent techniques and constant support has always made our lives easy and given us the opportunity for excellent patient care.

Professor Dr JN Khanna also deserves special mention, as I have had opportunity to work with him and to enrich my knowledge and skill and share the responsibility of the department of oral and maxillofacial surgery at Nair Hospital Dental College (NHDC), Mumbai, Maharashtra, India.

I acknowledge the unconditional assistance given to me in my day-to-day work by my Associate Professor, Dr M Deshpande and Senior Lecturer, Dr P Solanki, and I also thank all teaching and nonteaching staff members of the department.

My special thanks to all my present and past postgraduate students for the stimulation and encouragement, I derived from their enthusiasm and interest in the field of oral and maxillofacial surgery.

I am grateful and indebted to the following for their knowledge and assistance in specific areas:

- Dr Mrs Vandana Laheri (Associate Professor of Anesthesiology at TNMC) and my ever-helping good friend, for complete color diagrams and illustrations provided for the anesthesiology chapters. She has also given me unconditional assistance for scanning, preparing other text diagrams, etc.
- Dr Ajit Pillai (Resident in Anesthesiology at TNMC) for line diagrams and some of the sketches illustrated in the book.
- Mr Pradeep Sahani (Commercial Artist) for some of the illustrations and photographs in the book.
- Mr A Sawant—For preparation of the initial computerized typescripts of the entire textbook.

Thank you all for your kind support and understanding.

I would like to thank Dr MI Parkar, the past student/resident and currently practicing surgeon of oral and maxillofacial surgery, and teacher at Yerala Medical Trust's Dental College and Hospital at Navi Mumbai, Maharashtra, India, for his immense contribution towards the completion of this book.

Finally, my deep appreciation and love to my husband Dr Anil Malik for his personal sacrifice and constant support in permitting me to undertake and accomplish such a difficult endeavor and to my beloved daughter Dr Shambhvi Anil Malik for her motivation, inspiration and encouragement.

On the occasion of releasing this Fourth edition, I wish to thank profusely Shri Jitendar P Vij (Group Chairman), Mr Ankit Vij (Group President) and Mr Tarun Duneja (Director-Publishing) of M/s Jaypee Brothers Medical Publishers for publishing this book in excellent form. I thank the entire staff of Mumbai branch especially Mr CS Gawde (Branch Manager) and Mr Sabrish Menon (Commissioning Editor) for their cooperation and help.

I also wish to thank Dr Rishab Malhotra (Development Editor), Mr Manish Pahuja (General Manager) Mr Rajesh Sharma (Production Coordinator), Mr Sunil Kumar Dogra, Mr Shekhar Bhatt (Typesetter), Mr Manoj Pahuja (Graphic Designer) of M/s Jaypee Brothers Medical Publishers (P) Ltd, New Delhi, for giving competent technical support that has helped me to bring out this edition with added color and excellence.

Last but not the least, I would like to mention that I am indebted to the individuals (including patients) too numerous to mention separately.

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CHAPTER 1 Introduction to Oral and Maxillofacial Surgery

INTRODUCTION

Oral and Maxillofacial Surgery is one of the branches of health sciences. It is an internationally recognized surgical specialty. In India, it is one of the nine specialties of dentistry and recognized branch for post graduate studies in the subject, by Dental Council Of India.

The field of oral and maxillofacial surgery has evolved through the ages. From extracting teeth by tying a thread around the tooth to refined techniques of today, the field has come a long way. Andre Fouchard is considered to be the Father of Dental Surgery. Pioneers like Lister in the practice of asepsis, Wells in the introduction of anesthetic techniques, Bell in the field of orthognathic surgery, Gillie and Champy in the treatment of fractures have established a scientific basis to oral and maxillofacial surgical procedures. It is to them, we owe the modern day practice of oral and maxillofacial surgery.

DEFINITION

Oral and maxillofacial surgery is a surgical branch, to correct wide spectrum of diseases,injuries and defects in the head, neck, face, jaws region and the hard and soft tissues of the oral and maxillofacial region (Association of Oral and Maxillofacial Surgeons of India-AOMSI). It deals with the art of diagnosis and treatment of various diseases, injuries and defects involving the orofacial region.

Other Accepted International Definition

Oral and maxillofacial surgery is a surgical specialty, which involves the diagnosis, surgery and an adjunctive treatment of diseases, injuries and deformities/defects (congenital/acquired), involving both the functional and esthetic aspects of the hard and soft tissues of the oral (mouth) and maxillofacial (jaws, face and associated structures) region. This specialty is often seen as the bridge between medicine and dentistry.

Other specialties dealing with the cranio-oro-maxillofacial region include the plastic surgery, neurosurgery, ENT surgery and ophthalmology, etc. Although, there is a considerable overlapping between these branches, in the past few years a definite delineation has been made among each of these specialties. The oral and maxillofacial surgeon has carved a special niche in the multidisciplinary approach to craniofacial pathologies.

In some countries around the world, including USA, Canada and Australia, it is a recognized specialty of dentistry. In others, such as the UK and most of the Europe, it is recognized as a specialty, both of medicine and dentistry and a dual degree in medicine and dentistry is compulsory for treating conditions that require expertise from both the backgrounds, such as head and neck cancers, salivary gland diseases, facial disproportions, facial pain, temporomandibular joint disorders, etc.

SCOPE

- The scope of oral and maxillofacial surgery depends on the qualifications and capabilities of the dentist. There is a definite distinction in the case selection for an undergraduate, trained in oral surgery, and a postgraduate, trained in oral and maxillofacial surgery and for cases that require multidisciplinary approach.
  - **An undergraduate student trained in oral surgery:** He/she is expected to deal with simple exodontia, complications arising from routine extractions like tooth/root fractures, tissue laceration, postextraction bleeding, minor post-extraction infections, immediate management of medical emergencies in the dental office and minor surgical procedures like apicoectomy and alveoloplasty, etc.

- Oral and maxillofacial surgeon requires to undergo three years of further formal university training after obtaining BDS degree.
  - **A postgraduate student in oral and maxillofacial surgery:** He/she is expected to deal with both the outpatient department cases as well as the patients admitted in the indoor ward. Beginning with complicated exodontia, the postgraduate program gradually trains the student to become a full-fledged oral and maxillofacial surgeon, capable of handling the various problems or pathologies of the face and the jaw bones.
- Further fellowship programs or further specialized training can be acquired depending on area of interest, after formal MDS degree in oral and maxillofacial surgery.
  - Head and Neck Oncology Fellowship
  - Cleft lip and Palate Fellowship
  - Cosmetic Facial Surgery Fellowship
  - Craniofacial Surgery and Pediatric Maxillofacial Surgery Fellowship
  - Cranio-maxillo-facial Trauma Fellowship.

Various treatments performed by oral and maxillofacial surgeons include:

- Dentoalveolar surgery: Surgery to remove difficult tooth extractions/impacted teeth surgical extractions, dental extractions or any minor/major oral surgical procedures in medically compromised patients, bone grafting or preprosthetic surgery to provide better, adequate anatomical foundation for the placement of implants, dentures, or other dental prostheses.
  - Preprosthetic surgical procedures including implantology.
  - Surgery to insert osseointegrated (bone fused) dental implants and maxillofacial implants for attaching craniofacial prostheses and bone-anchored hearing aids.
- Diagnosis and treatment of problems in oral cavity, head, face, neck region
  - Benign pathology—cysts, tumors, etc. Treatment of cysts and tumors of both odontogenic and nonodontogenic origin, involving the jaw bones.

Premalignant lesions and conditions—early detection and treatment of lesions and conditions, such as, oral submucous fibrosis and leukoplakia.

  - Malignant pathology—oral cavity, head, face, neck region cancer:
    - Detection and management of oral cancer, with ablative and followed by postreconstructive surgery. Microvascular reconstructive surgery.
    - Cutaneous malignancy—skin cancers on the facial region, lip reconstruction, etc.
- Management of disorders of maxillary sinuses
- Congenital craniofacial malformations
  - Such as cleft lip and palate and cranial vault malformations such as craniosynostosis (craniofacial surgery)
- Soft and hard tissue trauma of the oral and maxillofacial region
  - Initial and definitive management of traumatic injuries of soft and hard tissues of orofacial region (jaw fractures, cheek bone fractures, nasal fractures, LeFort fracture, skull fractures and eye socket fractures). Post-traumatic reconstruction.
- Chronic orofacial pain disorders management
- Temporomandibular joint (TMJ) disorders
  - Temporomandibular joint disorders including internal derangement and ankylosis.
- Salivary gland diseases and their management.
- Corrective jaw surgery—Orhognathic surgery
  - Dysgnathia—incorrect bite and orthognathic is straight bite
  - Diagnosis and management of dentofacial deformities, either acquired, developmental or congenital (including clefts of the lip and palate).
  - Corrective surgery for jaw bones along with dentition-maxillo-mandibular advancement, setback, genioplasty, correction of facial asymmetry, correction of sleep apnea, etc.
- Management of orofacial infections involving the soft and hard tissues and handling life-threatening emergencies due to acute infections.
- Detection and management of facial neurological disorders
- Trigeminal neuralgia, Bell's palsy, Frey's syndrome, etc.
- Reconstruction of missing portion of jaw bones with bone graft/distraction osteogenesis.
- Surgical management of the complex airway, snoring and sleep apnea.

Cosmetic Surgery

Cosmetic surgery limited to the head and neck (rhytidectomy/facelift, browlift/blepharoplasty, otoplasty, rhinoplasty, septoplasty, cheek augmentation, chin augmentation, genioplasty, neck liposuction, lip enhancement, injectable cosmetic treatments, botox, chemical peel, hair transplant, etc.)

Goals of the Undergraduate Training Program in Oral and Maxillofacial Surgery

The training program is designed to train undergraduate students to competence in handling exodontias and minor oral surgical procedures under local anesthesia. Basically, it is a vertical integration of linking theoretical ideas with clinical practice. It is targeted to provide the students with a broad academic background in the biomedical sciences and surgical principles, in the diagnosis and management of basic oral and maxillofacial surgery, including the management of medically compromised patients, and the fundamental knowledge, principles and surgical skills in the treatment of minor oral and maxillofacial surgical problems.

It is structured to achieve the following objectives:

- **Knowledge:**
  - To acquire basic understanding of the etiology and pathophysiology, treatment planning of various common oral and maxillofacial minor surgical problems.
  - To understand the basic general minor surgical principles, along with pre- and postsurgical pain management.
  - To understand basic sciences relevant to practice of oral surgery.
  - Essential knowledge of personal hygiene and infection control, prevention of cross-infection and safe disposal of waste management, keeping in view, the high prevalence of hepatitis and HIV.
- **Skills:** To develop skills to perform simple extractions and to carry out minor dentoalveolar surgical procedures under local anesthesia.
- **Attitude:** To develop ethical attitude in all aspects of minor dentoalveolar surgeries. To also develop compassion, empathy, warmth and honesty for the welfare of the patients.
- **Communicative skills and ability:** With patients, professional colleagues and develop attitude to seek opinion from an allied medical/dental specialists, as and when required.
- Research and updated brief knowledge in recent advances in the subject.

Objectives

- To develop within the students a foundation of professional knowledge coupled with the surgical skills to enable them to recognize and select those cases for operation which lie within the limit of their ability, and to refer other surgical problems wisely. Develop a sense of confidence in the students' surgical skills and clinical judgment, and to encourage a desire for continued professional development and self-improvement through continuing education courses, postgraduate courses or graduate training for a teaching career or specialty practice.
- To teach the students a standard pattern of intelligent history taking, examination, critical analysis of case findings, and full utilization of appropriate diagnostic aids all directed toward a sound diagnosis for an oral surgical problem. To develop within the student a foundation of professional knowledge coupled with minimum surgical skills to enable him/her to competently diagnose and operate upon oral surgery problems related to the practice of general dentistry.
- The dentist assumes an ethical and legal responsibility too when he/she accepts a patient for oral surgery. When faced with a problem for which he/she is not qualified to treat, it is his/her professional responsibility to appropriately refer the patient for treatment.
- Undergraduate student in the subject of oral and maxillofacial surgery should be trained in following clinical procedures:
  - Use basic surgical instruments
  - Perform extraction of normally erupted teeth.
  - Remove fractured roots resulting from the extraction of normally erupted teeth.
  - Prepare the oral cavity for the reception of prostheses. This includes the surgical management of alveolar bone and soft tissues without mutilation for the requirements of prosthetic foundation.
  - Remove surgically uncomplicated periapical granulomas and cysts of dental etiology.
  - Incise and drain intraoral subperiosteal abscesses and other localized infectious processes of dental origin.
  - Control hemorrhage from bone and soft tissues.
  - Detect prodromal signs, prevent and treat reactions of syncope, shock or other untoward reactions to anesthesia or surgery, which may require resuscitative measures.
  - Provide general and specific postoperative care to all extraction problems.
  - Biopsy or refer for biopsy lesions of the mouth and jaws requiring this diagnostic aid.
  - Reduce and immobilize simple fractures of the alveolus
  - Understand operating room technique, hospital procedure, and patient care through hospital experience.

- Brief knowledge of the broad-spectrum of oral and maxillofacial surgery as a dental specialty, in the management of complicated facial fractures, orthognathic surgery, vestibuloplasty, bone and soft tissue grafting, dental implant surgery, tumor surgery, and other maxillofacial surgical procedures.

MULTIDISCIPLINARY TEAM APPROACH

Cleft Lip and Palate

The oral and maxillofacial surgeon forms an important part of the cleft lip and palate management team, that comprises of the plastic surgeon, the pediatric surgeon, the orthodontist, the pedodontist, and the speech therapist. The oral and maxillofacial surgeon plays an important role in the primary as well as secondary closure of the lip and palate, as well as in the correction of residual deformities of the maxilla and the mandible at a later stage.

Craniofacial Syndromes

The oral and maxillofacial surgeon also forms a part of the core group, consisting of neurosurgeon, plastic surgeon and ENT surgeon involved in treating craniofacial abnormalities, especially syndromal, like Crouzon's syndrome or Goldenhar syndrome, etc.

Trauma Unit

- The oral and maxillofacial surgeon is also involved in the polytrauma unit along with orthopedic surgeon, general surgeon and plastic surgeon.
- The oral and maxillofacial surgeon, thus, forms an important link between the various specialties in the treatment of craniofacial pathologies.

NEWER ADVANCES

The field of oral and maxillofacial surgery is constantly evolving and adapting newer techniques, to refine the surgical procedures, and to achieve precision with minimally invasive techniques. One such technique that has revolutionized the treatment of facial deformities is distraction osteogenesis. The technique deals with the elongation of the bone by gradual callus distraction.

CONCLUSION

It is extremely difficult to outline the scope of a subject, where there is a constant adaptation with the introduction of research-based technology and techniques. It is our aim to impart the knowledge with every new edition of this textbook. The students are advised to keep themselves updated with new literature on the subject.

CHAPTER 2 Art of Diagnosis and Diagnostic Imaging

INTRODUCTION

The advent of the new century is marked by technological advances that have revolutionized science in every field as in medicine. Newer diagnostic aids and treatment modalities are being developed and introduced facilitating easier and quicker diagnosis and thereby improving patient care and treatment.

The first step towards treating any patient is making a correct diagnosis. The diagnostic sequence can be divided into five levels:

1. History taking
2. Clinical examination
3. Radiological analysis
4. Laboratory investigations
5. Interpretation and final diagnosis.

The first four steps help in obtaining a clinical database that can be then interpreted by the clinician to arrive at a final diagnosis.

The aims and objectives of this preoperative assessment are to decide:

1. The choice of anesthesia
2. Whether the patient can withstand general anesthesia
3. Whether the patient can withstand the trauma of surgery
4. Any abnormalities in the patient's general health, that need to be taken care of, prior to surgery
5. Choice of premedication
6. Treatment plan that will suit/benefit the patient the most.

HISTORY TAKING

The aim of history taking is to obtain a correct account of the patient's problems, taking into consideration his/her symptoms, general condition, lifestyle, and socioeconomic background.

Art of History Taking

While talking to the patient, the clinician should establish a rapport with him/her, both by eye contact and positive body language. This goes a long way in eliciting information from the patient. The patient should be encouraged to narrate his problems in his own words, if possible in a chronological order. The clinician can help the patient in unfolding his/her story by asking a few gentle questions like "Is there a change in the swelling during the course of the day?" or "Does the pain spread to any adjoining area?"

Steps in History Taking

Obtaining General Information

The first step in history taking is to obtain general information about the patient regarding the name, age, sex, marital status, address, race and occupation.

Chief Complaints

The chief complaint ascertains the principal reason as to why the patient is seeking medical attention.

The following details are recorded:

- All the symptoms, chronologically, in the patient's own words.
- The onset, duration and progress of each of these symptoms.
- Any treatment taken earlier for the condition, and the patient's response to the same.
- A previous history of similar symptoms and treatment taken for the same, along with the outcome.
- If the patient gives a history of trauma, additional history regarding unconsciousness, vomiting, bleeding from

mouth, ear, nose or throat, retrograde/anterograde amnesia is obtained.

Medical History

A detailed picture of the general medical status of the patient is obtained, which may or may not bear relevance to the chief complaint, the management of the patient and outcome of the treatment. The medical history questionnaire should include a detailed history of the following:

- *Cardiovascular disorders* such as myocardial infarction, ischemic heart disease, rheumatic heart disease, angina, valvular septal defect, hypertension and congestive cardiac failure. All the medications taken by the patient are listed including details about anticoagulants, antihypertensive drug therapy.
- *Diseases of the respiratory system* such as chronic obstructive pulmonary disease, bronchial asthma, pneumonia, pleuritis, bronchitis, upper respiratory tract infections. These patients may be on bronchodilators, antihistaminics or steroid therapy. Any disease of the respiratory system significantly affects the anesthetic management of the patient. A history of sleep apnea may be obtained from the relatives. This condition is commonly seen in patients with severe mandibular retrusion secondary to bilateral temporomandibular joint (TMJ) ankylosis.
- *Neurologic conditions* such as epilepsy, hemi/paraplegia and past history of head injury and medications taken for the same. If the patient is an epileptic, then the last episode of seizure and the frequency of seizure episodes are recorded.
- *Diseases of the endocrine system* including thyroid disorders, diabetes, adrenal pheochromocytoma, and multiple endocrine neoplasia and medications taken for the same. If the patient is a diabetic, care must be taken to mention his/her latest blood sugar values and the route of administration of the antidiabetic therapy, i.e. oral drugs or insulin injections.
- *Hematological disorders* such as anemia, leukemia, hemophilia, platelet count abnormalities, etc. and the last available blood reports pertaining to the condition.
- *Infectious diseases* such as tuberculosis, syphilis, viral hepatitis, herpes, and other sexually transmitted diseases.
- *Reproductive system,* e.g. pregnancy, lactation, last menstrual cycle, number of children, abortions and use of oral contraceptives. Many common antibiotics are known to have interactions with oral contraceptives rendering them ineffective. The patient must then be advised to practice alternate methods of birth control for the period.
- *Gastric disorders* such as peptic ulcer, acidity problems, vomiting, and diarrhea.
- *Renal pathologies* such as glomerulonephritis, nephrotic syndrome, renal failure, and patients on dialysis.
- *Disorders of the liver* such as cirrhosis, alcoholic liver disease, hepatitis.
- *Autoimmune disorders* such as systemic lupus erythematosus, scleroderma, requiring long-term corticosteroid therapy.
- *Psychiatric ailments* and treatment taken for the same.
- *Digestive system* loss of appetite, loss of weight, polydipsia, polyuria.
- Allergy to any drug.
- Childhood illness/birth trauma.
- Details of previous hospitalization, blood transfusions and surgeries.
- Past/present history of radiation therapy.
- Current/past medications taken, e.g. nonsteroidal anti-inflammatory drugs (NSAIDs) for chronic inflammatory lesions, aspirin, anticoagulant therapy, anti-Koch's therapy, steroid therapy for autoimmune disorders.

Any of the above mentioned conditions can alter the patient's response to surgery and influence both the anesthetic and surgical management of the patient as well as postoperative recovery and wound healing.

Personal and Family History

This part of the history deals with both the personal habits and social history of the patient. It gives an overview of the patient's lifestyle. This gives a better perspective of the patient apart from contributing to the diagnosis of the disease as well as outcome of the treatment.

- Habits like chewing tobacco, quicklime, areca nut, *pan masala*, *gutkha*, chronic alcoholism, chronic smoking, drug abuse and frequent exposure to commercial sex workers.
- A detailed history of the immediate family of the patient, with their age, general health status, medical ailments, cause and age at the time of death of any deceased member is recorded. A family history of epilepsy, cardiac disorders, diabetes, bleeding disorders, and tuberculosis is of particular importance.

CLINICAL EXAMINATION

The clinical examination of the patient begins as he/she enters the clinic. The patient's gait, composure, as well as speech, reflect his/her general condition and psychological status. In this chapter, we will restrict ourselves to the orofacial region. For a detailed review of the other systems, one can refer to standard textbooks on surgery.

After the history taking, the patient's vital signs are first recorded, i.e. blood pressure, pulse, temperature and respiratory rate.

When examining the patient, the clinician should be well-versed with the four aspects of examination, i.e. inspection, palpation, percussion and auscultation. Of these, percussion has least importance in the maxillofacial region.

Extraoral Examination

Extraoral examination can be divided into frontal and profile examination. The following structures are examined:

- Face
- Skin and soft tissue
- Skull
- Bony skeleton of the face
- Temporomandibular joints (TMJs)
- Lymphatic systems
- Salivary glands
- Eyes.

Inspection

- **Face:** At the onset of the examination, the face is first observed for any signs of asymmetry, swelling, etc. The proportion of the upper, middle and lower thirds of the face is noted along with their relation to each other. The facial morphology is identified (dolichocephalic, mesencephalic or brachycephalic).
- **Skin and soft tissue:** The color and texture of the skin is indicative of many underlying systemic problems **(Table 2.1)**.
- **Skull:** While inspecting the orofacial region, the clinician should begin from the cranium and the frontal bone and proceed downwards. Any abnormality in the size and shape of the cranium is indicative of a probable congenital abnormality. Special care should be taken in trauma patients to detect head injuries. Edema, laceration, swelling and any depression in the contour of the skull vault are indicative of a head injury. Similarly any depression in the frontal bone is indicative of head injury.
- **Eyes:** The eyes are examined for any soft tissue injury to the cornea or conjunctiva. Pallor is indicative of anemia, icterus is indicative of jaundice, and exophthalmos in absence of trauma is suggestive of thyroid disorders. Any injury to the orbital skeleton and contents presents as any one or a combination of following signs—subconjunctival hemorrhage, circumorbital ecchymosis/edema, enophthalmos, exophthalmos, change in the level of the orbital contents, or increased intercanthal distance.

Table 2.1: Interpretation of skin color and texture

Colors	*Interpreted etiology*
Pallor	Temporary—shock, hemorrhage, intense emotion
	Persistent anemia
Abnormal redness	Overheating, extreme exertion, sunburn, febrile exanthematous and inflammatory skin diseases
Local redness	Telangiectasia, especially on the face
Cyanosis	Defective oxygenation of the blood, excessive decrease in the hemoglobin level
Subicteric, lemon yellow, daffodil tints	Pernicious anemia, acholuric jaundice
Yellow, orange or dark olive green color	Obstructive jaundice
Palms—orange yellow	Carotenemia (presence of excessive lipid-soluble yellow pigments in the plasma, distinguished from jaundice as it does not stain the conjunctiva)
Absence of pigmentation	Generalized—albinism Localized—piebaldism
Patches of white and darkly pigmented skin	Vitiligo
Pale skin with diminished pigmentation	Hypopituitarism/hypogonadism
Brown to dark brown pigmentation of the affected parts of the skin	Addison's disease
Dry, scaly skin	Protein deficiency

- **Nose:** When inspecting the nose, the following aspects are taken into consideration: (1) Depression of the nasal bridge, deviation of the nasal septum; commonly seen in fractures of the nasal bones; and (2) Obliteration of the lateral wall of the nose and deviation of the nasal septum; as with tumors of the maxilla; maxillary sinus and the nose. In patients with cleft lip, special attention should be given to the alar base width, the columella and the deviation of the nose. Any evidence of nasal discharge, epistaxis or loss of smell (partial or complete) should be recorded.
- **Malar and paranasal regions:** Two important things to be inspected in the paranasal region are any swelling present in the region, due to a cystic or tumorous lesion in the maxilla and hypoplasia of the paranasal area. Hypoplasia of the paranasal area can be a true hypoplasia or pseudohypoplasia secondary to mandibular prognathism. In trauma patients, the malar region has to be inspected for any "dimpling" along the contour of the zygomatic arch or depression of the zygomaticomalar complex. This is best appreciated from a bird's eye view (from above and behind the patient).

In addition, the clinician must evaluate any facial asymmetry, facial swelling, extraoral draining sinuses, scars, color and texture of the skin, and any signs of ecchymosis, hemorrhage, lacerations and abrasions. All patients with facial asymmetry/swelling have to be inspected from either below or from above and behind.

Areas best appreciated in the profile are the paranasal area, the frontal bone, the nasal projection, the chin and the mandibular plane. Profile inspection is very important for patients who have to undergo orthognathic surgery.

- **Ears:** Due to their close proximity to the TMJs, a close inspection of the ears is a must, especially in trauma cases. Very often, there is frank bleeding from one or both the ears, indicative of a fracture of the condyle. Another condition where abnormality of the ear is seen is the Goldenhar syndrome, where the external ear may be missing with just ear tags present. The ear is examined for any evidence of frank infection or pus discharge. The patient's complaints of tinnitus or hearing impairment are recorded.
- **Lips:** Few lesions involving the lips include clefts, ulcerative and nonulcerative growths, angular cheilitis, herpes infections, etc.

Palpation

Palpation must be done gently, without causing much distress to the patient. A quick and thorough palpation helps the clinician to establish his/her primary diagnosis. Palpation of the bony skeleton is begun from the frontal bone and proceeds downwards. Palpation of the facial skeleton is carried out simultaneously, bilaterally, starting from the supraorbital ridges, proceeding in the following order: the lateral orbital rim, the medial orbital rim, the infraorbital rim, the bridge of the nose and lateral nasal walls, the paranasal regions, the zygomatic bone and the arch contour, the TMJs, the posterior border of the ramus, the angle and the continuity of the inferior border of the mandible. The TMJs are usually palpated by placing the index fingers of both the hands just anteroinferior to the tragus of the ear. They can also be palpated intrameatally in a similar fashion. The joints are examined for any tenderness, clicking, crepitus on opening or closing of the mouth. The range of opening and left and right lateral excursions are checked and abnormalities are noted. The muscles of mastication are palpated for tenderness.

In a patient with a history of trauma, any step deformity, abnormal mobility of fragments, tenderness, reduced movements of the TMJs is indicative of a fracture in that area.

A facial swelling that is infective in nature will be soft, fluctuant, warm and tender on palpation. A facial swelling that is neoplastic or cystic in origin is usually firm to bony hard, with expansion of either or both the buccal and lingual cortical plates and may or may not be tender. If there is perforation of the cortical plate, the swelling will be soft on palpation in that region. Thinning of the buccal cortex is, many a times, indicated by a typical eggshell crackling sound on palpation. The inferior border is also examined for expansion. Expansion of the lingual cortex is very characteristic of ameloblastoma. An equal expansion in all directions is indicative of ossifying or cementifying fibroma. Lesions of bony origin are always bony hard to palpation, whereas vascular lesions produce a bruit or thrill.

For salivary gland disorders, the parotid and the submandibular glands are palpated extraorally. The parotid gland can be palpated in the preauricular, inferior auricular and postauricular regions. The submandibular gland is checked by bimanual palpation by placing a finger of one hand in the submandibular region and another intraorally in the floor of the mouth **(Figs 2.1A to H)**.

When examining the eyes, the eyelids are gently separated to detect soft tissue injuries and hemorrhage, the extent of hemorrhage, if any, and if the patient is conscious, the vision is tested on each side in all the directions.

The preauricular, submandibular, submental, and cervical lymph nodes are palpated for enlargement, tenderness, mobility and consistency. The submandibular nodes are best palpated from behind by asking the patient to flex his head forward and relax his neck muscles **(Table 2.2** and **Figs 2.2A to G)**.

Table 2.2: Lymph nodes and probable associated conditions

Lymph nodes	*Condition*
Tender, mobile, enlarged	Acute infection
Nontender, mobile, enlarged	Chronic infection
Matted, nontender	Tuberculosis
Fixed, enlarged	Squamous cell carcinoma
Rubbery, enlarged	Lymphomas

Auscultation

Auscultation is mainly used in two conditions in the orofacial region:

1. Vascular lesions to hear bruits.
2. TMJ pathological processes or to hear the joint movements.

Once the extraoral examination is complete, the oral opening should be measured prior to intraoral examination. Oral opening or maximal incisal opening is a distance measured between the incisal edges of the maxillary and mandibular central incisors.

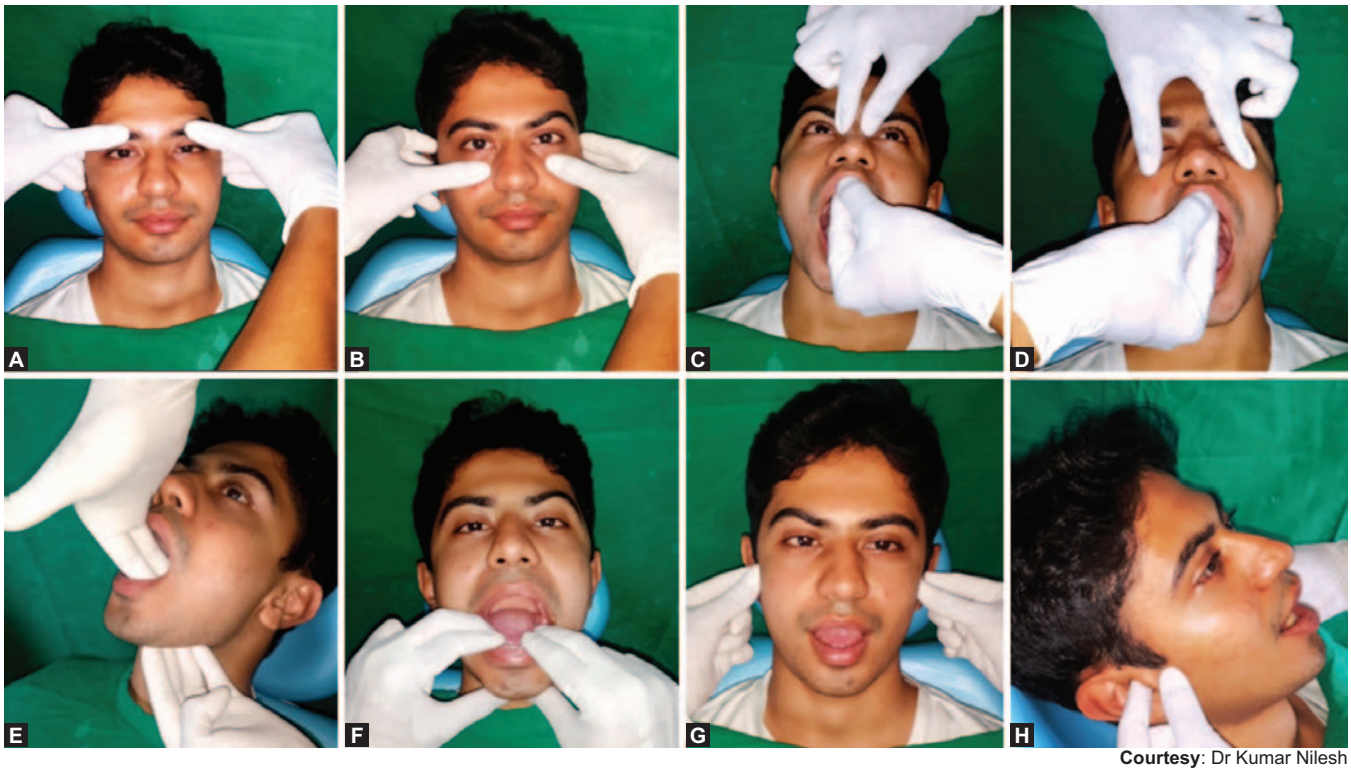
Intraoral Examination

The structures to be examined during intraoral examination are as follows:

- Buccal, labial and alveolar mucosa
- Hard and soft palate
- Floor of the mouth and tongue
- Retromolar region
- Posterior pharyngeal wall and faucial pillars
- Salivary glands and their orifices
- Dentition and occlusion.

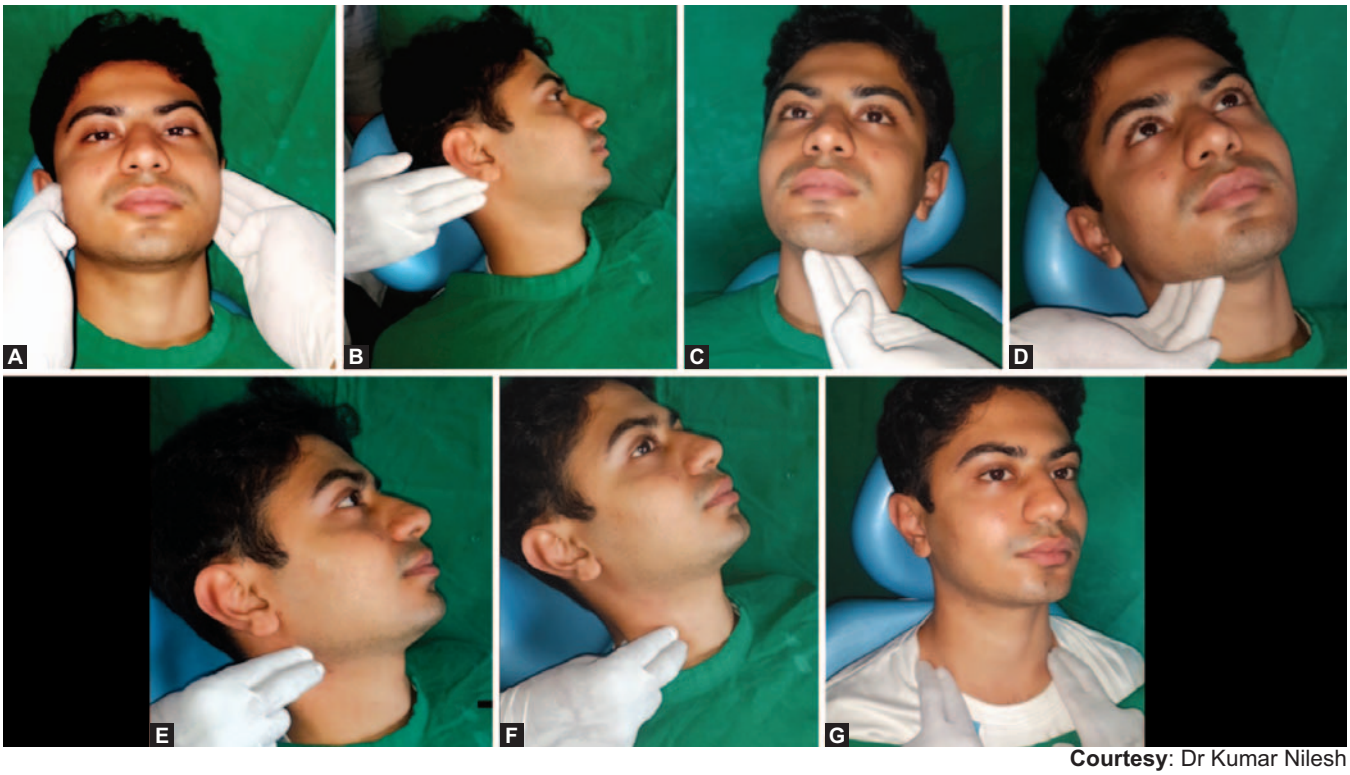
Inspection

When the patient opens his mouth, the first thing the clinician sees is the oral hygiene. A fetid odor is indicative of a poor oral hygiene or an infective process in the oral



Courtesy: Dr Kumar Nilesh

Figs 2.1A to H: Systematic extraoral examination of the facial region. (A) Palpation of supraorbital ridge region; (B) Palpation of infraorbital ridge region; (C) Checking the nasal bones/bridge/maxilla and its mobility/integrity in case of trauma; (D) Checking the higher region fractures of maxilla; (E) Bimanual palpation for lesions in the floor of the mouth; (F) Checking for mobility of mandibular bone in case of fracture; (G) Temporomandibular joint examination; (H) Endaural TMJ movement examination



Courtesy: Dr Kumar Nilesh

Figs 2.2A to G: Lymph node palpation. (A) Preauricular lymph node palpation; (B) Postauricular lymph node palpation; (C) Submental lymph node palpation; (D) Submandibular lymph node palpation; (E) Jugulodigastric lymph node palpation; (F) Jugulo-omohyoid lymph node palpation; (G) Supraclavicular lymph node palpation

cavity. The mucosa is inspected for color, texture, and presence of ulceration, growth or draining sinuses.

The size of the tongue, its mobility and surface are inspected. The tongue is then depressed to visualize the uvula, soft palate, and the lateral and posterior pharyngeal walls. Any deviation of the uvula, abnormal movement of the soft palate, mass at the base of the tongue, posterior pharyngeal walls and any swelling of the lateral and retropharyngeal space is identified.

The floor of the mouth is examined and a note of any inflammation, mass, hematoma is noted. The presence of a hematoma is usually indicative of a fracture in that region. A raised floor of the mouth in a patient having an abscess is suggestive of Ludwig's angina.

The salivary gland orifices are examined for any signs of inflammation or pus discharge.

The dentition is then examined, and a mention of missing, carious, mobile, restored and malposed teeth is made. The occlusion is checked and any deviation from the normal canine and molar relation, posterior gagging, anterior open bite, deep bite, reverse overjet, overjet is recorded. The arch form and the curve of Spee are also recorded.

The periodontal tissues are examined for the color and texture of the gingiva. Any sign of recession, hyperplasia, and infection is noted.

Edentulous ridges are thoroughly examined for the form of the ridge, any soft tissue abnormality, bony abnormalities like tori, bony protuberances, etc. and the presence of any remnant root pieces.

Palpation

Intraoral palpation is similar to what is described extraorally. An extra or intraosseous swelling is palpated to record the consistency and extent of the swelling. Further, palpation will reveal whether the swelling is sessile or pedunculated, and any breach in the buccal or lingual cortical plates.

Vascular lesions may produce a bruit or thrill, which can be appreciated on palpation.

In trauma patients, the palpation begins in the anterior maxillary region, and proceeds behind the zygomatic

buttress to the tuberosity region. The anterior border of the ramus is then palpated, coming downward to the vestibule and to the anterior mandibular region. Any signs of tenderness or step are recorded. Holding the alveolar fragments between the fingers of the two hands and exerting pressure checks the alveolar mobility. The maxillary mobility is checked at different levels by placing the fingers of one hand at the alar base, middle third of the nose and the nasal bridge, and exerting gentle pressure with the other hand on the maxillary anterior dentoalveolar segment. Any mobility of the teeth is checked.

The salivary glands are milked to check for normal salivary flow and quantity of the saliva.

Once the clinical examination is complete, the clinician has a general idea regarding the location, extent, and clinical nature of the lesion. A tentative diagnosis is established in the clinician's mind. This is put down as the provisional diagnosis. Radiological studies and other biochemical investigations, which will be discussed next, then support this provisional diagnosis.

CLINICAL DIAGNOSTIC AIDS

Diagnostic Imaging

Imaging has two roles:

1. The identification of an abnormality in terms of presence, site, size and nature (if possible).
2. Provision of information necessary for decision, for planning of surgical or other treatment.
   - A. The imaging objectives—depend on many factors:
     - The amount/type of information required.
     - The time period of the treatment rendered.
   - B. Decision will depend upon integration of the above two factors:
     - When to image?
     - Which imaging modality to use?
     - Design a procedure specific to the patient's clinical needs.
   - C. To define the precise extent of the lesion then to make specific diagnosis.

FUNDAMENTAL TENETS OF IMAGING MODALITY

- To yield maximum accurate diagnostic information.
- To maximize benefit/risk ratio.

The imaging modality is chosen, not necessary, because it costs the least or produces the lowest radiation exposure or is available in the vicinity.

DIAGNOSTIC IMAGING

As low as reasonably achievable (ALARA) for X-ray exposure.

SELECTION OF IMAGING MODALITY

- Improved technical image quality
- Reduced patient radiation risk
- Increased differentiation of nonosseous tissue.

The Goal

"Gold standard" of imaging modalities:

- To develop a "virtual operative environment"
- To preview patient's anatomy in both two and three-dimensional (2D or 3D) formats
- To analyze and measure the patient's deviation from normal
- To simulate an optimized and practical operative solution before surgery
- To have more accurate method of intraoperative navigation and measurements
- Efficient and accurate transfer of information
- Accurate documentation and quantification of the lesion.

We have to understand that "the complex architecture of the facial skeleton and its contents have created a challenge to the surgeon to find a surgical access and to the radiologist to image." *No other anatomic region in the body has got such a complexity. The complexity of the facial architecture is not only due to the multiplicity of its components, but also to the intricacy of their geometric relationships.*

The imaging modalities are broadly classified into two groups:

1. **Invasive or interventional imaging:** This is rapidly changing technology, mostly used for diagnostic, therapeutic and curative purposes.
   Examples—embolization, delivery of cytotoxic drugs, calculus destruction, angiography, angioplasty, etc.
2. **Noninvasive imaging**
   - Plain conventional radiography
   - Computed tomography (CT)
   - Magnetic resonance imaging (MRI)
   - Radionuclide studies—scintigraphy—bone scan
   - Ultrasonography (USG)

We will be discussing noninvasive imaging modalities used in oral and maxillofacial surgical field **(Table 2.3)**.

Table 2.3: X-ray versus nuclear medicine imaging

X-ray imaging	*Nuclear medicine imaging*
Produced by differential absorption of X-rays by the body tissue	Obtained by mapping the distribution of radioactivity of an injected body tissue radionuclide within the body
Depicts anatomic architecture of bone	Reflects physiologic status to assess viability, vascularity and metabolic activity of bone
Often insensitive until pathology is well-established	Ability to detect early physiological changes. Metabolic alteration at 5–10% level can be detected within 48 hours
At least 30–50% of mineral content change is required	
Can be detected after 10 days to 3 weeks	

RADIOLOGICAL EXAMINATION

Radiological imaging is one of the most important diagnostic aids available to the clinician. Apart from the site and extent of the lesion, the radiological picture also to some extent, reveals the nature of the lesion, since each lesion has its radiological presentation. For example, a multilocular lesion may be indicative of an ameloblastoma or a giant cell lesion or an odontogenic myxoma. Fibro-osseous lesions exhibit a mixed radiopaque-radiolucent lesion. Chronic osteomyelitis may have a moth-eaten appearance radiographically.

Apart from determining the site and extent of an obvious lesion, radiographs also enable the clinician to pick up silent lesions (incidental findings). With the advances in information technology, the field of radiology has been revolutionized. The acquirement and storage of data has been simplified to a minute volume of tissue, and with the help of a computer, an integration of these data images has been made possible. It is possible today for the clinician to have an accurate picture of the lesion before surgical intervention.

We divide this section into two parts:

1. Conventional radiography
2. Specialized imaging.

Conventional Radiography

Plain conventional radiography is a versatile diagnostic tool. Conventional radiography can be further divided into intraoral views and extraoral views.

Intraoral Radiographs

1. **Intraoral periapical (IOPA) view**—areas best appreciated are as follows:
   - Teeth
   - Periapical region
   - Lamina dura and periodontal ligament space
   - Supporting alveolar bone.

   This view is useful in locating changes in the teeth and periapical tissues.

Indications for IOPA in oral surgery:

- Studying impacted third molars
- Periapical lesion
- Relation of the maxillary sinus to the teeth
- Localizing fractured or remnant root pieces
- Localizing foreign bodies, in interdental/periodontal regions
- Differentiating between cystic and tumorous lesions
- Locating the exact extent of the periapical lesion, especially in the maxilla
- In trauma cases to identify dentoalveolar fractures and to rule out tooth fractures.

Advantages: Excellent view of the teeth and periapical region with minimal distortion.

Disadvantages: It cannot be used when the oral opening is reduced or for extensive lesions.

2. **A. Occlusal view of the mandible—areas best appreciated are as follows:**
   - Floor of the mouth
   - Lingual aspect of the mandible
   - Lower arch contour and continuity.

   B. Occlusal view of the maxilla—areas best appreciated:
   - Hard palate
   - Contour and continuity of the upper arch.

Indications for occlusal view in oral surgery:

- Locate impacted wisdom teeth
- Locate ectopic/supernumerary teeth
- Check for buccal/palatal cortical plate expansion
- Localization of salivary calculus in the submandibular salivary duct
- Study the hard palate and its lesions like palatine tori, palatal tumors
- Locate the presence of foreign bodies in the soft tissues
- Study the tumors arising on the lingual aspect of the mandible, like mandibular osteomas.

Advantages

- The only view that gives excellent visualization of the hard palate and the floor of the mouth.
- When used in correlation with periapical views, they help to give an idea of the buccopalatal/lingual position of the object under consideration.

Extraoral Radiographs

1. **Orthopantomogram**—areas best appreciated are as follows:
   - The TMJ, posterior and anterior border of the ramus, the ramus, the angle and the body of the mandible, the continuity of the inferior border of the mandible, the pterygomaxillary fissures, the maxillary tuberosity, the maxillary sinuses, and the teeth.
2. **Lateral oblique view of mandible**—areas best appreciated are as follows:
   - Two lateral oblique projections are required, each showing a different area of the mandible to its best advantage, i.e. the regions of the body and the ramus.
   - The mandibular body projection demonstrates the premolar-molar region and the inferior border of the mandible.
   - The ramus projection demonstrates the mandibular ramus from the angle to the condyle.
   - Third molar regions of both the maxilla and mandible are well-visualized.
3. **Posteroanterior view or Water's position (occipitomental projection)**—areas best appreciated are as follows:
   - Maxillary sinuses
   - Frontal and the ethmoid sinuses
   - Frontozygomatic suture
   - Supraorbital and infraorbital rims
   - Nasal cavity
   - Position of the coronoid process of the mandible between the maxilla and the zygomatic arch.
4. **Posteroanterior view of mandible**—areas best appreciated are as follows:
   - Body of the mandible
   - Inferior border, anterior border of the ramus
   - Condylar neck
   - Nasal cavity.

   The shadow of the vertebrae does not allow visualization of the mandibular symphysis region.
5. **Transorbital view**—area best appreciated mandibular condylar neck. Useful in the diagnosis of subcondylar fractures.
6. **Transcranial view**—areas best appreciated are as follows:
   - Glenoid fossa
   - Articular eminence
   - Condylar heads and their relation to one another.

   This view is taken in mouth open and closed positions for TMJ internal derangements, dislocation and subluxation.
7. **Lateral cephalogram view**—areas best appreciated are as follows:
   - Skull
   - Facial bones
   - Paranasal air sinuses
   - Hard palate
   - Nasopharyngeal tissues
   - Soft tissue outline of the face.

   Using the various cephalometric points, the relation between the maxilla, mandible and the skull, as well as their dental components can be established.
8. **Posteroanterior view of skull**—areas best appreciated are as follows:
   - Skull
   - Frontal and ethmoidal air sinuses
   - Nasal fossa and orbits.
9. **Lateral skull view**—areas best appreciated are skull and the bones of the middle third of the face.
10. **Submentovertex view (Jug Handle view)**—areas best appreciated are as follows:
    - Base of the skull
    - Position and orientation of the condyles
    - Sphenoidal air sinuses
    - Curvature of the inferior border of the mandible
    - Lateral wall of the maxillary sinus
    - Projection of the zygomatic arch
    - Medial and lateral pterygoid plates, and
    - Foramina at the base of the skull.
11. **Chest X-ray (posteroanterior view)**—areas best appreciated are as follows:
    - Bony skeleton, that is, ribs, sternum, and the vertebral column
    - Position of the trachea and the tracheal passage
    - Size, shape and position of the heart and aorta
    - Size and position of the diaphragm
    - Lung fields.

Shortfalls of Plain Conventional Radiography

- Two-dimensional record of three-dimensional object
- Superimposition of various structures above and below, in the pathway of X-ray in the region of interest
- Requires multiple projections
- Difficult to detect subtle pathology or trauma
- Limited value, poor understanding of the relationship of normal to abnormal structures.

That is why traditional conventional radiography is being replaced by the newer modalities for their obvious advantages.

Specialized Imaging

Tomogram

Tomography is the term used to refer to all types of body sectional radiographic techniques. The tomographic techniques used in maxillofacial surgery can be divided into two categories:

1. Conventional tomography.
2. Computed tomography (CT).

Conventional tomography: During tomography, the radiographic tube moves in one direction, the film moves in the opposite direction, and the fulcrum in the system remains stationary. The level of fulcrum is represented in the patient, as the layer of interest, where the anatomic structures are in sharp focus. All the points above and below this plane are blurred. Tomography is most often used for imaging of the TMJs, and occasionally to examine other facial structures, e.g. orbital cavity.

Computed tomography: It was first introduced in the mid-1970s. The CT scanners basically produce a digital data measuring the extent of X-ray transmission through an object. This numerical information is transformed into a density scale and used to reconstruct a visual image. The theoretical basis for CT began almost 70–80 years back. In 1971, Hounsfield's first practical scanner was used for clinical application. In 1973, first scanner in USA generated CT scans of the brain. From 1975 onwards rapid improvements in computer software and hardware allowed widespread use of second, third and newer generation machines. CT uses X-rays to perform its work. These X-rays come from an X-ray tube, which is placed inside a square machine called the gantry. The part of the patient's body to be scanned goes inside a hole in this gantry. The standard format of the CT scan which is obtained, is in axial plane.

CT Scan

- Landmark technique
- Tomo—slice, graphy—picture
- Gives cross-sectional information (axial)
- Allows evaluation of soft tissue and bony structure.

Different Techniques of CT Scan

- Plain studies without contrast
- Simple vs. high resolution
- Contrast enhanced studies
- Reconstructions—coronal, sagittal.

Newer Advanced Software for CT Scans

- 3D CT—with or without disarticulation of individual bone, rotation in any angle is possible
- Multiplanar real-time reconstructions
- Spiral CT—ultrafast electron gun CT
- CT angiography
- Circular, spiral, hypocycloidal are the tube motions employed.
- Dental CT—DentaScan, CBCT.

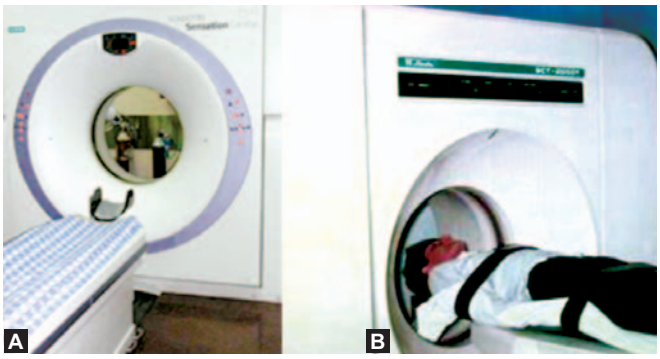
Advantages

Advantages of a CT scan over conventional radiographs

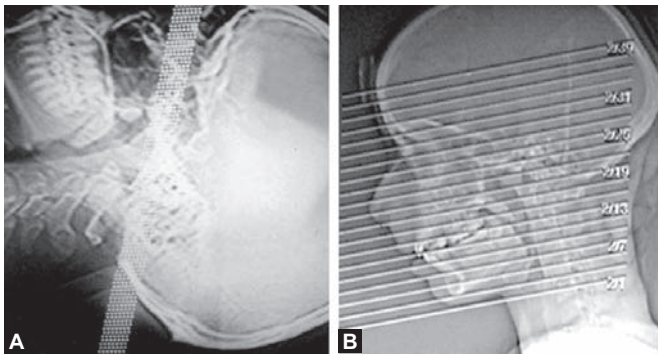
- No special patient preparation
- Very good speed, quick imaging, reduced patient motion artifact
- Exact contiguity of images
- Emergencies, trauma patients, children, oncology—very helpful. Scan time is less than 1 minute, transfer of information is in few seconds—display in 5 minutes
- Better visualization of structures in various minute levels and planes
- Greater geometric precision
- Three-dimensional view of the facial structures
- Sensitivity to discriminate between objects with small difference in density like blood and fat or blood and cerebrospinal fluid (CSF)
- Better visualization of the paranasal and orbital structures
- Exact localization of the lesions and their extent.

Disadvantages

- Requires a cooperative patient
- Respiratory motion or body motion—degradation of the image
- Medical radiation burden
- Allergic reaction to contrast medium.



Figs 2.3A and B: Computed tomography (CT)scan machine



Figs 2.4A and B: Axial computed tomography (CT) scan for maxillofacial area

Computed Tomographic Scan

Computed tomographic scan is considered as "gold standard" today. The introduction of CT scanning technology revolutionized diagnostic radiology, not only because of improved visualization of complex bony anatomy without superimposition, but also because of high contrast discrimination of soft tissues **(Figs 2.3A and B)**.

Acquisition of Axial CT Scan

Very young patients are lightly sedated and body of the patient is stabilized by strapping. High resolution of axial CT scans with 5 mm axial slices with 4 mm feed from the angle of the mandible to the squamous temporal bone without tilting the gantry (horizontal or zero degree angulation). This will cover the entire maxillofacial area. 2D reconstruction scans are thus recorded on double density floppy and transferred to an independent CT scan viewing console **(Figs 2.4 to 2.6A)**.

Record maintenance: These images are stored on radiographic films or they can be photographed from the monitor screen. CT scans records are kept on 14″ × 17″ sheets of films, with a multiformat camera, in a 20-image-on-one format. The patient's name, age, date of examination, etc. are marked on each image.

This standard format of the CT scan (axial images) with restricted orientation and sequential multiple images is abstract, in areas of anatomic complexity and needs an interpreter, i.e. diagnostic radiologist. These images bear no direct resemblance to the findings of either physical examination or surgery. Axial sections are not optimal, because of the following:

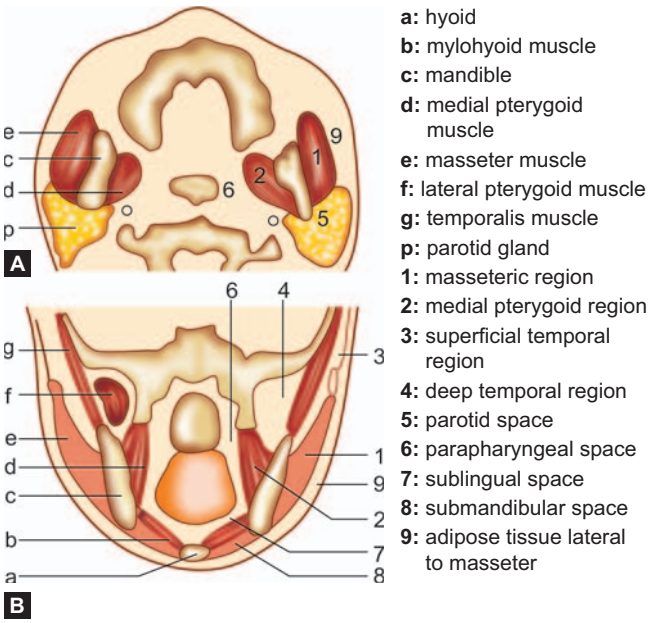
- Sections lie parallel to the large part of the surfaces of interest
- Can miss the areas of interest
- During actual surgery, the surfaces exposed, never oriented axially.

Coronal sections are better as these coronal views correspond to the angle of vision used for the clinical examination of the patient, but it requires additional scan time and radiation exposure **(Figs 2.5B and 2.6B)**.

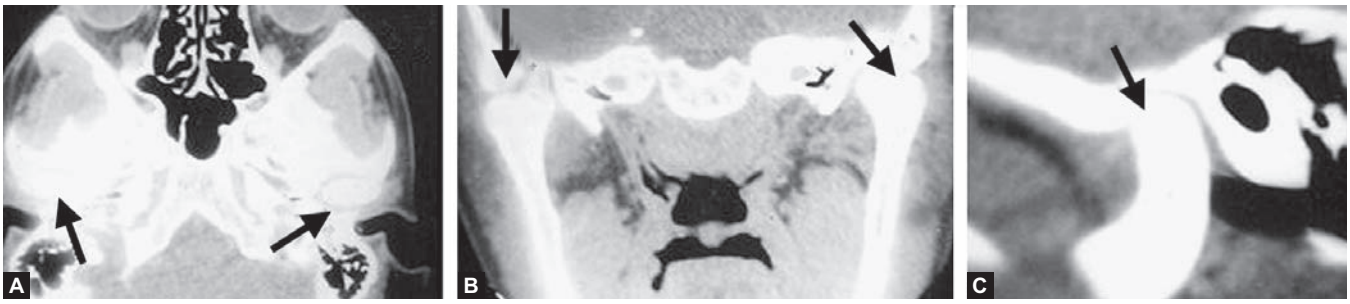
Sagittal sections are also taken, whenever indicated for additional information **(Fig. 2.6C)**.

3D Imaging

Recently a new system stacks 2D slices sequentially and 3D information can be obtained from routine CT data.



Figs 2.5A and B: Diagrammatic representation of MIF region (A) Axial; (B) Coronal images



Figs 2.6A to C: (A) Axial computed tomography (CT) scan of both normal condyles; (B) Coronal scan for both normal condyles; (C) Sagittal CT scan of (L) condyle in closed mouth position

The introduction of 3D image display has provided a method of object analysis in three planes of space, obviating the need for mental reconstructions and yielding more spatial information than was previously available.

Conceptually, when sequential slices of CT scan data are "stacked layer upon layer", a 3D matrix of digital information representing the scanned object, results. These images can be rotated, split and anatomic structures can be separated and individual images of different tissue types can be generated. 3D image display data are obtained from high-resolution axial CT scans. HIQ Siemen's scanners can be used. 3D program is located in a second independent console. The Siemen's software program accepts 2D high-resolution CT scan data as input and produces a set of 3D reconstruction images as output. Depending on the number of piled sections, the acquisition reconstruction time varies around 20 minutes. The 3D images recorded on 14″ × 14″ sheets in 8–10 on one format or they can be stored on the CD or printed on paper **(Figs 2.7** and **2.8)**.

The 3D reconstruction images produced, resemble photographs of a skull. This program computes mainly four contours—frontal, rear and both lateral orientations **(Fig. 2.9)**.

Rotation of the original scan data by a selected angle (0–90°) permits the reconstruction surfaces from oblique projections and thereby disclosing regions, which are inaccessible to other radiographic procedures.

Several outstanding features make this technique a very useful asset:

- Surgeons can readily assimilate complex anatomic relationships from these images, which look like anatomic dissections.
- It delineates the abnormal bony morphology.
- Gives correct representation of the size of the structure to be reviewed, its relative position and its relations to other structures and also gives idea about unilateral or bilateral involvement of the lesion, etc.
- Easy interpretation, efficient in computer line and storage.
- 3D reconstruction is simple, since preselection views are automatically generated.
- Facilitates surgical planning.
- Reduction in operating time.
- Lesion can be accurately documented and quantified (yields true life-size images).
- Can be used for quantitative postoperative evaluation and follow-up.
- Very helpful as effective tool for communication.
- Excellent teaching aid for the institutions.
- Radiation exposure does not exceed that of conventional radiography. Radiation is minimum as pencil beam is used. Minimum secondary radiation.

Dentascan

The technique of 'Dental CT' also called 'Dentascan' was developed by Schwarz et al. In 1987, when they used curved multiplanar reconstructions of the jaw **(Figs 2.10A to D)**.

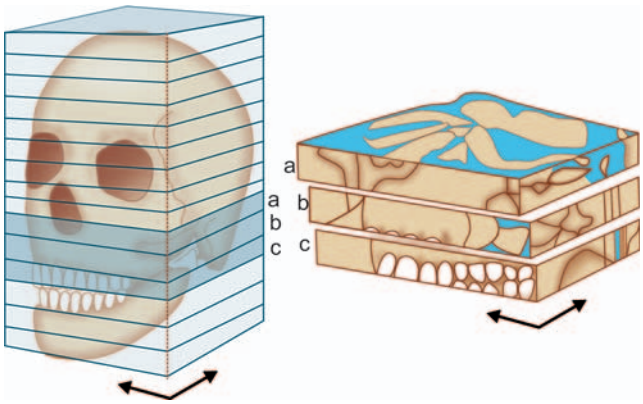
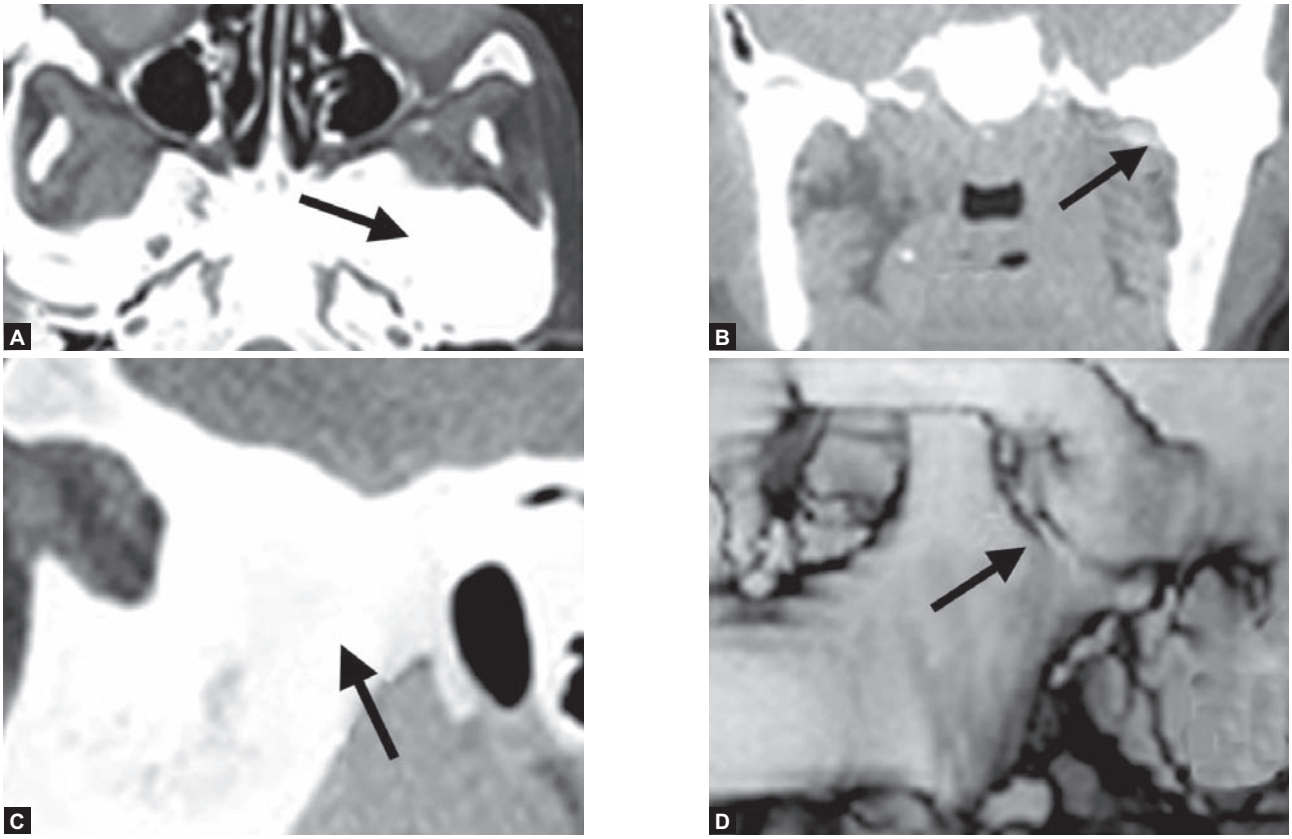


Fig. 2.7: Sequential slices of computed tomography (CT) scan data are stacked layer upon layer for obtaining 3D information (3D CT scan)



Figs 2.8A to D: (A) Axial CT scan; (B) Coronal CT scan; (C) Sagittal scan; (D) 3D CT scan. All showing ankylosis of (L) temporomandibular joint

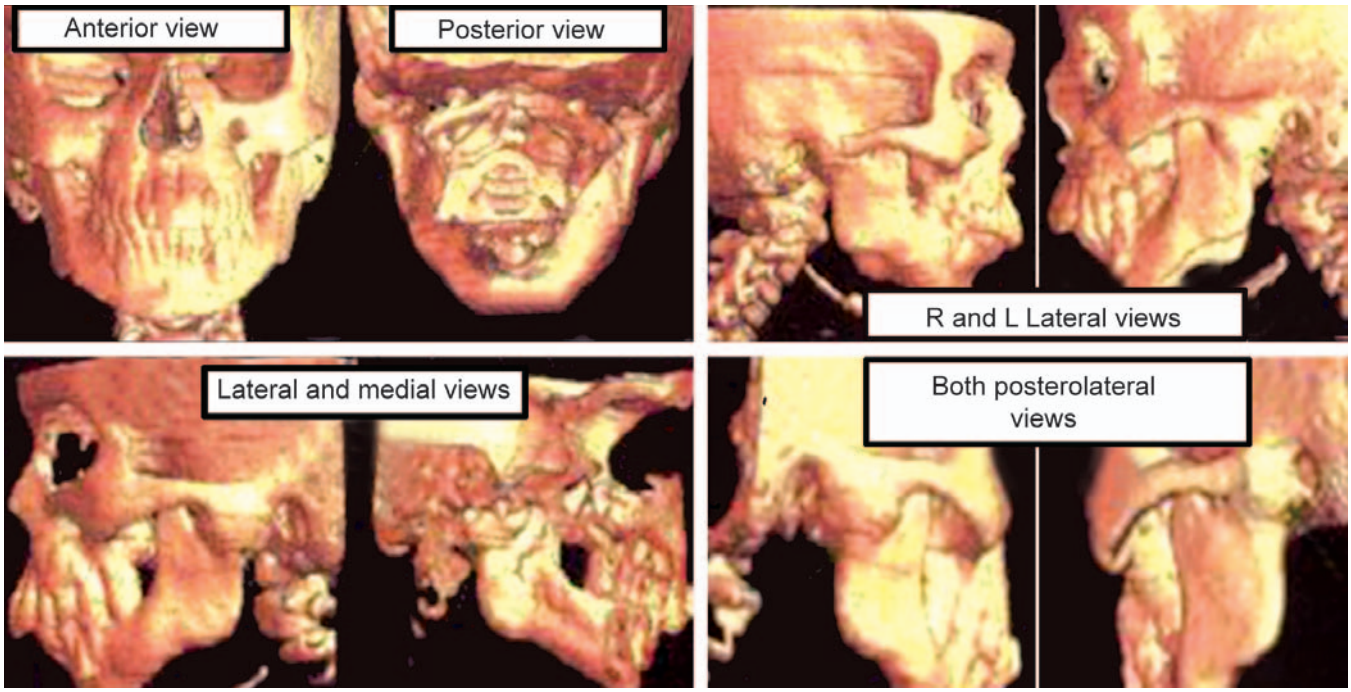
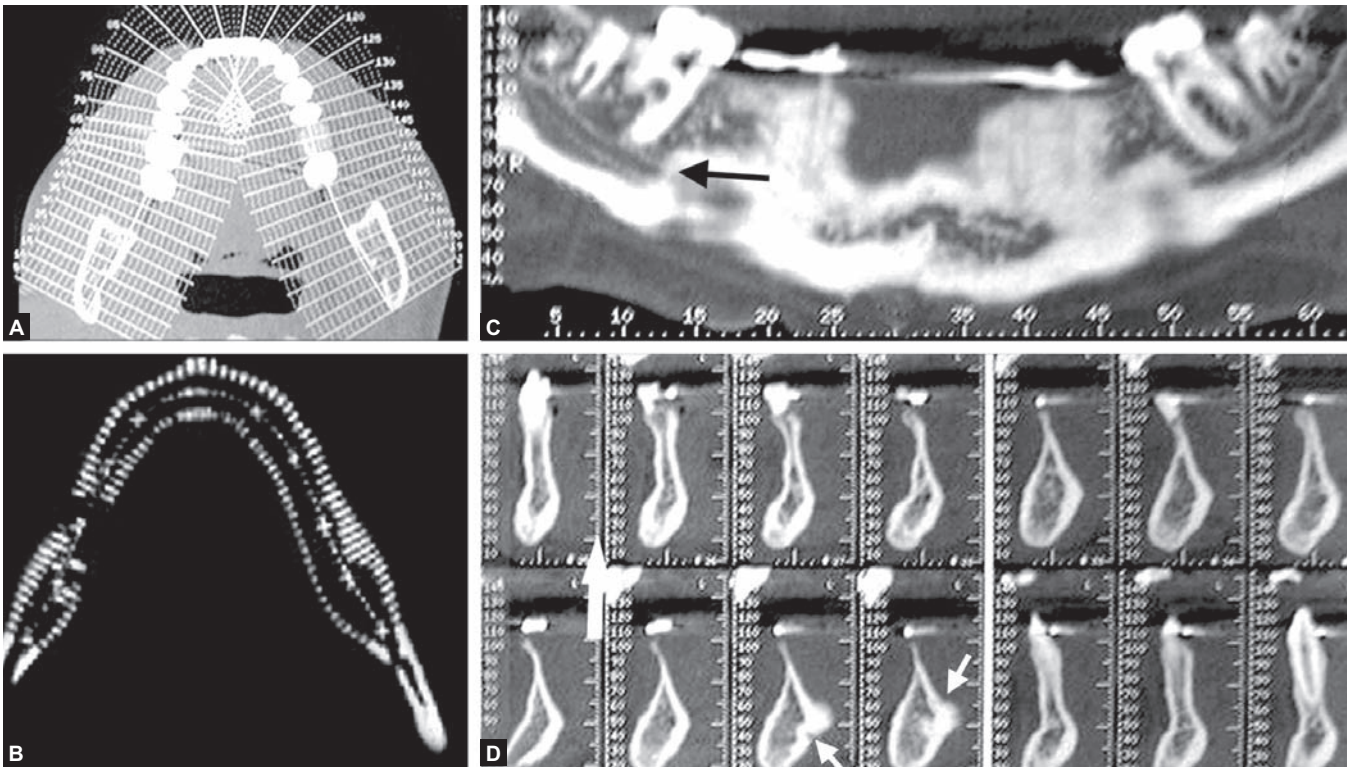


Fig. 2.9: Temporomandibular joint (TMJ) ankylosis—3D scan pictures in various rotations views



Figs 2.10A to D: Dentascan using specialized software. (A) Axial view of maxilla; (B) Axial view of mandible; (C) Panoramic dentascan reconstruction; (D) Cross-sectional images perpendicular to alveolar process of the mandible taken for location of mandibular nerve (arrows)

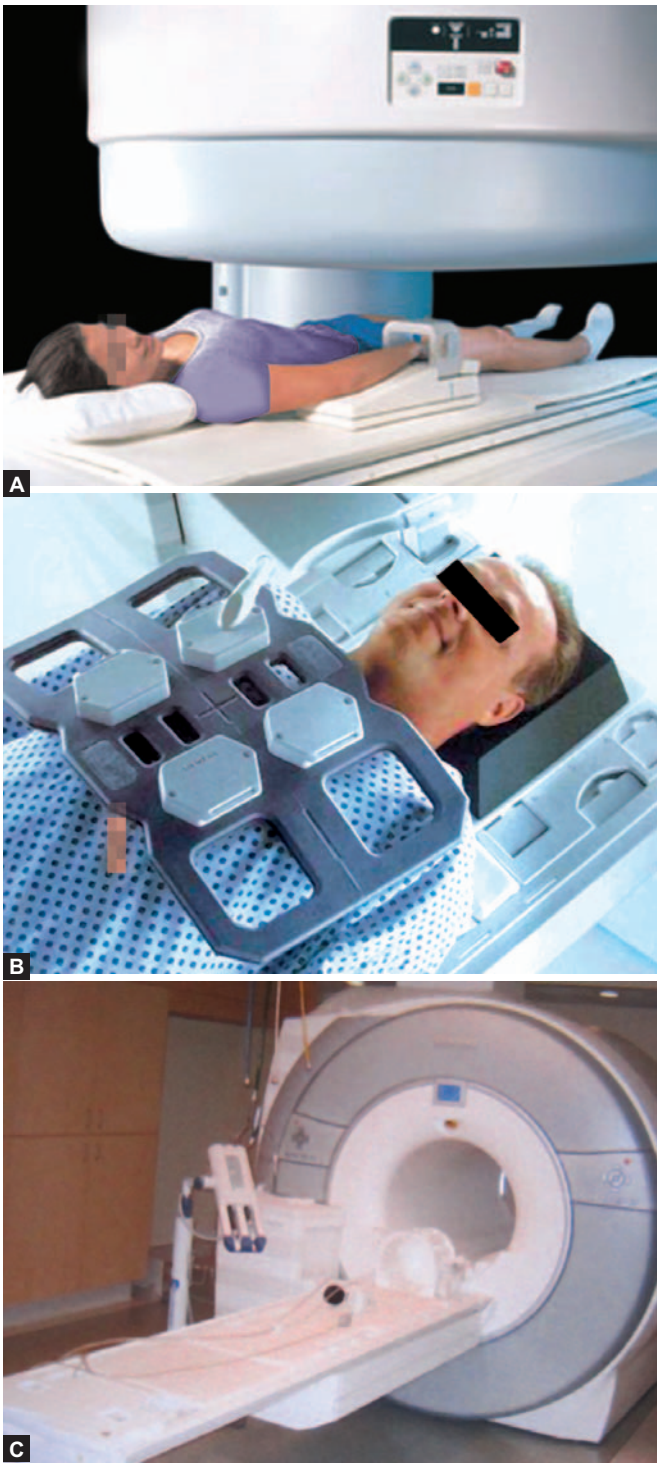
The term 'Dental CT' does not represent a particular modality, but rather a specific investigation protocol. The main features of this protocol include the acquisition of axial scans of the jaw with the highest possible resolution together with curved and orthoradial multiplanar reconstructions.

Dental CT has become an established method for imaging of jaw anatomy prior to dental implant placement. In axial plane, the metal artifacts from tooth fillings are kept in the occlusal plane and hence the jaw bone remains undistorted (unlike medical CT scan). This allows for accurate display of the vertical as well as the important buccolingual dimensions of the jaw in actual 1:1 life size. The anatomy of the alveolar ridge along with the quality and quantity of bone at the proposed sites of implant placements also can be assessed. Vertical bone height and horizontal bone width can be measured easily from point to point. Selection of the proper length and diameter of the implant can be easily done. Life-sized cross-sectional and/or panoramic images can be obtained.

Magnetic Resonance Imaging

Magnetic resonance imaging (MRI) was introduced into clinical practice in the 1980s, and in a very short time has gained immense importance in the field of diagnostic radiology. The MRI is unquestionably the best imaging modality available for lesions encountered in the central nervous system, the musculoskeletal system, and the cardiovascular system. It is a computer-based tomographic technique that is developed to image tissues using positron emission from isotopes, or signals derived from the nuclear magnetic resonance properties of protons in the tissue water **(Figs 2.11A to C)**.

- In 1946, Block and Purcell described the phenomenon of magnetic resonance and won the Nobel Prize in 1952.
- In 1972, Lauterbur used it for the first time for medical imaging
- Most innovative, noninvasive technique
- Magnetic resonance imaging (MRI) is considered as cornerstone of medical imaging



Figs 2.11A to C: (A) Open magnetic resonance imaging (MRI) machine. Most MRI machines have a long tunnel, which can lead to discomfort and a sense of claustrophobia. An "Open MRI" is a C-shaped machine, which is open on three sides. This makes the entire procedure very comfortable without claustrophobia; (B) Surface coils; (C) Closed MRI machine

- It employs radiofrequency radiation in the presence of carefully controlled magnetic fields
- It produces high quality cross-sectional images of the body in any plane
- New MRI scanner designs bring about motion and fat suppression, which can achieve faster scan sequences
- Addition of surface coils improves resolution and decreases scan time **(Fig. 2.11B)**
- MRI shows superior soft tissue contrast
- Easier multiplanar imaging
- Sensitivity and accuracy of 100% in detecting small tumors
- IV contrast increases sensitivity
- Modality of choice for nasopharynx, tongue, skull base pathology
- Decreases the artifact scatter seen in CT due to dental fillings, metallic crowns, etc.

Applications in maxillofacial region: The MRI is an excellent imaging modality for soft tissues and has superseded CT scans in the evaluation of the imaging of the temporomandibular joint and the tumors of the nasopharynx, parapharyngeal area, salivary glands, tongue and oropharynx **(Tables 2.4** and **2.5,** and **Figs 2.12 to 2.16)**.

Limitations of MRI

- Inability to image bone due to lack of signal from cortical bone
- Knowledge of normal MR anatomy is necessary for detection of pathology and interpretation
- Motion artifacts due to long time procedures.

Though in India, MRI is not very popular in the field of maxillofacial surgery, mainly because of nonavailability and high cost factor, its best application is in the evaluation of the TMJ disk deformities **(Figs 2.12A and B)**.

The standard plane of MRI used to study TMJ disk deformities is usually sagittal plane **(Figs 2.13A** and **B)**. It can also be used for evaluation of various spaces of head and neck region **(Figs 2.14 to 2.16)**.

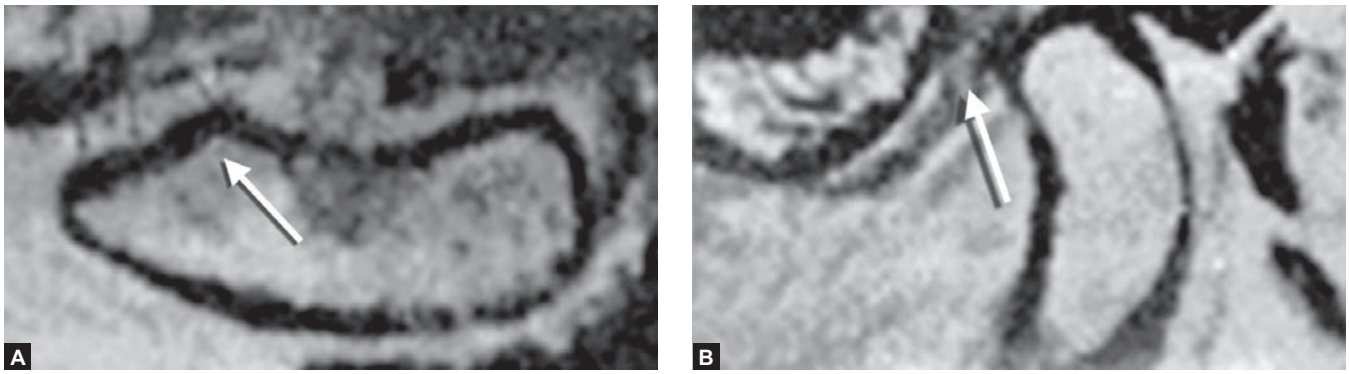
Ultrasonography

It is the refinement of wartime naval sonar system. Used extensively in central nervous system, cardiovascular system, for internal organ studies, (kidney, spleen) **(Figs 2.17A and B)**.

3D sonography, color Doppler ultrasonography can be used to assess the flow in the large vessels. Ultrasonography diagnostic imaging system uses high frequencies and a large transducer. Ultrasound generated from transducer penetrates the organ to be imaged. Ultrasound (US) waves



Figs 2.12A to C: (A) Normal temporomandibular joint (TMJ) MRI scan image in sagittal view; (B) Normal TMJ MRI scan image in coronal view; (C) Dissection of normal TMJ region (anatomy specimen)



Figs 2.13A and B: Magnetic resonance imaging (MRI) axial and sagittal view. (A) Axial view of (L) TMJ gives the information, that there is a flattening of anterior aspect of the condyle and presence of osteophyte (arrow); (B) Sagittal view of (L) TMJ shows slightly anteriorly placed disk (arrow). Osteophyte is not seen in this view

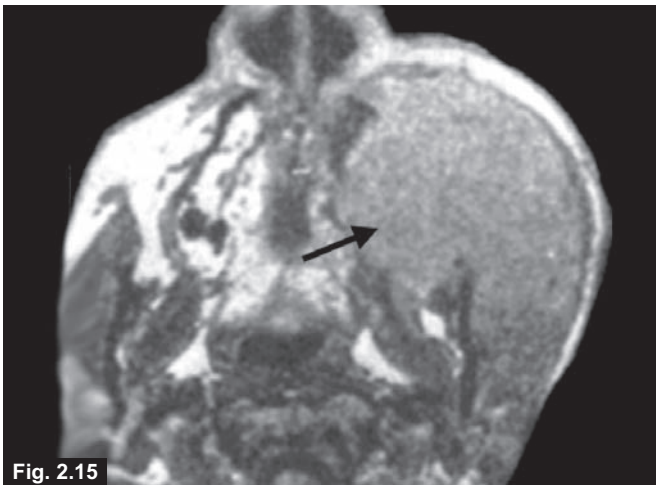
Table 2.4: Advantages of magnetic resonance imaging (MRI) versus computed tomography (CT) scan

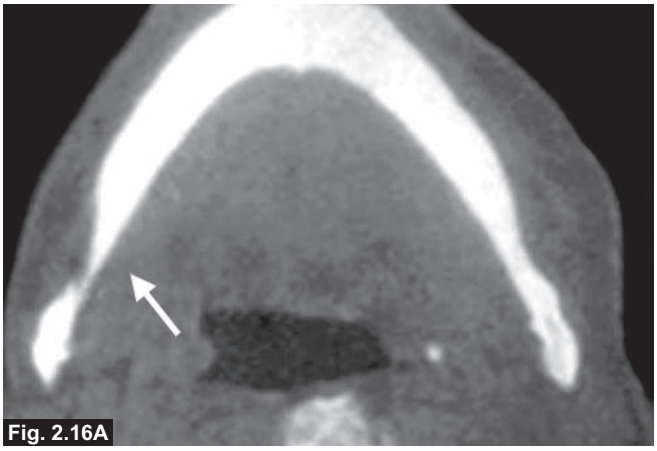
MRI	*CT scan*
Noninvasive—no ionizing radiation	Large radiation dose
Vessels shown without IV contrast	IV contrast necessary for soft tissue, blood vessels enhancement
Direct multiplanar easy imaging	Axial images reformatting requires large radiation
High soft tissue contrast	
Safe procedure	
Can be repeated again following previous studies	

Table 2.5: Advantages of computed tomography (CT) versus magnetic resonance imaging (MRI)

CT scan	*MRI*
Widely available in most countries	A scarce resource in many countries
No claustrophobia	Long time—claustrophobia, discomfort in closed MRI machine
Less expensive than MRI	MRI machine expensive
Few restrictions	Restrictions—metal implants, pacemakers, intraocular foreign bodies, ferromagnetic clips, neurostimulator units
	Motion—image suffers


Fig. 2.14


Fig. 2.15


Fig. 2.16A

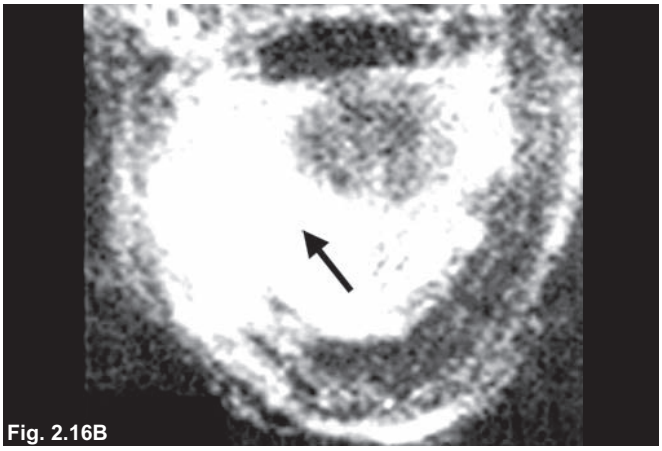
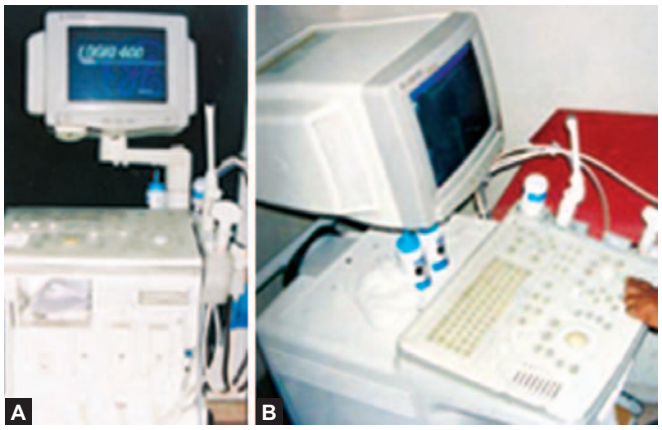

Fig. 2.16B

Fig. 2.14: Magnetic resonance imaging (MRI) scan for 4-year-old male child shows the involvement of infratemporal space due to odontogenic infection (arrow). **Fig. 2.15:** Magnetic resonance imaging (MRI) scan of the (L) maxillary sinus showing tumor. **Figs 2.16A and B:** Magnetic resonance imaging (MRI) gives indication of the soft tissue growth which can be missed in CT scan. (A) CT scan for (R) mandibular retromolar area was declared as negative involvement; (B) MRI scan for the same patient gives positive imaging of the retromolar area with soft tissue growth seen (arrow). Biopsy report proved as squamous cell carcinoma

emitted from the surface and the skin and body-internal organs reflect incident wave. Ultrasound (US) system receives the reflected wave, calculates the information and forms images. It is sensitive in detecting fluid collection.

Advantages

- Noninvasive
- Economical
- Painless
- Quick
- No adverse reaction
- Mobile equipment—bedside access
- Easier repeatability
- Low cost of storage.


A

B

Figs 2.17A and B: The ultrasound diagnostic imaging system

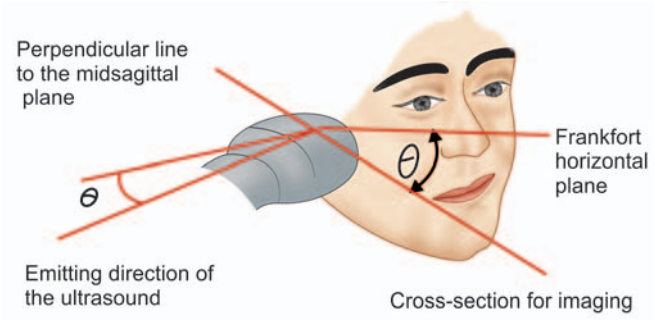


Fig. 2.18: A transducer application to the facial region for ltrasonography (USG)

Limitations

- A detailed knowledge of sonostructure is required for interpretation
- Operator dependent
- Bone does not transmit sound—limited use.

Ultrasonography Procedure

Ultrasonography uses the principle of echo, obtained from sound waves, as they pass through various structures. These echos are recorded and converted into a visual image.

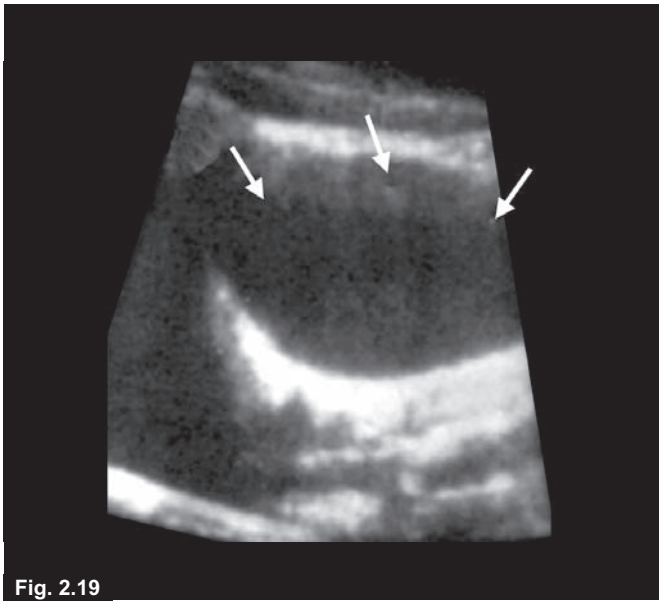
A transducer converts electrical energy into high frequency sound waves, which pass into the tissues of different densities. The vibrational energy is reflected back to the scanning transducer, where the sound waves are converted to images, which are displayed on a monitor **(Fig. 2.18)**.

Application

- Widely used to detect cervical lymph node metastasis
- Examination of various masses in the neck including abscesses and diseases of salivary glands.
- Aids in differentiation of solid and cystic masses
- Valuable for guided aspiration and biopsy **(Figs 2.19 and 2.20)**.

Scintigraphy

Nuclear medicine utilizes radioactive compounds having affinity to particular tissues. These agents when injected into the patient, concentrate in large volumes in the target tissues and these tissues are studied under both dynamic and static conditions. The scans obtained are called scintigraphy or radionuclide scans. The most common radiopharmaceuticals used are, ^{99m}Technetium (^{99m}Tc), methylene diphosphonate, and 67Gallium (67Ga).



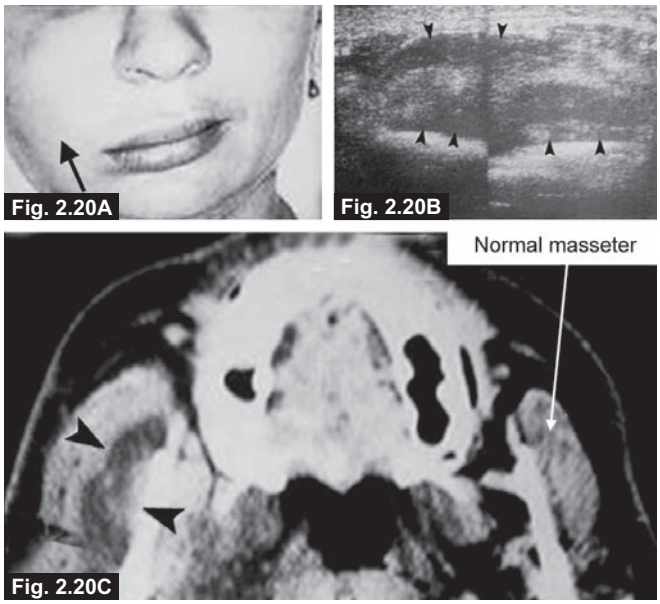
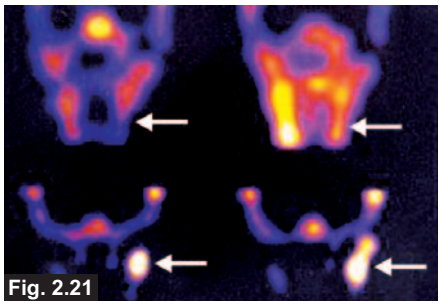
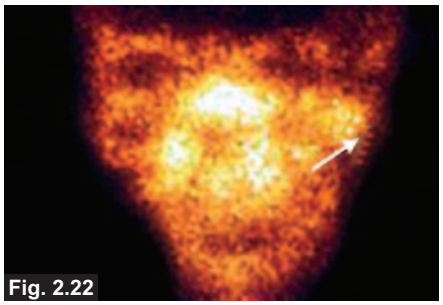


Fig. 2.19: Ultrasonography of parotid gland. Intraglandular cyst. Sharply bordered echo free area. **Figs 2.20A to C:** Comparison of ultrasonography and computed tomography (CT) scan in facial space infection (A) Facial swelling on right cheek; (B) Ultrasound (US) scan performed along right mandible. Fluid collection is indicated by hypoechoic area, which is superficial to mandible and just below the masseter muscle. US is very sensitive in detecting fluid collection. It is quick and inexpensive. It can be used to diagnose a stage of infection, (cellulitis or abscess formation); (C) CT scan confirms well-defined abscess in submasseteric space


Fig. 2.21


Fig. 2.22

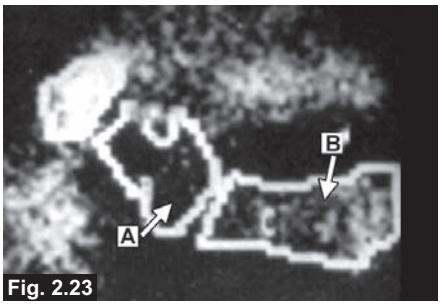
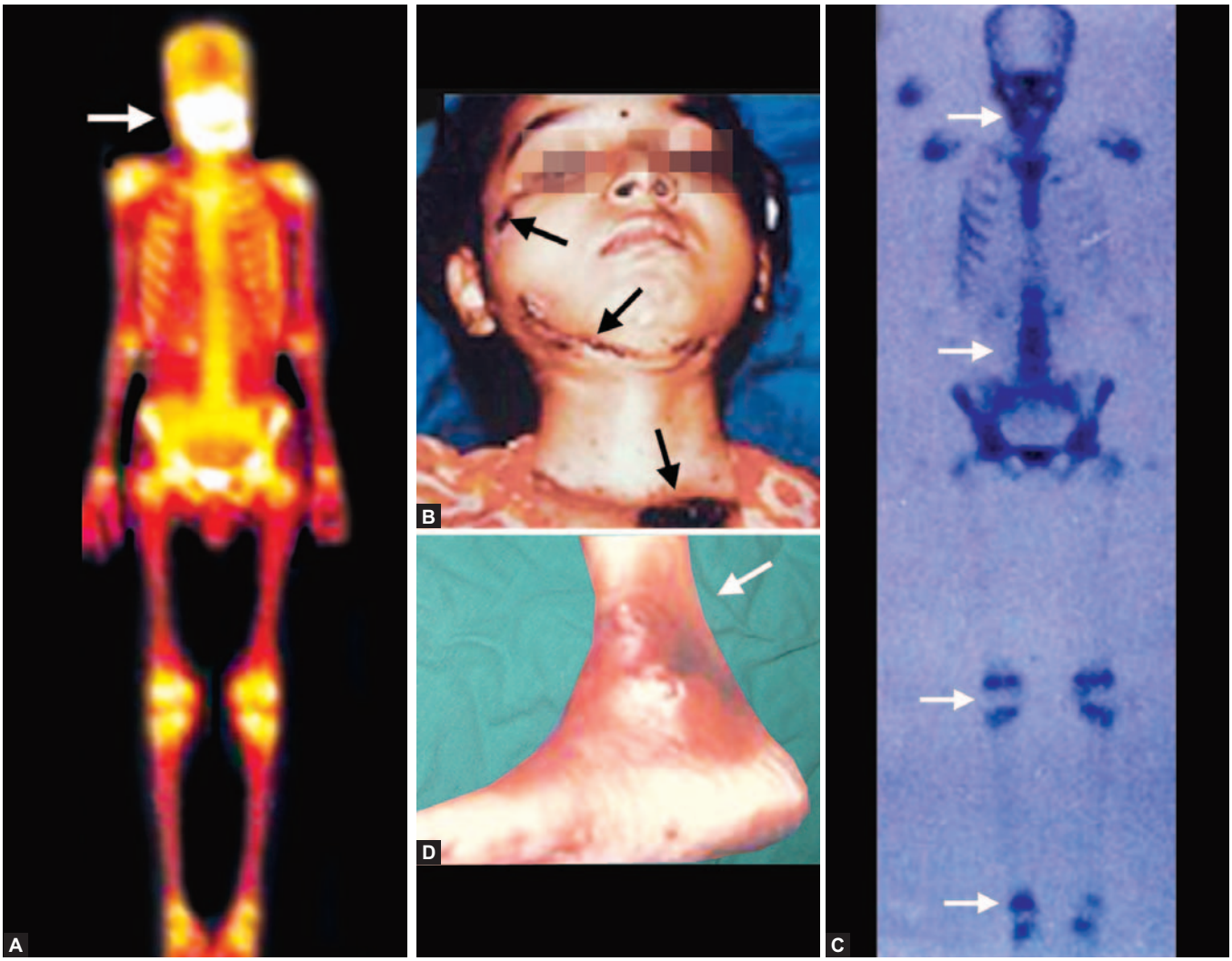


Fig. 2.23

Fig. 2.21: Bone scan of the skull showing malignant tissue in the bone, not detected by other imaging modalities. **Fig. 2.22:** Scintigraphy showing hot lesion in (L) temporomandibular joint (TMJ) area for the case of (L) TMJ ankylosis. **Fig. 2.23:** Bone scan of (R) mandibular body after reconstruction with bone graft (A—bone graft rejection, B—viable bone graft)



Figs 2.24A to D: Tuberculous osteomyelitis of the bone. An 18-year-old girl with multiple draining sinuses, involving the jaw bone and sternum: (A) Bone scan showing "hot spots" in the jaws; (B) Clinical picture—4 months later, after the start of AKT drugs, patient stopped the medication on her own; (C) Follow-up bone scan with hot spots in the mandible, vertebra, sternum and ankle joint; (D) 2 months later patient came back with sinuses at the ankle. The changes were detected early in the bone scan



Fig. 2.25: Bone scan machine: single photon emission computed tomography (SPECT) rotating camera system. A modern triple-headed gamma camera with a scanning couch. The heads are mounted on a rotating gantry and can be moved into a variety of geometrics

The various structures best examined in the maxillofacial region are the bony structures, the salivary glands, the thyroid and the parathyroids. A "hot" area on the scintigram indicates increased tracer uptake and thereby increased vascular activity in the region, which suggests normal bone growth, bone stress, repair, osteoblastic activity, increased vascularity, new bone formation, acute osteomyelitis, vascular uptake of a bone graft. A decreased uptake will be represented by a 'cold' area indicating reduced vascularity, e.g. a cyst or a necrotic area.

Cold lesions are also suggestive of decreased metabolic activity, metastases, infection, radiation therapy, vascular compromise, etc **(Figs 2.21 to 2.24)**.

The technique of radionuclide imaging has high sensitivity and low specificity. It can detect early the silent lesions that are not visible radiographically. A single bone scan is sufficient to evaluate the entire bony skeleton of the body, preventing the necessity for repeated radiographs **(Fig. 2.24A)**.

Radionuclide Imaging

- First introduced by Subramanian and Macfee—1971.
- IV injection in small, safe amounts of radioactive elements, such as 99mTc-P or 67Gallium is used.
- Highly sensitive to blood flow and metabolic activity of bone tissue.
- Accumulation within the skeleton. Fifty percent deposition is seen in one hour.
- Remainder of the radioactive element, disperses in the soft tissues.
- It is excreted via the urinary tract.
- After the injection, patient is encouraged to drink several glasses of water and encouraged to go for frequent micturition.
- This type of hydration reduces the radiation and accelerates the soft tissue clearance and enhances image quality of skeleton, at the end of two/four hours after the injection.
- Uptake of the radionuclide is monitored with a gamma or single photon emission computed tomographic (SPECT) imaging camera or scintillation camera.
- In SPECT camera, detectors can rotate 360° around the patient, acquiring up to 128 images in different angulations **(Fig. 2.25)**.
- 3D or surface displays are also possible.
- Record of radioactivity is shown in the form of images.
- Tracer uptake record can be seen on computer monitor.
- Accuracy of bone scan is now compared to MRI, but bone scan provides information at very low cost.

Indications for Scintigraphy

Radionuclide imaging in the maxillofacial region

- Dynamic method—for growth assessment of facial skeleton. Comparison of uptake can be done in paired structures.
- To identify skeletal metastases in early stage.
- To survey the presence of occult lesion.
- To locate the presence or extent of multiple osseous lesions.
- To diagnose the presence of neoplasm—benign/malignant.
- To locate abnormal metabolism or growth in the skeleton/jaw bone.
- To assess cessation of growth and fix the time for corrective surgery.
- To study the fate of bone grafts—rejection, vascularity, viability, uptake, etc.

Clinical Applications

- To detect salivary gland disorders.
- To detect early silent lesions of the bony skeleton.
- For early detection of metastasis from a primary malignant lesion.
- For early detection of spread of infections like tuberculosis.

- For evaluation of bone graft uptake postoperatively. A free graft will begin to show tracer uptake at the ends first, and gradually progresses to the center as the days progress. A cold area is indicative of graft rejection. A vascularized graft shows good tracer uptake throughout the graft immediate postoperatively **(Fig. 2.23)**.
- To evaluate the progress of the treatment given to the patient, e.g. in patients with tuberculous lesions of the jaw bones, repeated scintigrams can be used to evaluate the pre- and post-treatment extent and activity of the lesion **(Fig. 2.24)**.
- Inflammation/infection—osteomyelitis, avascular necrosis
- Neoplasms—primary bone tumors, osteosarcoma, Ewing's sarcoma, metastasis detection/therapy, follow-up for early indication of recurrence in the stump
- Metabolic disorders
- TMJ afflictions—condylar hyperplasia, ankylosis, etc. **(Figs 2.21 and 2.22)**.

Advantages

- ^{99m}Tc is easily available
- Inexpensive, noninvasive
- Low-radiation dosage
- No adverse effects
- Painless, safe procedure
- High-proton yield
- Short time is required—ideal for children
- No special preparation is required.

Sialography

Sialography is a radiographic technique to detect and monitor salivary gland disease (discussed in detail in salivary gland section). The technique is used to examine all the ductal and acinar systems of the major salivary glands, especially the parotid and submandibular glands. The procedure reveals the integrity and location of the salivary glands.

- Detection of sialoliths or foreign bodies.
- Evaluation of the extent of ductal damage secondary to infection.
- Evaluation of suspected neoplasms, as to the location, extent and size.
- Evaluation of fistulae, diverticulae and strictures.
- Diagnosis of autoimmune disorders like Sjögren's syndrome and Mikulicz's disease.

Arthrography

Arthrography is the introduction of an opaque contrast material in the joint space, so as to permit evaluation of structures that would otherwise be radiographically invisible. Arthrography has immense importance in TMJ imaging, to delineate the upper and lower joint compartments, the articular disk (the meniscus). It is contraindicated in acute infections and in patients with sensitivity to the contrast media.

Angiography

This is a method for studying the intracranial and extracranial vessels. A suitable radiopaque contrast medium is injected percutaneously into the carotid artery in the neck or into a vertebral artery, either by catheterization of a major blood vessel such as the femoral, axillary, brachial, or subclavian arteries. Radiographs are taken in various planes in the following few seconds. The arterial, capillary and venous circulation can be studied and abnormalities in the distribution, size, position and lumen of the vessels can be studied.

In the maxillofacial region, this technique is particularly useful in the study of the distribution pattern of the external carotid artery and the diagnosis of aneurysms, arteriovenous (AV) malformations and their feeder vessels, and vascular tumors. The procedure can also be coupled with identification and embolization of the feeder vessel in AV malformation prior to surgery.

Electrocardiography

Electrocardiogram (ECG) records the changes in the electrical potential in association with the contraction of the heart.

- It is useful to:
  - Determine the changes in the cardiac rate and rhythm.
  - Determine the changes in the impulse generation and conduction.
  - Detect areas of infarction.
  - Determine valvular dysfunction (stenosis and regurgitation).
  - Detect changes in the heart size.
- Electrocardiogram (ECG) is advised in the following:
  - Patients above the age of 40 years.
  - In known cases of heart ailments.
  - In known cases of renal disorders.
  - In known cases of thyroid disorders.

INVESTIGATIONS

Hematological Investigations

Hemoglobin

Hemoglobin (Hb) indicates the oxygen-carrying capacity of blood.

- Normal value
  - Females: 12–16 g%
  - Males: 14–18 g%
- A decreased value is indicative of anemia (less than 12 g% in adults). The most common cause of anemia is iron deficiency due to decreased intake of essential compounds, viz. vitamin B_1, B_6, B_{12}, iron, vitamin C. Other causes of anemia are decreased absorption of iron and vitamin B_6 as in sprue and pernicious anemia, respectively. Bone marrow depression, increased blood loss as in bleeding piles, gastric/duodenal ulcers, heavy menstrual flow, hemoptysis and postpartum bleeding are also other causes.
- Patients with low hemoglobin must be referred to the proper specialists for identification of the cause and necessary treatment prior to any surgical procedure.

Complete Blood Count

Complete blood count (CBC) includes the red blood cell (RBC) count, white blood cell (WBC) count, differential white blood cell count, an estimation of platelet number and a description of blood smear.

- Helps to determine the nutritional status
- Helps to detect the presence of infection
- Helps to detect/rule out bleeding disorders
- Helps to decide whether the patient's immune response will be adequate to facilitate postoperative recovery.

Red blood Cell Count (RBC)

- Normal value
  - Females: 4.5–5.5 million cells/mm^3
  - Males: 4.5–6.2 million cells/mm^3
- A decrease in the RBC count is seen in anemia, pellagra, hemorrhage and liver disease. An increase is seen in polycythemia and in extreme dehydration.

White Blood Cell Count (WBC)

- Normal value—
  - Females: 5,000–10,000 cells/mm^3
  - Males: 5,000–10,000 cells/mm^3
  - Children below 7 years: 6,000–15,000 cells/mm^3
- White cell count is increased (leukocytosis) in acute infections, uremia, leukemia and with steroid therapy. The count is decreased (leukopenia) in aplastic anemia, radiation therapy, infectious mononucleosis, malaria, AIDS, enteric fever and drug poisoning.
- A physiological increase in the WBC count is seen in pregnancy, exposure to heat and cold, muscular exercise and emotional stress.

Differential White Blood Cell Count

This count is the cell type distribution of the total white cell blood count.

- **Polymorphonuclear leukocytes (neutrophils): 50–70%**
  - Neutrophils are increased in infections, granulocytic leukemia, postsurgery, after severe exercise, severe hemorrhage and burns. The count is decreased in aplastic anemia, viral infections and in patients undergoing radiation or dialysis.
- **Lymphocytes: 25–40%**
  - Lymphocytes are increased in viral infections, tuberculosis, mononucleosis, syphilis, whooping cough, and lymphocytic leukemia. The count is decreased with stress, uremia and in steroid therapy.
- **Monocytes: 3–8%**
  - Monocytes are increased in monocytic leukemia, tuberculosis, chronic inflammation, collagen diseases (rheumatoid arthritis, systemic lupus erythematosus), subacute bacterial endocarditis, malaria, typhoid, kala-azar and protozoan infections.
- **Eosinophils: 1–8%**
  - Eosinophil count is increased in allergies, parasitic infection, collagen vascular diseases, Addison's disease and malignancy. Eosinophilia can be classified as:
    - Parasitic—helminthiasis, filariasis
    - Allergic—asthma, urticaria, dermatitis
    - Skin related—scabies, eczema, pemphigus.
- The count is reduced in stress, steroid therapy, adrenocorticotropic hormone excess and in Cushing's syndrome.
- **Basophils: 0–1%**
  - Basophil count is increased in polycythemia, and chronic myeloid leukemia. The count is decreased in stress, steroid therapy, acute rheumatic fever and thyrotoxicosis.

Platelet Count

- **Normal value:** 150,000–400,000 cells/mm^3
- Platelet count is increased in malignancy, postsurgery or postsplenectomy, rheumatoid arthritis, iron deficiency anemia, trauma, and acute hemorrhage. The count is decreased in idiopathic thrombocytic purpura, marrow invasion or aplasia, hypersplenism, disseminated intravascular coagulation, cirrhosis of liver, massive transfusions, viral infections and infectious mononucleosis.

Erythrocyte Sedimentation Rate

- Normal value:
  - Females: 0–20 mm/hour
  - Males: 0–10 mm/hour by Wintrobe's method.
- Erythrocyte sedimentation rate (ESR) is a nonspecific test and values above normal are indicative of chronic infections, infarctions, trauma and inflammatory processes. *Correlation with clincal symptoms is a must.*

Coagulation Tests

- **Bleeding time:** About 3–5 minutes by Duke's method (use of filter paper).
  - Bleeding time is the lag between the start of bleeding and the beginning of clot formation. It is increased in thrombocytopenia, capillary wall abnormalities (vitamin C deficiency), and platelet abnormalities which may be drug induced (use of aspirin, warfarin).
- **Clotting time:** About 4–10 minutes by Lee-White method (use of capillary tube).
  - Clotting time indicates the time interval beginning from the formation of platelet plug to the completion of vasoconstriction and clot formation. Prolonged clotting time is seen in thrombocytopenia, hypersplenism, clotting factor deficiency and use of anticoagulants.
- **Prothrombin time:** Usually 12–14 seconds. This value is always given with a control. Values within 2 seconds of the control are considered to be normal. It measures the extrinsic and the common pathways of the coagulation cascade. The prothrombin time is prolonged in factor I, II, V, VII, and X deficiency and in anticoagulant therapy, cirrhosis of liver, hepatitis, obstructive jaundice, colitis, celiac disease, sprue and salicylate therapy.
- **Partial thromboplastin time:** Usually 25–45 seconds. This value is always given with a control. Values within 4 seconds of the control are considered to be normal. It is prolonged in factor I, II, V, VII, IX, X, XI and XII deficiencies and in patients undergoing heparin therapy.
- **Thromboplastin generation time:** The normal range is 12 seconds or less. It is used to differentiate specific factor deficiencies, namely V, VIII, IX, X, XI, and XII.

Biochemical Analysis

1. Renal Function Tests

Blood Urea Nitrogen

- **Normal value:** 10–20 mg/100 mL
  - Decreased levels are associated with advanced liver disease and low-protein diets.
  - Increased levels are seen in renal disorders and are associated with decreased glomerular filtration rate.

Serum Creatinine

- **Normal value:** 0.7–1.4 mg/100 mL
  - Increased values are associated with impaired renal functions and muscle diseases. Serum creatinine is a more sensitive indicator of glomerular filtration rate than blood urea nitrogen.

Serum Electrolytes

Serum Sodium

- **Normal value:** 135–145 mEq/L
  - Hyponatremia is associated with cirrhosis of liver, congestive cardiac failure, adrenal insufficiency, nephritis, excessive use of diuretics, and water intoxication. Hypernatremia is associated with excessive water loss due to diarrhea, vomiting, and sweating and in diabetes mellitus.

Serum Potassium

- **Normal value:** 3.2–5.5 mEq/L
  - Hyperkalemia is associated with the release of cellular potassium secondary to surgery, crush injuries, hemolysis of RBCs, renal failure and acidosis. Hypokalemia is seen in excessive fluid loss through the gastrointestinal tract or urinary tract.

Serum Chloride

- **Normal value:** 95–105 mEq/L
  - These levels fluctuate according to the serum sodium levels.

2. Liver Function Tests

Alkaline Phosphatase

- **Normal value:** 1.5–4.5 Bodansky Units
  - Increase is associated with hepatic obstruction, and in any increase in the osteoblastic activity as in Paget's disease and Cherubism.

Serum Albumin

- **Normal value:** 3.5–5.0 g/100 mL
  - Increase in serum albumin is associated with dehydration. Decrease in serum albumin levels is seen in kidney disorders such as nephritis, chronic glomerulonephritis, gastrointestinal diseases such as ulcerative colitis, and protein-losing enteropathy, and liver diseases such as Laennec's cirrhosis and hepatocellular damage secondary to hepatitis.

Serum Bilirubin

- **Normal value:**
  - Total bilirubin less than 0.8 mg/100 mL
  - Direct bilirubin less than 0.5 mg/100 mL
  - Indirect bilirubin less than 0.3 mg/100 mL
- Bilirubin is an important measure of hepatic function. It is measured in two forms—(1) direct (conjugated) and (2) total (conjugated and unconjugated). The difference between the two represents the unconjugated form.

Serum Glutamic Oxaloacetic Transaminase (SGOT)

- **Normal value:** 10–50 mU/mL
  - SGOT levels are elevated in myocardial infarction, hepatitis, cirrhosis and liver neoplasms, hepatic necrosis.
  - The levels are reduced in beriberi, uncontrolled diabetes mellitus with acidosis.

Serum Glutamic Pyruvic Transaminase (SGPT)

- **Normal value:** 6–36 mU/mL
  - SGPT levels are elevated in myocardial infarction, and liver damage. The levels are more elevated in liver damage.

3. Serum Calcium

- **Normal values:** 8.5–10.5 mg/100 mL
  - Increased values are associated with excessive osteolysis, as in hyperparathyroidism and malignancies with bone metastasis. Decreased values are associated with hypoparathyroidism, pseudohypoparathyroidism, tetany, hypoalbuminemia, acute pancreatitis, renal failure and starvation.

4. Serum Phosphorus

- The normal values between 2.5 and 4.5 mg/100 mL.
- Increased levels are associated with hypoparathyroidism, pseudohypoparathyroidism, secondary hyperparathyroidism caused by chronic renal failure and metabolic acidosis. Decreased levels are associated with primary hyperparathyroidism, vitamin D deficiency, malabsorption diseases, and chronic antacid usage.

5. Blood Glucose

- The normal fasting glucose value is between 65 and 110 mg/100 mL of blood.
- The normal postprandial glucose level is 120–160 mg/100 mL of blood.
- Increased levels are seen in diabetes mellitus, Cushing's syndrome, pancreatitis, and pheochromocytoma. Decreased levels are indicative of hypoglycemia.

6. Blood Gases

Blood gases are measured when there is an altered ventilatory status, hypoxemia, hypocapnia, hypercapnia, and pH disturbances. The parameters measured and their normal values are:

- Partial pressure of oxygen (PO_2): 80–95 mm Hg
- Oxygen saturation (SaO_2): 93–98%
- Partial pressure of CO_2 (PCO_2): 36–43 mm Hg
- Bicarbonate (HCO_3) content: 20–30 mEq/L
- Arterial pH: 7.35–7.45.

Specific Investigations

ELISA for HIV 1 and 2 Antibodies

Enzyme-linked Immunosorbent Assay (ELISA) is used as a screening test for HIV-infected patients. Two positive tests by different methods are confirmatory for HIV infection.

Australia Antigen Test

This is a test to detect presence or absence of hepatitis B virus. A positive result is indicative of a hepatitis B carrier.

Urine Analysis

Usually 100 mL of the first morning sample is collected in a sterile container

Normal Values

- Color and appearance—straw yellow and clear
- Turbidity is indicative of presence of cells and casts
- Specific gravity—1.001–1.035
  - pH: 4.6–8.0.

Chemical Examination of Urine

- RBC count: Male—0–3/high power field (HPF); Female—0–5/HPF
- WBC count 0–4/HPF
- Epithelial cells—occasional
- Hyaline casts—occasional
- Bacteria—none (presence is indicative of urinary tract infection)
- Blood—negative (presence is indicative of trauma, infection, menses, renal stones, transfusion reaction)
- Bilirubin and bile pigments—negative (presence is indicative of hepatitis or obstructive jaundice)
- Glucose—negative (presence is indicative of diabetes mellitus, pancreatitis, shock, coronary thrombosis)
- Ketones—negative (presence is indicative of pregnancy, diabetic ketoacidosis, hyperthyroidism, fever, starvation)
- Proteins—Usually 35 mg of proteins are seen in a 24-hour urine sample. Albumin may normally be present in the urine. The other proteins that may be excreted in the urine are globulin, Bence Jones protein, mucin and hemoglobin. Bence Jones protein is synthesized in the plasma cells and its presence is indicative of multiple myelomatosis. Presence of hemoglobin is indicative of hemolysis with urinary tract bleeding.
- Proteinuria occurs in the following conditions:
  - **Prerenal causes:** Postural, severe infections and fever and cerebral injury
  - **Renal:** Glomerulonephritis and diabetic glomerulosclerosis
  - **Postrenal:** Inflammation of the ureter and the urinary bladder.

Bacterial Culture and Antibiotic Sensitivity Tests

Cultures can be obtained from the throat, sputum, draining pus, urine or stools. Cultures from the oral cavity can be obtained either by gathering exudative material or by aspiration with a needle and syringe or by use of a swab. A throat or pus culture is obtained by collecting the sample on an autoclaved swab stick. A transport medium must be used when the sample cannot be inoculated immediately onto a primary culture medium. *For smear and culture in suspected cases of tuberculosis, the sample is sent in normal saline.* The culture is then grown on any of the various culture media available, e.g. blood agar or chocolate agar. *Antibiotic sensitivity testing evaluates the susceptibility of the isolated pathogenic organism to various antibiotics.* The testing is carried out either by agar disk diffusion method, with small paper discs impregnated with the standard concentrations of the antibiotics or by serial dilution method, in tubes containing serial dilutions of various antibiotics.

Biopsy

- Biopsy is a Greek word. By-Op-See. Bio-Life, Opsy-To Look.
- Ruge and Johamvert in 1870, in Berlin, first introduced a concept of biopsy. In 1889,Emarch emphasized on the confirmation of the diagnosis via biopsy.
- *The term biopsy most often indicates the removal of suitably representative tissue from a living subject for histological microscopic evaluation and analysis to obtain diagnosis.* It is important for the clinician to obtain a proper specimen from the lesion for evaluation and final diagnosis.
- We are in the era of evidence-based medicine; the use of biopsy in surgery cannot be overemphasized.

Aims

- To establish the diagnosis of the lesion
- To grade the tumor
- To detect the receptors
- To carry out mass screening for community-based detection programs
- To detect enzymes and antigens
- To monitor treatment, recurrence, prognosis, for research purpose
- For microbiological studies
- For medicolegal purpose.

Steps

- A detailed health history of the patient
- A history of the specific lesion
- A thorough clinical examination
- A radiological examination
- Laboratory investigations
- Choosing a method for obtaining specimen for histopathological/cytological examination.

Indications for Biopsy

- Any lesion that persists for more than 15 days with no apparent etiologic basis.
- Any inflammatory lesion that does not respond to local treatment after 10–14 days.
- Persistent hyperkeratotic changes in surface tissues.
- Any persistent swelling/mass, either visible or palpable beneath relatively normal tissue.
- Inflammatory changes of unknown cause that persists for long periods.
- Lesions that interfere with local function.
- Bone lesions not specifically identified by clinical and radiographic findings.
- Any lesion that has the characteristics of malignancy.

Lesions that Raise the Suspicion of Malignancy

- Erythroplasia—lesion is totally red or has a speckled red appearance.
- Ulceration—lesion is ulcerated or presents as an ulcer.
- Duration—lesion has persisted for more than 15 days.
- Growth rate—lesion exhibits rapid growth
- Bleeding—lesion bleeds easily even on gentle manipulation or even without it
- Induration—lesion and surrounding tissue is firm to the touch
- Fixation—lesion feels attached to adjacent structures/base

Oral cancer is the 6th most common form of the cancer. If the detection is done early, the survival rate is around 5 years in 76%. The use of tobacco products is responsible for 80 to 90% of all oral cancers. A pack of cigarettes a day increases oral cancer risk 4.5 times, six alcoholic drinks a day, increases the risk by 3.3 times, and 7 to 9 drinks a day increases the risk 15 times more. Heavy alcohol use combined with heavy tobacco use can increase the risk up to 100 folds. *While taking the history, every clinician should bring these facts to the notice of the patients and motivate them to reduce these risk factors.* Dentists see potentially harmful, but innocuous, unexplained white or red spots in the oral cavity, on a daily basis. Identifying unsuspected early and potentially curable oral cancers, precursor lesions, dysplasias is of utmost importance to prevent the progression of these lesions to oral cancer. *The early detection also will improve the survival rate by treating them at early curable stage.*

Recommended yearly oral health check-ups for all people over 40 years and for people between 20 and 39 years of age, once in 3 years. Oral cancers are readily detected by clinical examination in their late stages, but not in their early stages. More than half of all patients with oral cancer have evidence of metastasis at the time of diagnosis and only 50% of these patients have 5-year survival rate. *Therefore early screening measures on yearly basis are recommended.*

Guidelines for Evaluating Oral Lesions

- Oral lesions that appear suspicious of a malignancy, should be referred for immediate biopsy.
- If the lesion is caused by an infection, such as herpes or candidiasis, then treatment should be instituted promptly.
- Oral lesions with obvious etiology, such as trauma or aphthous ulcers require palliative treatment and observation to ensure that the lesion resolves.
- If the lesion looks harmless and its cause unexplained, a brush biopsy should be performed or any other screening method should be employed to have early detection. This is also done to determine if it is potentially precancerous or cancerous.
- Patients with positive screening results should be advised to undergo scalpel biopsy.

Mass Screening Methods—Adjunct methods (not the substitute for surgical biopsy)

- Exfoliative cytology
- Toluidine blue detection test
- Oral ICDx brush biopsy
- Light-based detection systems—Velscope, Vizilite plus, Microlux DL.

Exfoliative cytology: Cytology is a branch of pathology dealing with diagnosis at cellular level. It is the examination of cells and their architecture that have been obtained by cells physical removal. It was first introduced by Papanicolaou and Traunt for the detection of uterine cancer. They used special staining method. Commonly known as *Pap smear* in honor of its inventor. Developed as a diagnostic screening procedure to monitor large tissue areas for dysplastic changes.

Most frequently used to screen for oral malignancy.

It may be helpful with monitoring postradiation changes, herpes, and pemphigus.

This technique is particularly used for diagnosing lesions of the epithelial surfaces. The lesion is repeatedly scraped with a moistened tongue depressor or a wooden or plastic spatula. The cells obtained are smeared on a glass slide and immediately fixed with a fixative spray or solution.

The smear is then stained with a suitable stain, like Gram stain, and the cells are studied. This technique is of immense value in diagnosing malignant lesions of the oral cavity.

Body fluids like blood, urine, cerebrospinal fluid or any other aspirated fluid also can be studied for cytology.

The study of the cells is reported as one of the five following categories:

- *Class 1:* Normal
- *Class 2:* Atypical (presence of minimal atypia but no evidence of malignancy)
- *Class 3:* Intermediate (wider atypia, that may suggest cancer, but not clear cut)
- *Class 4:* Suggestive of cancer (few cells with malignant characteristics, many cells with borderline characteristics)
- *Class 5:* Positive for cancer (cells obviously malignant).

Disadvantage of oral cytological procedures include:

- Not very reliable, often with many false positives results
- Expert trained staff in oral cytology is not available in all the centers.
- Only superficial layer cells can be obtained by this method.

Toluidine Blue Detection Test

Tolonium chloride also known as toluidine blue (TBO) is a blue cationic (basic) thiazine metachromatic vital dye, with high affinity for acidic tissue components, thereby staining tissues rich in DNA and RNA. Dysplastic cells contain nucleic acid and fast growing cells contain sulfated mucopolysaccharides. TBO is used in histology, as well as *in vivo* clinical set up. It stains nucleic acids royal blue and polysaccharides purple and increases sharpness of histology slide images. It is used today, for staining chromosomes in plant or animal tissues. It is also used in forensic examination, neuropathy, etc. It has got wide application both as vital staining in living tissues and as a special stain owing to its metachromatic property. This dye is used by surgeons to help highlight areas of mucosal dysplasias in premalignant lesions or conditions. This helps to choose the best site of the lesion (intensive stained areas) for biopsy or during surgery to remove the lesion and to decide whether to remove more tissue from the margins of the excision defect or not. Detection of unnoticed or satellite tumors delineate margins of premalignant and malignant lesions, is also possible. In histology tissue sections, it is used to highlight components such as mast cell granules, mucin and cartilage. TBO also binds to negatively charged mitochondrial membranes.

Clinical use for Oral Dysplasia Detection

100 mL of 1% TBO consists of:

- 1g TBO powder
- 10 mL of 1% acetic acid
- 4.19 mL absolute alcohol
- 86 mL distilled water (the pH is regulated to 4.5)

For obvious lesions, the solution is either applied with cotton swab or given as an oral rinse, when no obvious lesion is detected.

The technique of application usually involves rinsing the mouth twice with water for 20 sec to remove the debris. 1% acetic acid is then applied for 20 sec to remove ropey saliva. This is followed by 1% TBO application for 20 seconds. Again two rinses with 1% acetic acid are done to reduce the extent of mechanically retained stain. Finally mouth is rinsed with water. The interpretation is based on the color. A dark blue (royal or navy) stain is considered positive, light blue is doubtful and no color is negative. Sensitivity and specificity of TBO in detection of oral cancer is supposed to be in the range of 78–100%.

In oral and maxillofacial surgery TBO is used:

- For mass community camp screening
- As an adjunct to clinical examination
- To delineate margins of the lesion and to identify the location of biopsy
- To detect multicentric or second tumor
- To help in follow-up of patients with oral cancer after treatment.

Any lesion which is not clinically suspicious, but shows TBO uptake, (due to irritation or inflammation) should be re-evaluated after 10–14 days after the regression of the condition. If still positive, then biopsy should be done.

Lugol's iodine solution was also used earlier, as brown/black stains are obtained due to reaction of iodine with glycogen.

Oral CDx Brush Biopsy

It is a hybrid of fine needle aspiration biopsy (FNAB) and exfoliative cytology. It is again a screening test, here computer-assisted automated microscopic analysis is done using a especially designed nylon oral brush. It is used to collect cells from all three layers of the epithelium (including basal layer) of the lesion (complete transepithelial sample). This method is different from older exfoliative cytology, where only superficial epithelial cells are collected and examined. This method is introduced in 2000, it is a reliable, noninvasive, simple, chairside, painless procedure to detect precancerous lesions and early stage oral cancer. The brush biopsy empowers

dentists with a tool that can be used to accurately evaluate commonly encountered harmless looking lesions. This is a cytological examination to determine the presence of atypia.

Method

The kits are provided by the company. The oral biopsy brush provided has two cutting surfaces, the flat end of the brush and the circular border. The cutting edge is pressed against the lesion firmly and rotated 5 to 10 or more times in a clockwise fashion, depending on the thickness of the lesion. The cellular material which is entrapped on the bristles of the brush is collected and is then transferred onto a glass slide. The cells are then fixed on the slide using alcohol fixation and sent to oral scan laboratory for computer image analysis, assisted identification and display of any abnormal cells. This method also can be used for mass screening and results are given by the laboratory as atypical, positive and negative. The printout of color images of cellular abnormalities with an accompanying explanation is given. If the positive report is obtained, then scalpel biopsy should be planned.

Light-based Detection Systems—Velscope, Vizilite plus, Microlux DL, Chemiluminescence

Velscope (narrow emission tissue fluorescence): It is a portable tool for screening of oral cancer. It emits intense blue excitation light: 400 to 460 nm. A pale green autofluorescence is emitted by the normal mucosa, which is seen through the narrow band filter, incorporated in the instrument handpiece. Abnormal atypical tissues appear darker than the adjacent normal tissue due to decreased amount of normal autofluorescence.

Vizilite Plus and Microlux DL

- These are the companies that market the light-based detection tools.
- Patient is asked to rinse the mouth with 1% acetic acid solution and inspection of oral cavity is done by a blue white light. Normal epithelium appears light blue, while abnormal tissue will appear white under the blue white light. This is also used as baseline screening procedure.

Different Methods of Biopsy

A. Closed Indirect Methods
   1. Fine needle aspiration cytology (FNAC)
   2. Core needle biopsy
   3. Punch biopsy
   4. Loop biopsy
   5. Endoscopic Biopsy—curative or diagnostic

B. Closed Image-guided Biopsy
   1. Stereotactic—use of image intensifier
   2. Ultrasound, CT, MRI-guided biopsy—to guide the passage of a needle or biopsy instrument into internal organ or lesion.

C. Open Direct Methods
   1. Incisional biopsy
   2. Excisional biopsy—marginal, wide, local, radical.

1. Fine Needle Aspiration Cytology (FNAC)

FNAC uses a fine needle (23–26G) to aspirate the contents of the lesion, by the puncture of the lesion. Aspiration of cells, fluid, tissue fragments is done. The tissues/cells within the lumen of the needle are obtained by rotation of the needle and the needle withdrawn. A smear is prepared, stained and studied. This test may not be significant at times. The test is painless, speedy, inexpensive, and can be done as bedside procedure.

Indications for FNAC

- To determine the presence of fluid within a lesion
- To ascertain the type of fluid within a lesion
- When exploration of an intraosseous lesion is indicated
- To rule out vascular lesion prior to open surgery
- Can be used as diagnostic screening at community level for head and neck masses
- Areas which are difficult to access—use of ultrasound, CT or MRI guidance will help in finding the correct location or target zone.

2. Core Needle Biopsy—Fine Needle Cutting Biopsy (FNCB)

Tru-cut, Abram's, Silverman's, Menghini's wide bore needles are used. These are especially designed biopsy needles with outer needle with trocar point-8 swg, Luer Lock mount, inner needle square cut end 11 standard wire gauge (SWG), stilette.

Here core of the deep tissue is taken by using one of the above mentioned needles. Aspiration of chunks of cell aggregates is done by approaching the lesion at 45 degrees. It is transferred on the slide, air-dried or fixed with 95% ethanol and stained. Useful for grading the malignant tumors and to know their invasiveness. In case of deep lesions, exact location and depth of the tumor can be directly visualized via computer image. Sometimes automated suction device is attached to core biopsy needle to carry out vacuum-assisted needle biopsy. Large amount of tissue can be obtained from deeper area via suction method. For core biopsy, fully mechanical guns are also used.

3. Punch Biopsy

It is simple, inexpensive method, needs local anesthesia. This is an alternative to traditional incision biopsy. A small part of the lesion is obtained as a specimen using an especially developed sharp cylindrical circular blade punch, attached to a handle. Varying sizes are available, diameter ranging from 4 to 10 mm. This technique is of particular use in mucosal lesions from inaccessible regions that cannot be reached by conventional methods. The punch is inserted into the suspicious area tissue, through full thickness of the lesion and gently rotated, so that a core of the tissue is separated from its surrounding area. The base of this can be simply and atraumatically removed using curved scissors. The technique produces some amount of crushing or distortion of the tissues. The tissue is then transferred for histopathological examination. This method is usually used for flat lesions, mucocutaneous lesions like erythroplakia, pemphigus vulgaris, lupus erythematosus, vesicles, ulcerative lesions, etc. The resultant wound may not require suturing if using the smaller diameter punches. Difficult to obtain biopsy from freely movable tissues like soft palate or floor of the mouth.

Incisional Biopsy

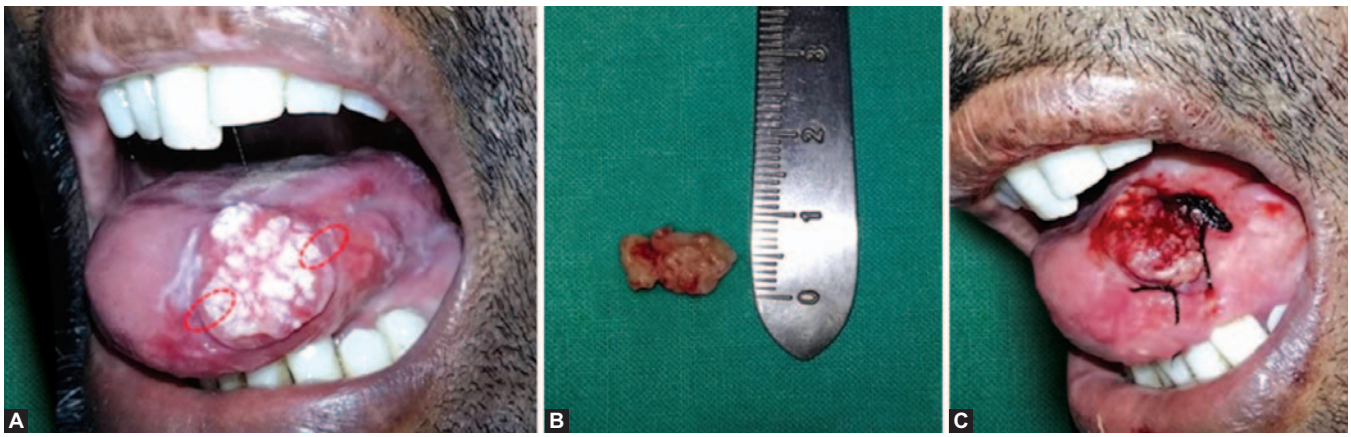
- An incisional biopsy is a biopsy that samples only a particular portion or representative part of a lesion.
- If a lesion is large or has different characteristics in various locations, more than one area may need to be sampled.
- When there is a large diffuse lesion, a "representative" section of the lesion is incised with the help of a scalpel along with the normal tissue and sent for histopathological evaluation **(Fig. 2.26A to C)**.

Indications for Incisional Biopsy

- Size limitations—large lesions requiring proper planning for surgery
- Hazardous location of the lesion
- Great suspicion of malignancy.

Technique

- Representative areas are biopsied in a wedge fashion. The length of the tissue should be approximately three times the width. A narrow deep specimen is better than a broad shallow one.
- Margins should extend into normal tissue on the deep surface.
- The center of the large tumor may be often necrotic. This tissue should be avoided. Electrocautery should be avoided. Fulguration artifact is an important problem induced during electrosurgical or laser cutting of tissue. The resulting effect of a layer of carbonized tissue, a zone of thermal necrosis and a zone of tissue exhibiting thermal damage makes histopathological interpretation more difficult.
- Incisional biopsies should never be performed in vascular lesions, hemangiomas, etc. Laser or cryosurgery is used for the ablation of such lesions.
- In case of lichen planus, lichenoid and other similar mucocutaneous lesions, an area of nonerosive tissue



Courtesy: Dr Kumar Nilesh

Figs 2.26 A to C: Incision biopsy of white ulcerative lesion on the tongue (A) Selection of two areas for incisional biopsy, including the margin; (B) Excised specimen; (C) Suturing the wounds. H/P diagnosis-CA tongue

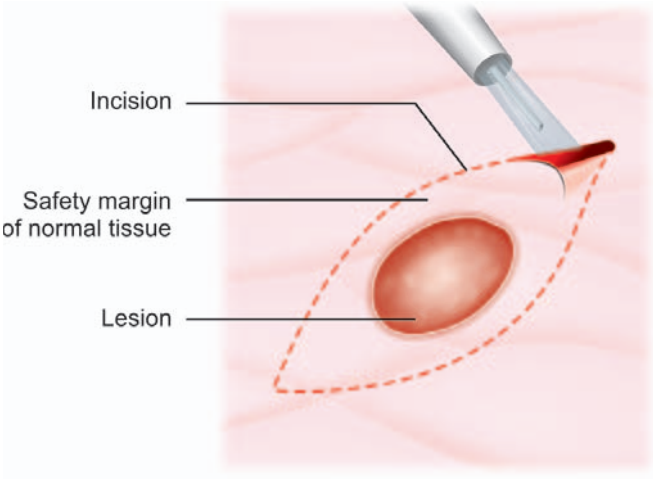


Fig. 2.27: Excisional biopsy diagram

should be chosen. In suspected vesiculobullous disorder, the site of biopsy should be adjacent to bulla, where the epithelium is still intact. In precancerous lesions of leukoplakia and erythroplakia, a nonhomogeneous and speckled area is chosen, as these areas have higher incidence of dysplasia and malignant transformation. If the lesion is extensive or there are numerous patches, then more than one area should be biopsied.

Excisional Biopsy

- Excisional biopsy is taken if the lesion is extremely small in size. In these cases, the entire lesion is excised *in toto* at the same sitting and sent for histopathological examination. It is a combination of diagnostic and, curative/ablative procedure and is suitable for lesions less than 1 cm **(Figs 2.27 to 2.29)**.
- With all the investigations in hand, the clinician has a clear picture of the type, the location, extent and behavior of the lesion. A final diagnosis is then obtained and a suitable medical or surgical line of treatment is decided upon.

Indications

- Should be employed with small lesions, less than 1 cm and when the lesion on clinical examination appears benign
- When complete excision with a margin of normal tissue is possible without mutilation.

Technique

The entire lesion with 2–3 mm of normal appearing tissue surrounding the lesion is excised, if benign.

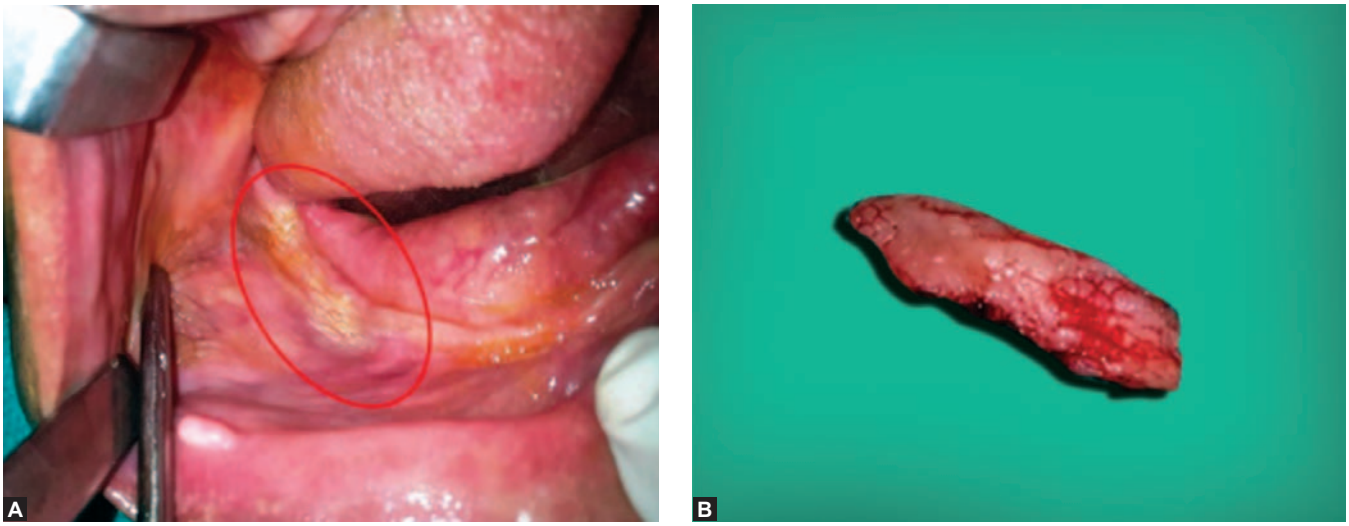
Principles to be Followed during Biopsy Procedure

Obtain Informed Written Consent

The indications for biopsy and details of possible risks involved in the procedure should be included in the consent form.

Anesthesia

- Block anesthesia is preferred to infiltration



Courtesy: Dr Kumar Nilesh

Figs 2.28A and B: Excision of white patch over (A) Alveolar mucosa; (B) Excised specimen

- When blocks are not possible, distant infiltration may be used
- Never inject directly into the lesion, direct injection will produce artifactual tissue edema or distortion.

Tissue Stabilization during Biopsy

- Digital stabilization
- Specialized retractors/forceps
- Retraction sutures
- Towel clips.

Hemostasis

- Suction devices should be avoided
- Gauze compresses are usually adequate
- Gauze wrapped low volume suction may be used, if needed.

Incisions

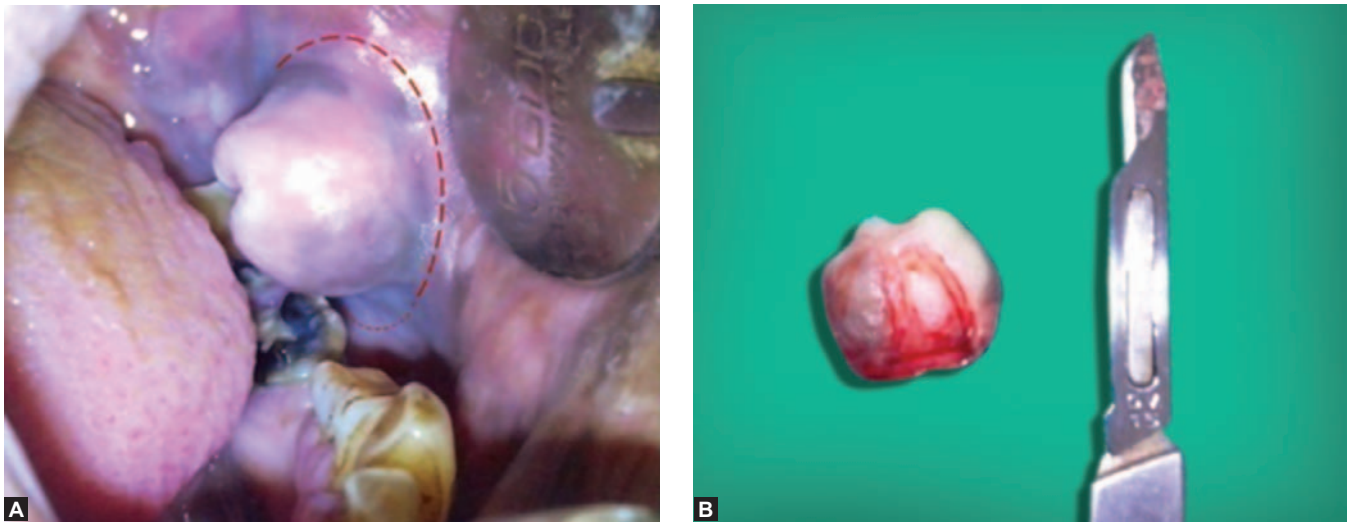
- Incisions should be made with a scalpel.
- They should be converging.
- Should extend beyond the suspected depth of the lesion.
- They should be parallel to important structures to avoid injury.
- Margins should include 2–3 mm of normal appearing tissue, if the lesion is thought to be benign. 5 mm or more may be necessary for lesions that appear malignant, vascular, pigmented, or have diffuse borders.

Handling of the Tissue Specimen

- Direct handling of the lesion will expose it to crush injury (crush artifact resulting in alteration of the cellular architecture).

Specimen Care—Fixation

The specimen needs to be fixed to stop tissue autolysis (Rendering the tissues progressively undecipherable histologically) prior to the sample reaching the pathology laboratory. The specimen should be immediately placed in 10% neutral buffered formalin solution (a 4% solution of formaldehyde and for electron microscopy—fixation is done with glutaraldehyde, specimens for cytogenetics should be submitted in universal transport medium, which is stored at 4°C), and be completely immersed. Volume of this solution should be at least ten times the volume of the specimen. Formalin fixes specimen by forming intermolecular bridges between proteins and crosslinks between protein endgroups. It is desirable to send soft and bony/tooth tissue separately, whenever possible. Otherwise the pathologist should be informed about inclusion of bony or tooth tissue. Mineralized sample, such as bone or tooth may require decalcification before it can be processed. The time for decalcification will vary according to the size and consistency of the specimen, as well as the methods employed by the laboratory.



Courtesy: Dr Kumar Nilesh

Figs 2.29A and B: Excision biopsy of fibroma over buccal mucosa and excised specimen

Margins of the Biopsy

Margins of the tissue should be identified to orient the pathologist. Placing a silk suture at one known margin is often adequate. Illustrations are also very helpful and should be included.

Surgical Closure

Punch biopsy can be left unsutured. Primary closure of the conventional incisional biopsy wound is usually possible. Mucosal undermining may be necessary. Elliptical incision on the hard palate or attached gingiva may be left to heal by secondary intention.

Biopsy Data Sheet

A biopsy data sheet should be completed and the specimen immediately labeled. All pertinent history and descriptions of the lesion must be conveyed. Patient's detailed demographic data information, unit and consultant incharge, nature and clinical appearance of the lesion, the site of specimen, type of biopsy procedure, provisional diagnosis, date of biopsy specimen collection, previous histopathology report, if any, clinical features and intraoperative notes and radiological findings and other laboratory investigations, specific findings must be provided to the pathologist.

Intraosseous and Hard Tissue Biopsy

Indications for Intraosseous Biopsy

Any intraosseous lesion that fails to respond to routine treatment of the dentition. Any intraosseous lesion that appears unrelated to the dentition.

Clinical Examination

Palpation of the area of the lesion with comparison to the opposite side. Any radiolucent lesion should have an aspiration biopsy performed prior to surgical exploration. The aspiration will provide valuable information about the lesion:

- Solid
- Fluid filled
- Vascular
- Without contents.

Principles of Surgery to be Followed for Intraosseous Lesions

- Mucoperiosteal flaps should be designed to allow adequate access for incisional/excisional biopsy. Incisions should be over sound bone.
- Cortical perforation must be considered, when designing flaps.
- Flaps should be of full thickness.
- Major neurovascular structures should be avoided.
- Osseous windows should be submitted with the specimen.
- Osseous perforations can be enlarged to gain access.
- Avoid roots and neurovascular structures.
- The tissue consistency and nature of the lesion will determine the ease of removal.
- Incisional biopsies only require removal of a section of tissue.
- Soft tissue overlying the lesion should be reapproximated following thorough irrigation of the operative site. The specimen should be handled as previously described.

Biopsy Results

- If the biopsy results do not match with clinical impression, then repeat the biopsy.
- Determine if the tissue was looked at by an expert oral pathologist.
- The results show malignancy in doubtful cases, then also plan for repeat biopsy.

When to Refer for Biopsy to the Specialist

When the health of the patient requires special management that the dentist feels unprepared to handle. The size and surgical difficulty is beyond the level of skill, that the dentist feels he/she possesses. If the dentist is concerned about the possibility of malignancy.

Intraoperative Procedures

Intraoperative lymphatic mapping—sentinel node Biopsy: Sentinel node is the first lymph node to receive lymphatic drainage from a malignant tumor. A dye and a radioactive agent is injected into the body, which causes certain nodes to "light up" indicating that is the most appropriate area. Detected by both the light created by the dye and the radioactive substance that is monitored by a gamma camera. If the sentinel nodes do not contain malignant cells, this usually eliminates the need for removal of more distant nodes.

Frozen Sections

Rapid histopathological examination of the tissue for knowing the clear margins of the total excision of the lesion. Here the unfixed tissue is rapidly frozen using CO_2 in a cryostat machine to –20 to –300°C and the tissue is cut into the thin slices of 1 μm. These sections are examined after staining histopathologically. It is a quick assessment for the surgeon to decide upon the next step.

Histopathological Evaluation

Pathologist will grade the abnormality of the tissue as well as carry out complete characterization of the lesion histopathologically. Histopathological evaluation is the final and confirmatory test for a lesion. It needs proper expertise and training to diagnose the lesions, which are often confusing. At the same time, clinician who will be sending a sample must do proper planning prior to performing a biopsy. It will be beneficial to the receiving pathologist in reaching a helpful and meaningful diagnosis, and more importantly to the patient.

Points to Remember

- History Taking
- Clinical Examination
- Clinical Diagnostic Aids
- Selection of Imaging Modality

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CHAPTER 3 Management of Medically Compromised Patients in Oral Surgery

INTRODUCTION

Knowledge regarding the patient's medical condition is of utmost importance, in patient management and care, pre- and post-surgically. A detailed medical history (as described in Chapter 2) will give the practitioner all the necessary and relevant information regarding the patient's general condition as well as physical status. Follow a rule, "know your patient well and do not treat a stranger".

CLASSIFICATION OF PHYSICAL STATUS

- In 1962, the American Society of Anesthesiologists (ASA) adopted the ASA physical status classification. This classification identifies the medical risk to a patient undergoing a surgical procedure. The classification is as follows:
  - **ASA I:** A patient without systemic disease; a normal, healthy patient.
  - **ASA II:** A patient with mild systemic disease.
  - **ASA III:** A patient with severe systemic disease that limits activity, but is not incapacitating.
  - **ASA IV:** A patient with severe systemic disease which is incapacitating that is a constant threat to life.
  - **ASA V:** A moribund patient not expected to survive 24 hours with or without surgery.
  - **ASA E:** Emergency operation of any kind, E precedes the ASA number, indicating the patient's physical status.
- The key to uneventful/successful dental procedures in a medically compromised patient is a thorough evaluation and assessment of risk to determine whether a patient can safely tolerate a planned procedure.
- The risk assessment:
  - The nature, severity, stability of the patient's medical condition
  - The functional capacity of the patient
  - The emotional status of the patient
    - The type and magnitude of the planned procedure: invasive/noninvasive, length of the procedure, blood loss, vasoconstrictor use.

General Stress Reduction Protocols

- Communication with the patient about fears/concerns
- Short appointments
- Morning appointments
- Preoperative sedation—short acting benzodiazepines; Triazolam 0.125–0.25 mg night before and 1 h before appointment
- Intraoperative sedation—N_2O/O_2
- Profound local anesthesia—topical local anesthesia prior to injection
- Avoid postural hypotension
- Maintain constant verbal contact during treatment
- Limit epinephrine to 0.04 mg maximum
- Avoid hypoglycemia and fatigue
- Adequate postoperative pain control
- Contact and postoperative follow-up.

CARDIAC (CARDIOVASCULAR) DISEASES

Cardiovascular patients fall into the following categories:

- Congenital Heart Disease (CHD) or Rheumatic Heart Disease (RHD)
- Ischemic Heart Disease (IHD) or Coronary Artery Disease (CAD)
- Heart diseases needing prosthetic valve replacement
- Hypertension.

Although all types of cardiac diseases are at high-risk of serious complications, when undergoing surgical procedures under general anesthesia, certain conditions like unstable angina, congestive cardiac failure, valvular septal defects and myocardial infarction increase the risk fourfold. A history of Coronary Artery Bypass Grafting

(CABG), angioplasty or valve replacement is of significant importance. Although cardiac disease is not an absolute contraindication, the surgeon should weigh the benefits against the risks, before deciding the choice of anesthesia.

Preoperative Investigations

- Chest radiograph—posteroanterior view
- Electrocardiogram
- Echocardiogram
- Stress test

Blood investigations like lipid profile and bleeding time, clotting time and prothrombin time and index [International Normalized Ratio (INR)], in case the patient is on long-term anticoagulants.

Preoperative Medications

If the patient is a case of rheumatic heart disease or has undergone valve replacements, a suitable antibiotic prophylaxis must be given. If the patient is on injection Penidura (Penidura La) every 3 weeks, the surgery should be scheduled immediately after the scheduled dose to reduce the risk of infective endocarditis.

Intra and Postoperative Management

- All the patients should be monitored intra and postoperatively by means of an ECG, pulse oximeter, and arterial line.
- A central venous pressure (CVP) cut down may be performed, if necessary.
- The patient should be maintained on intravenous cardiac drugs till oral feeds are given.
- Fluid overload should be avoided, especially in cases of congestive cardiac failure. The fluid volume can be judged by the CVP.

Management of the patients, who are on long-term anticoagulant and antiplatelet drugs: For the prevention and management of arterial and venous thrombosis (intravascular clot), many patients are advised to take antiplatelet/anticoagulant drugs on long-term basis. As per the current information, the patients will have potential precipitation of a thromboembolic event, in case the anticoagulant therapy is withdrawn. **There is no need to withdraw the anticoagulant drugs for nonsurgical or minor surgical dental procedures.**

If the patient's INR and prothrombin time ratio (PTR) values are within the current recommended therapeutic range, then the minor incidents of local postoperative bleeding should be managed with adequate measures.

In case, if PTR and INR values are not within permissible therapeutic levels, then the patient should be shifted to intravenous anticoagulants like heparin.

Indications for Prescribing Anticoagulant Drugs

- Deep Vein Thrombosis (DVT)
- Pulmonary Embolism (PE)
- Rheumatic Heart Disease (RHD) and Arterial Fibrillation (AF)
- Prosthetic heart valve replacement
- Coronary Artery Disease (CAD)—Myocardial Infarction (MI) and unstable angina
- Cerebrovascular Accidents (CVA)—stroke.

(The use of warfarin in CAD and CVA is controversial).

Oral Anticoagulant Drugs

- **Coumarins and Indandiones:** Acenocoumarol (Acitrom) 1 mg, 2 mg, 3 mg, and 4 mg tablets, dicoumarol 50 mg tablets, phenindione, warfarin (Uniwarfarin) 1 mg, 2 mg, and 5 mg tablets.
- Oral anticoagulant drug acts by interfering/antagonizing with the synthesis of vitamin K dependent clotting factors in the liver (factors II, VII, IX and X). Their effect does not become apparent, until the body's existing supplies of prothrombin and other factors mentioned above have been exhausted. Similarly on withdrawal, the anticoagulant activity will not disappear, until the liver has once again produced these factors.

Protocols for Treating the Patients on Anticoagulants

- Proper history—drug dosage, status of medical condition, PTR and INR level.
- Proper antibiotic cover.
- Schedule the appointment within 2 days, once desired range of PTR and INR is achieved.
  - PTR 1.5–2 and INR 2.0–3.0—do not stop or alter the drug dosage.
  - PTR 2.0–2.5 and INR 2.5–3.5—dosage may be altered.
  - PTR >2.5 and INR >3.5—delay invasive procedure, until dosage is decreased.
  - Physicians should be consulted regarding the dosage modification.
- Confirm status of PTR and INR on the day of surgery.

- Use atraumatic surgical technique. Control post-operative bleeding by local measures.
- Patients' anticoagulant dosage can be regulated back in 48–72 hours in consultation with physician.

Antiplatelet Drugs

- Aspirin—Colisprin, ecosprin 75/150 mg tablets; dipyridamole, clopidogrel 75 mg tablet, ticlopidine 250 mg tablet.
- These drugs irreversibly acetylate and inhibit the enzyme cyclo-oxygenase in the platelets; thus preventing thromboxane A_2 (TXA_2) synthesis by the platelets and altering platelet function—mainly platelet aggregation. This results in prevention of platelet plug formation and increased bleeding time. These drugs are used in CAD-post myocardial infarction and in unstable angina, CVA, coronary artery bypass grafting.

Dose Regulation

- Prior to oral surgical procedures, two laboratory tests for screening the patients on oral antiplatelet drugs should be carried out.
  - The Platelet Function Analyzer 100 (PFA 100)—normal value 60–120 seconds.
  - The Ivy Bleeding Time (Ivy BT)—normal value 1–6 minutes.
- If Ivy BT is more than 20 minutes, then only clinically significant postoperative bleeding is expected. In that case, the aspirin can be discontinued for 3–5 days, which will allow new platelets in sufficient numbers to arrive into the circulation. The life cycle of platelets is 8–10 days.

1. Congenital Heart Disease (CHD)

Potential Problems

1. Infective Endarteritis
2. Prolonged bleeding following scaling and surgical procedures.

   Bleeding problem may be present in patients with Right to Left shunting of blood caused by:
   i. Thrombocytopenia,
   ii. Lack of coagulation factor as a result of thrombosis occurring in small vessels.
   iii. Anticoagulation medication to prevent thrombosis.
3. Congestive Cardiac Failure (CCF)
   a. Infection, (b) Cardiac arrest, (c) Cardiac Dysrrhythmia, (d) Breathing difficulties (caused by Pulmonary edema).

Treatment

1. Proper Antibiotic Prophylaxis.
2. Avoidance of dehydration in patient with oral infection.
3. Bleeding Time and Prothrombin Time should be tested before any surgical procedures --- consultation with physician if prolonged.

Rheumatic Heart Disease (RHD)

- Potential Problems
- Infective Endarteritis.

Management

a. Antibiotic prophylaxis—two gm amoxicillin to be taken 1 hour prior to procedure.
b. Patients taking low daily dose of penicillin or monthly injections of penicillin to prevent recurrent attacks of Rheumatic fever.

Then Instruct patients to continue the medications.

2. Ischemic Heart Disease (IHD) or Coronary Artery Disease (CAD)

(a) Angina Pectoris (b) Acute Myocardial Infarction

Angina Pectoris

Potential problems

1. Stress and anxiety related to dental visit—may precipitate anginal attack in dental office
2. Myocardial Infarction (MI) may occur when the patient is in dental office.
3. Sudden death caused by disruption of cardiac rhythm or cardiac arrest without acute MI may occur in dental office.
4. If patient develops chest pain during dental treatment;
   i. Stop the procedure and
   ii Give the patient tablet Nitroglycerin (NTG) 0.4 mg sublingually and observe the patient.
   iii. If the pain continues longer than 2–3 minutes, monitor Vital parameters.
   Give up to a total of 3 tablets, NTG within 15 minutes.
   iv. If pain persists and patient's condition is stable, transfer the patient to the hospital Emergency room and call for physician.
   If unstable call for medical assistance and be prepared to render CPR
   v. If patient has stable angina; and pain is relieved within 2–3 minutes with NTG, dental treatment may be continued or terminated depending upon the circumstances.

5. Patient with unstable angina, whose pain is relieved with NTG within 2–3 minutes should have appointment terminated and physician informed about the episode
6. Terminate appointment, if patient becomes fatigued or develops changes in pulse rate or rhythm.
7. Avoid use of vasopressors except epinephrine 1:100 000 or 1: 200 000 in local anesthetic solution;
   i Do not use vasopressor to control bleeding
   ii. Do not use gingival cords that contain vasopressor (packing material).

Stable angina: routine dental care
Unstable angina: only dental care needed to relieve of pain or infection or both.

Management

1. Detailed history of Angina Pectoris
2. Referral to physician
3. MH evaluation and for treatment Of Angina Pectoris
4. Patient under treatment for Angina Pectoris-, the following measures to be taken:
   i. Every effort should be made to reduce stress
   ii. concern and warm approach by staff and Dental Practitioner.
   iii. Make the patient feel free to talk of fears
   iv Schedule morning appointments
   v. Schedule short appointments
   vi. Premedication: Diazepam (valium, calmpose 5–10 mg)
   Prophylactic NTG 1 tablet preoperatively.
   vii. Nitrous oxide (N_2O) sedation
   viii. Effective Local Anesthesia: epinephrine 1:100000 can and should be used; aspirate; inject slowly.

Acute Myocardial Infarction (AMI)

1. Potential problems:
   i. Cardiac arrest
   ii. Congestive Cardiac Failure (CCF)
   iii. Bleeding tendency secondary to anti-coagulant
   iv. Infective endocarditis, complicating implanted pacemaker,
   v. Electrical interference with pacemaker.

Management

1. No routine dental care, until at least six months after myocardial Infarction because of increased risk of new infarction.
2. Consultation with patient's physician – current status.
3. Morning appointments.
4. Short appointments.
5. Termination of procedure, if patient becomes fatigued; or short of breath, develops change in pulse rate and rhythm, or develops chest pain—inform patient's physician.
6. Use of Local Anesthetic agent with epinephrine 1:100000, not more than 3 cartridges, aspirate before injection; inject slowly.
7. Premedication prior to appointment to reduce stress associated with dental visit: diazepam 5–10 mg.
8. Anticoagulant medications:

If surgical procedure or scaling is planned, the physician to be contacted and dosage of anticoagulant adjusted, so that PT will be twice normal or less will take 3–4 days; check to see if desired result was obtained on the day of procedure by having another PT done.

9. Digitalis: Patient is more prone to nausea and vomiting avoid stimulating gag reflex.
10. Antisialogogues such as atropine, methantheline may cause tachycardia; check with patient's physician before using.
11. Antiarrhythmic agents such as quinidine, procainamide —nausea and vomiting may occur; oral ulceration may indicate agranulocytosis.
12. Antihypertensive agents-check BP.
13. Avoid using instruments such as cavitron, electrocautery equipment etc. with patients having pacemaker

3. Prosthetic Heart Valves Replacement

Potential Problems

1. Prosthetic valve endocarditis can occur following dental procedures – that may cause transient bacteremias.
2. Prolonged bleeding may occur following scaling or surgical procedures in patients being treated with anticoagulants.

Management

1. Antibiotic prophylaxis is given to prevent prosthetic heart valve endocarditis for all dental procedures.
2. Patients taking anticoagulants: If scaling or surgical procedures are planned, dosage of anticoagulant medications should be reduced by physician so that on the day of procedure PT is twice normal or less.

HYPERTENSION

- Hypertension is considered to be the elevation of the blood pressure greater than 140/90 mm of mercury.

- Uncontrolled hypertension can have the following surgical and anesthetic complications:
  - It reflects on the cardiac status of the patient, thereby increasing the anesthetic risk to the patient.
  - It causes excessive bleeding from the operation site, thereby complicating the surgical procedure, as well as significant blood loss for the patient **(Tables 3.1 to 3.3)**.

Preoperative Investigations

- Chest radiograph—posteroanterior view for detecting cardiac enlargement
- Electrocardiogram (ECG)
- Ultrasonography (USG) of the kidneys
- Ophthalmic evaluation for papilledema and retinal hemorrhage
- Renal function tests (blood urea nitrogen, serum creatinine and serum electrolyte).

Preoperative Medication and Management

The patient's blood pressure should be monitored and controlled within the normal permissible limits, prior to the surgical procedure. If the patient is on antihypertensives, the morning dose of medication prior to surgery must be given with sips of water.

Table 3.1: From the National Heart, Lung, and Blood Institute. The 7th Report of the Joint National Committee (JNC) on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (The JNC 7th Report) 2003;42:1206-1252 (Complete version) JAMA. 2003;289:2560-2572

Classification	*SBP mm Hg*	*DBP mm Hg*
Normal	<120	<80
Pre hypertension	120–139	80–89
Stage I hypertension	140–159	90–99
Stage II hypertension	≥160	≥100
Hypertensive crisis	>220	>120

Table 3. 3: Recommendations for lifestyle modifications to manage and prevent high BP

- Maintain normal body weight
- Decrease portion sizes of meals and snacks
- Limit consumption of calorie-containing beverages
- Reduce dietary saturated and total fat
- Increase intake of fruits, vegetables, and low-fat dairy products (foods rich in K^+ and Ca^{++})
- Reduce daily salt consumption to <6.0 g of NaCl
- Reduce the amount of time spent in sedentary behavior
- Engage in regular daily aerobic physical activity
- Limit alcohol consumption to no more than two drinks per day (equal to 0.5 ounces ethanol each) for most men; for women or individuals of lighter weight, limit alcohol consumption to no more than one drink per day

Table 3.2: BP Classifications and Dental Management Strategies for Adults

Classification	*Systolic mm Hg*	*Diastolic mm Hg*	*Dental management recommendation*
Normal	<120	<80	Regular dental care
Prehypertension	120–139	80–89	Regular dental care; Advise patient of BP status; Recommend lifestyle modifications
Stage I hypertension	140–159	90–99	Regular dental care; Recommend physician consultation; Employ Stress Reduction Protocol (SRP)
Stage II hypertension	≥160	≥100	Recheck BP in five minutes; Perform Noninvasive care only; Definitive emergency care only if BP is <180/110; Refer to physician for immediate follow-up; Employ SRP
Hypertensive crisis	>220	>120	Recheck BP in five minutes; Do not perform dental therapy, routine or emergency, until elevated BP is corrected; Manage emergency with antibiotics and/or analgesics; Hospitalization and immediate BP reduction when signs and symptoms of organ damage are present, otherwise refer to physician for immediate follow-up

Adapted: Chobanian AV, Bakris GL, Black HR et al: Seventh report of the National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure, Hypertension 42:1206, 2003.
*Treatment determined by highest blood pressure category

Intra- and Postoperative Management

- The blood pressure should be monitored continuously intra- and postoperatively.
- The patient's cardiac status should also be monitored on the ECG machine and on the pulse oximeter.
- Antihypertensives must be continued intra- and postoperatively.
- If the patient is on diuretics, the patient must be supplemented postoperatively with intravenous potassium supplements.
- If the procedure is performed under local anesthesia, then local anesthetic without adrenaline or bupivacaine, which does not have any significant effect on the cardiac status, is to be used.

Potential Problems of Hypertension

1. Stress and anxiety associated dental visit may cause increase in BP; in patients with already elevated BP, as a result of hypertensive disease, MI or CVA may be precipitated.
2. If BP is significantly elevated, excessive bleeding may occur following surgical or scaling procedures.
3. Patients being treated with antihypertensive agents may become nauseated and vomit, may become hypertensive, or may develop postural hypotension.
4. Excessive use of Vasopressors will cause significant elevation of BP, which in these patients may be very dangerous.
5. Many antihypertensive agents will potentiate sedative action of barbiturates.
6. Sedative medications used in patients taking certain antihypertensive agents may bring about hypotensive episode(s).

Management

1. History—BP and medications
2. Referral to physician—medications.
3. In Patients being treated with antihypertensive agents.
   - Reduce stress and anxiety of dental visit by
     - Premedication
     - Short appointments.
     - Morning appointments.
     - Open and concerned atmosphere by Dental practitioner and staff
     - Free talk about fears.
     - Use of N_2O sedation
     - Avoid hypoxia.
   - If patient becomes stressed, terminate appointment.
   - Avoid orthostatic hypotension by changing chair positions slowly and supporting patient, when he gets out of chair.
   - Avoid stimulating gag reflex – nausea.
   - Sedation: -Select sedative medication and dosage based on consultation with patient's physician.
   - Avoid excessive use of Vasopressors.
4. Drug considerations:
   - Use local anesthetic agents with small concentration of vasopressor (epinephrine1:100 000) & no more than 3 cartridges; aspirate before injection & inject slowly.
   - Do not use vasopressors to control local bleeding.
   - Do not use gingival cords containing vasopressors.
   - Reduce dosage of barbiturates and other sedatives whose actions are enhanced by many antihypertensive agents.
   - Avoid use of CNS depressants-sedative/ hypertensives and narcotics etc. – in patients being treated with MAOIs.
   - Epinephrine should not be used in any form – in patients being treated with antihypertensive agent paryline (Ecetonyl) or any other MAOI.

RESPIRATORY DISEASES

- Respiratory diseases can be categorized into obstructive and infiltrative pulmonary diseases. Obstructive pulmonary diseases include chronic obstructive pulmonary conditions like asthma, chronic bronchitis, pneumothorax and emphysema. Infiltrative diseases are inclusive of diseases that cause inflammatory changes in the alveolar walls. Any respiratory disease is first characterized by dyspnea.
- The patient with decrease in the pulmonary reserve poses a great risk for procedures under general anesthesia. The patients should be asked for a thorough history of bidi/cigarette smoking as well as past history of tuberculosis. If the patient is suffering from tuberculosis, then details of his drug regimen and duration of treatment should be asked. From the surgeon's point of view, the most important aspect is the patient's respiratory reserve and his ability to tolerate general anesthesia. If the patient is treated under local anesthesia, the bronchodilator inhaler should be kept ready for use in case of an emergency.

Preoperative Investigations

- Chest radiograph—posteroanterior view
- Pulmonary function tests
- Blood investigations like arterial blood gases
- Sputum for AFB/culture
- Bronchoscopy, if required.

The patient should be counseled to discontinue bidi/cigarette smoking prior to the procedure. Any acute infection should be treated by antibiotics. The patient should be on bronchodilators pre-, intra-, and postoperatively. The patient must carry inhaler for use in case of an emergency.

Intra- and Postoperative Management

- Arterial blood gas monitoring should also be carried out intra- and postoperatively.
- Avoid fluid overload.
- Blood loss should be replaced by whole blood or packed cells to avoid decrease in the oxygen carrying capacity of blood.

BRONCHIAL ASTHMA

It is described as a chronic inflammatory disorder involving many cell types, manifesting with episodes of chest tightness, coughing, laboured breathing and wheezing, all of which are related to bronchiole inflammation. Symptoms can last for a few moments or for many days. The airway obstruction in asthma is initiated by inflammation and muscle spasm, but is mostly reversible.
Risk: The strongest identifiable factor for development of asthma is atopy, an inherited propensity to exhibit allergic reactions, and people with a family history of allergy have an increased predilection for developing asthma.

Oral Health Changes in Patients with Asthma

The literature has described several oral health conditions associated with asthma:

1. An increased rate of caries development with reduced salivary flow.
2. An increased prevalence of oral mucosal changes.
3. An increased levels of gingivitis.

Management in Dental Care

The administration of safe dental treatment for asthmatic patients depends on the following:

1. Pulmonary function
2. Propensity for developing an acute asthmatic episode during dental treatment
3. Immune function, and
4. Adrenal status.

Prevention of a sudden episode of airway obstruction is essential, when treating an asthmatic patient.

Identification of the risk factors of an acute exacerbation should be done and should be taken into account.

Risk Factors are as follows:

1. Frequency of asthmatic attacks
2. Precipitating agents
3. Types of pharmacotherapy used, and
4. The length of time, since an emergency treatment owing to acute episode of asthma.

As a general rule, elective dentistry/surgery should be performed, only on asthmatic patients, who are:

1. Asymptomatic, or
2. whose symptoms are well controlled, such as cough and wheezing.

Oral Health Care Professionals (OHCPs) should be aware of the potential for dental materials and products that exacerbate asthma. These items include—dentifrices, fissure sealants, tooth-enamel dust, and methyl methacrylate. Fluoride trays and cotton rolls also have been implicated in promoting asthmatic events.

Immune Status of the patient

It depends on the level of immunosuppressive medications patient is taking. Only the most severely affected asthmatic patients, who are taking large doses of systemic corticosteroids fall into this category. The same category of patients also may be at the risk of adrenal suppression.

The clinician should consider:

1. The need for prophylactic administration of antibiotics to prevent postoperative complications, and
2. For corticosteroid replacement therpy to prevent acute adrenal crisis.

Management

The management can be divided into following treatment: A. Before, B. During, and C. After.

Before Treatment

1. Assessment of risk level by taking detailed history of illness.
2. Ascertaining the frequency and severity of acute episodes.

3. Reviewing the patient`s medications, as they provide an indicator of disease severity, and
4. Determining the patient`s specific triggering agents.

Major Concern

In the management of asthmatic patients undergoing routine dental care is the prevention of an acute exacerbation. This simply consists of the following:

1. Confirming that patient has taken his/her most recent scheduled dose of medication.
2. The patient's own metered dose inhaler of broncho-dilator should be handy at each visit.
3. The appointment should be in the late morning or late afternoon.
4. If the patient is not using an inhaler/bronchodilator routinely, he/she should be given one from the emergency kit.
5. Both the bronchodilator and oxygen should be available during the treatment.
6. It has been suggested that a prophylactic dose of B2 antagonist bronchodilator could prevent diminished lung function during dental treatment.
7. The H1 blocking antihistaminic is shown useful in blunting of bronchoconstriction response with a pretreatment dose.
8. Promethazine and Diphenhydramine have the benefit of being antiemetic and sedative as well as antihistaminic.
9. Anxiety: It is a known asthma trigger. The dental environment is a common site for an acute asthmatic attack. Therefore, (i) it should be ascertained that the patient has taken the routine medication, (ii) in addition, Stress Reduction Protocol (SRP) should be used

According to Malamed, the use of nitrous oxide conscious sedation in patients with mild to moderate asthma can prevent acute symptoms. However, in severe asthmatic patient use of nitrous oxide is contraindicated, as it may cause airway irritation.

Oral Health Care Professional should be aware that:

1. Long-term use of nonsteroidal anti-inflammatory (NSAIDs) can complicate clinical presentation and diagnosis by masking infection and inflammation.
2. Patients, who are receiving or who recently finished taking long-term corticosteroid therapy, may need steroid replacement therapy before undergoing dental treatment.
3. The same patients may also exhibit an increased susceptibility to bacterial infections, which would indicate the need for antibiotic prophylaxis prior to treatment.
4. During treatment, improper suction tip positioning, fluoride trays or cotton rolls can trigger the reactive response.
5. Rubber dams should be used judiciously to avoid possible respiratory compromise or aggravation.
6. Prolonged supine positioning, bacteria laden aerosols from plaque or carious lesions and ultrasonically nebulized water also can be asthma triggers in the dental clinics.
7. Aeroallergens, such as tooth enamel dust also may be harmful.

RENAL DISEASES

Patients with renal diseases like renal failure, acute glomerulonephritis, nephrotic syndrome, pose a significant surgical risk. Disturbances in the renal function leads to changes in the acid-base balance, serum calcium and phosphorus levels, fluid retention and electrolyte concentration. A patient with chronic infection may develop sepsis postoperatively. These patients also have associated hypertension secondary to fluid retention and anemia.

Preoperative Investigations

- Renal profile—blood urea nitrogen, serum creatinine, serum electrolytes
- Creatinine clearance test
- Serum calcium and phosphorus
- Urine analysis—physical and microscopic
- USG of the kidneys
- Renal Doppler studies
- Radionuclide scanning for renal clearance time.

Intra- and Postoperative Management

- Fluid balance, acid-base balance and electrolyte balance must be closely monitored.
- Renal profile tests must be performed intraoperatively as well as postoperatively.
- Blood replacement is done by washed packed cells.
- Potassium overload during fluid replacement is to be avoided.
- The patient should be covered with broad-spectrum antibiotics to prevent sepsis. As most antibiotics are excreted through the kidneys, only a few have been proved safe for use. Amoxicillin, doxycycline and minocycline are a few recommended antibiotics.

HEPATIC DISEASES

A history of chronic alcohol intake, substance abuse, repeated blood transfusions and viral hepatitis is indicative of a probable silent liver disease. The liver is the site of biotransformation of various drugs and anesthetic gases and synthesis of vitamin K. A patient with viral hepatitis should be handled with care to avoid inadvertent transmission of the disease to the operation theater personnel or another patient. The risk of transmission depends on the type of hepatitis carrier the patient is, i.e. hepatitis A, B, C or D carrier. In our practice, the maximum risk is from a hepatitis B or C carrier.

Preoperative Investigations

- Liver enzymes—serum glutamic oxaloacetic transaminase (SGOT), serum glutamic pyruvic transaminase (SGPT)
- Total bilirubin, direct and indirect bilirubin
- Serum albumin
- Serum alkaline phosphatase
- Bleeding time and clotting time
- Prothrombin time, plasma thromboplastin time and index (INR)
- USG liver
- Australia antigen test.

Intra- and Postoperative Management

- Avoid anesthetic gases that are metabolized in the liver, like halothane.
- Correction of coagulation deficiencies by IV vitamin K, fresh frozen plasma transfusions.
- Careful intra- and postoperative management of blood volume, cardiac output, urine volume and composition.
- Potassium supplementation during fluid replacement.
- Appropriate precautions and sterilization techniques to prevent transmission of disease in a carrier of viral hepatitis.

DIABETES MELLITUS

- Diabetes mellitus is caused by an absolute or relative deficiency of insulin in the body. It can be classified into type 1 (insulin dependent) and type 2 (noninsulin dependent).
- Type 1 is more commonly seen in young patients and type 2 in adults. A patient can be classified as a diabetic, when his fasting glucose levels are constantly above 140 mg/dL.
- The nature of problems faced by the surgeon during the management of a known diabetic patient is:
  - Optimal blood sugar levels are to be maintained during the procedure, as well as postoperatively to prevent hypoglycemia or hyperglycemia and ketoacidosis. Both the conditions may be life-threatening to the patient.
  - The patient is prone to infections and has to be given adequate preoperative and postoperative broad-spectrum antibiotic coverage to prevent infections.
  - The patient may have additional systemic complications like renal failure, cardiac disorders, ophthalmic problems and generalized vascular disease due to long-standing diabetes.
- For surgical purpose, a diabetic can be classified in three groups:
  - Sugar levels controlled by diet and oral hypoglycemics.
  - Sugar levels controlled by insulin.
  - "Brittle diabetes", usually of juvenile onsets, whose metabolic needs are labile and have sequelae of long-standing disease such as renal failure, retinopathy, and generalized vascular disease.

Elective surgeries can be usually performed without complications in the first two types. In the third type, although the management remains same, a more rigid control is to be exercised intra- and postoperatively.

Preoperative Investigations

- Chest radiograph—posteroanterior view
- Electrocardiogram
- Blood investigations like:
  - Blood sugar fasting and postprandial
  - Glucose tolerance test
  - *Renal profile:* Such as blood urea nitrogen, serum creatinine, serum electrolytes.
- Urine analysis for sugar and acetone.
- If the patient is on oral hypoglycemics, he must be shifted to insulin on the day of surgery. The general principle for the management of the patient under general anesthesia is to provide at least 200 g of carbohydrate with adequate insulin to cover this need.

Intra- and Postoperative Management

- Check the patient's blood and urine sugar levels on the morning of surgery, with the help of hemoglucose strips and urostrips or glucometer.

Table 3.4: Sugar levels and insulin dose

Sugar levels (mg%)	*Insulin dose*
80–120	Plain 5% dextrose
120–180	4 units in 5% dextrose
180–250	8 units in 5% dextrose
250–300	14 units in 5% dextrose
300 and above	14 units in normal saline

- Prepare a sliding insulin scale to be followed intraoperatively based on the patients sugar levels **(Table 3.4)**.
- Pre- and postoperative broad-spectrum antibiotic coverage.
- Intra- and postoperative close monitoring of the blood and urine sugar levels.
- Prevent the patient from going into ketoacidosis or hypoglycemia.
  - **Signs of hypoglycemia:** The patient is apprehensive, restless, agitated, the skin is moist and pale, and there is tachycardia. The patient then lapses into coma.
  - **Treatment:** In a conscious patient, oral carbohydrates are given to correct the glucose levels. In an unconscious patient, intravenous administration of 50% glucose solution restores consciousness in 5–10 minutes or 1 mg glucagon IM restores consciousness in 15 minutes.
  - **Signs of diabetic ketoacidosis:** Vomiting, tachypnea, Kussmaul (deep, rapid breathing at regular intervals) breathing, dehydration and circulatory collapse.
  - **Treatment:** Administration of insulin to normalize body metabolism and restoration of body fluids and electrolytes.
- Shift the patient at the earliest possible to his regular oral feeds and antidiabetic medications.

THYROID DISORDERS

Patients having thyroid disorders can be broadly divided into three groups:

1. Hypothyroid,
2. Euthyroid and
3. Hyperthyroid.

- Out of these, euthyroid patients pose no risk for any surgical procedure. In both hypo- and hyperthyroidism, elective surgery is best postponed till the patient is euthyroid.
- The signs of hypothyroidism are water and mucopolysaccharide retention, slowing of metabolic processes leading to bradycardia, constipation, lethargy and hypothermia. Untreated hypothyroid patients respond poorly to stress and proceed into myxedema coma.
- Hyperthyroidism leads to a hypermetabolic state in the body, resulting in a catabolic state with tachycardia, diarrhea and heat intolerance. If this patient is subjected to stress, he goes into what is known as "thyroid storm", which is a state of metabolic hyperactivity lasting for 24–48 hours. There is a severe exacerbation of the signs and symptoms of hyperthyroidism and is usually accompanied by hyperpyrexia. The condition is life threatening and requires control of hyperpyrexia, tachycardia and cardiac failure.

Preoperative Investigations

- **Thyroid hormone levels:** T3, T4, TSH
- Serum electrolytes
- Serum proteins
- Radionuclide thyroid scan to study the gland.

Intra- and Postoperative Management

- Monitor the hormone levels intra- and postoperatively.
- Continuous monitoring of vital parameters, blood pressure, pulse and temperature.
- Check for signs and symptoms of hypo/hyperthyroidism.
- Continuous monitoring of the cardiac function, especially during thyroid crisis. Infuse thyroid hormone, if the patient shows signs of hypothyroidism.
- If the patient is in a thyroid storm, treat by cooling the patient, intravenous infusion of glucose and IV fluids, glucose and corticosteroids.
- Use narcotic agents and anesthetic medications judiciously in hypothyroid patients, as they can have a profoundly depressing effect.

ADRENAL DISEASES

- Two common adrenal disorders that have to be dealt with during surgical procedures are Cushing's syndrome (overproduction) and Addison's disease (underproduction).
- The symptoms of Cushing's syndrome are diabetes, sodium and water retention, potassium excretion, hypertension and fat redistribution. The patient also has

a tendency to osteoporosis, poor wound healing and purpura formation. During surgery, attention must be paid to maintaining optimum levels of carbohydrates in the body, sodium and potassium ion levels and the blood pressure. There may be postoperative problems of bleeding and delayed wound healing.

- Underproduction can occur due to adrenal suppression due to exogenous steroids or due to a disease of adrenal origin (Addison's disease). Usually any patient, who has received steroids for longer than 2 weeks within a year prior to surgery should be considered as a candidate for adrenal insufficiency.

Preoperative Investigations

- Renal profile
- Serum electrolytes
- Blood sugar fasting
- Platelet count
- Coagulation profile
- Patients with adrenal insufficiency should be supplemented with adequate exogenous steroids prior to procedure to help the patient combat with stress.

Intra- and Postoperative Management

- Continuous monitoring of the vital signs.
- Adequate intravenous corticosteroid supplementation to prevent adrenal crisis.
- Maintain fluid and electrolyte balance.
- Monitor blood sugar levels.

NEUROLOGICAL DISORDERS

Neurological disorders can be categorized into patients with cerebrovascular disorders, seizure disorders, chronic respiratory disorders and patients with head injury. The main factors of consideration in these patients are to maintain adequate cerebral perfusion intraoperatively and postoperatively and to control any seizure episode during this period. Patients with seizure disorders usually do not pose a great problem for intraoperative management, except for cases of status asthmaticus, where there can be life-threatening complications. The surgeon should weigh the risks and benefits, before the surgical procedure. Patients with cerebellar infarcts, aneurysms and arteriovenous malformations are very high-risk candidates and are absolute contraindications for surgical procedures.

Preoperative Investigations

- Routine skull radiographs—posteroanterior and lateral views
- CT scan/MRI brain
- Electroencephalogram
- Liver function tests.

If the patient is an epileptic, adequate control of seizure episodes must be achieved prior to the surgical procedure. The anticonvulsant must be continued till the morning of the surgery. The morning dose is given with sips of water.

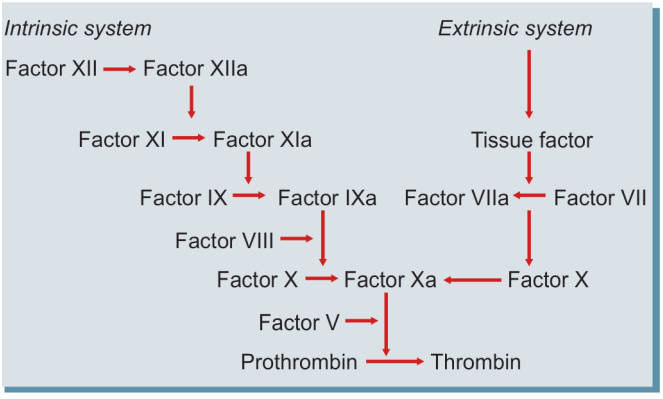
Intra- and Postoperative Management

- The patient should be given intravenous anticonvulsants intraoperatively.
- Postoperatively, the patient should be shifted to his normal dose of anticonvulsants at the earliest possible.
- Throughout the procedure, hypotension/hypoxia is to be avoided and an adequate cerebral perfusion is to be maintained.

DISORDERS OF HEMOPOIETIC SYSTEM

- Disorders of the hemopoietic system can be grouped into anemias, leukocyte disorders and coagulation factor abnormalities (hemophilia) **(Flowchart 3.1)**. Anemias include iron deficiency anemias, thalassemia, sickle cell anemia, and leukocyte disorders include leukocytosis and agranulocytosis.
- Coagulation factors:
  - Fibrinogen
  - Prothrombin

Flowchart 3.1: Coagulation pathway or cascade



  - Thromboplastin
  - Calcium ions
  - Proaccelerin
  - Proconvertin
  - Antihemophilic factor
  - Christmas factor/plasma thromboplastin component
  - Stuart factor
  - Plasma thromboplastin antecedent
  - Hageman factor
  - Fibrin stabilizing factor.
- Any disturbance in the hemopoietic system:
  - Predisposes the patient to prolonged bleeding during any surgical procedure, which cannot be controlled by routine hemostatics.
  - May cause severe internal bleeding due to blunt injury following intubation, a condition if unnoticed may pose a life-threatening complication.
  - Leukemic and thalassemic patients may be on repeated blood transfusions and may have liver disorder due to excessive deposits of hemosiderin.
  - The rate of postoperative infection and delayed wound healing is also very high, especially in agranulocytosis, leukemia and anemia.

Preoperative Investigations

- Complete blood count
- Bleeding time and clotting time
- Prothrombin time and index (INR)
- Partial thromboplastin time
- Coagulation factor assay (in case of factor abnormalities)
- Platelet count
- Hemoglobin
- Liver function tests.

Prior to the procedure, the patient's blood counts must be built up to the normal values by transfusion of whole blood, packed cells, plasma or plasma components and clotting factors.

For a hemophiliac, the factor VIII level should be raised to at least 50–70% prior to the procedure. Once the blood levels are normal, the patient can be treated as a normal patient with regards to surgical bleeding. Adequate blood must be cross-matched and kept ready for transfusion intraoperatively, if required. In case of leukemics, the patient should be posted for surgery, during his remission phase. The patient should be covered with broad-spectrum antibiotics pre- and postoperatively.

Intra- and Postoperative Management

- Avoid undue trauma to the tissues during any procedure performed.
- Avoid entering deep tissue spaces blindly, thereby preventing any internal bleeding.
- Complete hemostasis must be achieved prior to wound closure.
- Intraoperative transfusion of blood/blood products, if found necessary.
- Monitoring of hemoglobin, complete blood counts intra- and postoperatively.
- Maintain adequate blood volume throughout the procedure and at the same time avoid cardiac overload.
- Monitor the vital parameters closely for any changes in the fluid volume indicated by the pulse and blood pressure.
- Postoperatively the patient may be maintained on systemic oral coagulants like vitamin K for 3–5 days.
- Cover the patient with adequate broad-spectrum antibiotics.
- Avoid medications that can exacerbate the underlying condition, especially in agranulocytosis.

In view of the rise in blood-borne transmission of diseases, such as AIDS, hepatitis B and hepatitis C, the government has made it compulsory for testing of all the three viruses before stocking the blood in the blood bank. But the decision to transfuse blood and blood products must still be made judiciously weighing the risks and benefits.

Management of a Hemophiliac Patient

Classically hemophilia is of two types: hemophilia A (factor VIII deficiency) and hemophilia B (factor IX deficiency).

The disorder is a sex linked recessive trait. Approximately, 50% of the female offsprings are carriers of the disorder and 50% of the male offsprings have the clotting disorder. These patients have a tendency to bruise easily and have prolonged bleeding.

The successful management of a hemophiliac is dependent on the adequate maintenance of the antihemophilic globulin. The normal antihemophilic globulin level is 50–100%. In a hemophiliac, for good hemostasis, the factor level must be 20% above normal, though a normal level is also acceptable.

Thromboplastin regeneration time not only determines the factor VIII deficiency, but also distinguishes it from factor IX deficiency.

Factor VIII replacement can be provided through blood, plasma, fresh frozen plasma and cryoprecipitates. The latter is the replacement choice, as it offers only the deficient factor.

Management

- Build up factor VIII level to 50–70%.
- Avoid injecting into deep tissue spaces, i.e. avoid block techniques. Use infiltration anesthesia.
- Atraumatic extraction, surgical procedure.
- Avoid unnecessary trauma to the soft tissues, avoid suturing if not required.

IMMUNOCOMPROMISED PATIENTS

Immunocompromised patients can be grouped into:

- Patients having deficiency in cell mediated, humoral immunity, neutrophils, and complements.
- Patients on immunosuppressive drugs such as chemotherapeutic agents and steroids.
- Patients suffering from long-standing debilitating conditions such as diabetes and nutritional deficiencies.

These patients are highly susceptible to infections and must be given broad-spectrum antibiotic coverage for the same.

Preoperative Investigations

- Complete blood count
- Liver function tests
- Renal function tests
- Serum proteins
- Blood sugar levels
- Urine analysis
- Routine chest radiograph.

Intra- and Postoperative Management

- The management will vary according to the condition the patient is suffering from. Usually, it is almost impossible to correct the causative factor, and the treatment is usually supportive only.
- Constant monitoring of the vital parameters.
- Broad-spectrum antibiotic coverage.
- While handling HIV infected patients, special care must be exercised to prevent the transmission of the disease.

AUTOIMMUNE DISORDERS

- The group of autoimmune disorders includes systemic lupus erythematosus, scleroderma, collagen disorders, rheumatoid arthritis, Sjögren's syndrome, polyarteritis nodosa, etc. These patients may have significant cardiac, renal and bone marrow impairment, which may contraindicate elective surgery. The patients, whenever possible must be operated during their remission phase. A few of these patients may be on long-term corticosteroid therapy; therefore, precautions to prevent adrenal insufficiency must be taken.
- A few of these patients have loss of flexibility in the joints, especially the thoracic cage and neck joints, thereby posing problems in intubation and ventilation. In scleroderma, the patients have a restricted oral opening as well as restricted expansion of the chest wall.
- Patients with collagen disorders may also have delayed postoperative wound healing.

Patients Suffering from HIV

- In India, the current dramatic spread of blood-borne infections from HIV/AIDS and hepatitis C patients is increasing the morbidity and mortality, and hence aggravating the suffering of the community. India has 3rd highest number of HIV-infected people (the UN report).
- However, two important aspects are identified and therefore, to be taken care of. Firstly, all necessary measures should be taken during management to prevent further transmission of HIV in the community.
- An equally important aspect is to protect health care providers from affliction of HIV. In this context, dental professionals merit separate and specific contemplation as they stand at risk while performing dental procedure.
- Oral lesions have been reported to be early clinical features of HIV infection and are associated with disease progression. Oral lesions are an important component of the spectrum of disease seen in HIV infection and are often indicators of immune suppression. There are almost forty different lesions reported in association with HIV disease. Presence of any of these lesions may be an early diagnostic indicator of immunodeficiency and HIV infection. These lesions can cause pain,

discomfort and other symptoms and in the most cases, warrant treatment.

Current classification of oral lesions of HIV disease is based on their strength of association with HIV infection (by EEC workshop in Amsterdam, August 1990): Three categories of lesions are now recognized:

- **Group 1:** Lesions strongly associated with HIV infection
  - Fungal infection
    - Pseudomembranous candidiasis
    - Erythematous candidiasis
    - Candida angular cheilitis
  - Hairy leukoplakia
  - Linear gingival erythema
  - Necrotizing ulcerative gingivitis
  - Necrotizing ulcerative periodontitis
  - Necrotizing ulcerative stomatitis
  - Kaposi's sarcoma
  - Non-Hodgkin's lymphoma.
- **Group 2:** Lesions less commonly associated with HIV infectiona.
  - Viral infection
    - Herpes simplex virus infections
    - Herpes zoster
    - Human papilloma virus lesions
    - Condyloma acuminata
    - Verruca vulgaris salivary gland disease:
      - Xerostomia
      - Salivary gland swelling
  - Thrombocytopenic purpura
  - Recurrent aphthous ulcers
  - Melanotic hyperpigmentation
  - Cryptococcosis
  - Histoplasmosis
  - Bacterial infections—*Mycobacterium tuberculosis*.
- **Group 3:** Lesions rarely may be seen in HIV infection
  - Drug reactions
    - Erythema multiforme
    - Ulcerative lesions
    - Lichenoid reactions
  - Tuberculous ulcers
  - Neurologic disturbances:
    - Trigeminal neuralgia
    - Facial palsy
  - Cat-scratch disease
  - Bacterial infections—*Actinomyces israelii*, *Escherichia coli*, *Klebsiella pneumoniae*
  - Fungal infections other than *Candida-neoformans*, aspergillosis, histoplasmosis.

HIV TESTING AND COUNSELING

Early diagnosis of HIV infection is critical to control the spread of the virus. Persons infected with HIV are more likely to adopt behavioral changes to reduce transmission of virus. Diagnosis is also the first step into medical care for HIV infected patients.

Different HIV Antibody Assays

Enzyme-Linked Immunosorbent Assay (ELISA): HIV antibodies in the test serum are detected using an antibody sandwich capture technique. Essentially, HIV antibodies, if present, in the test serum are 'sandwiched' between HIV antigen, which is fixed to the test well and to 'enzymes' that are added to the test well following addition of the test serum. The test well is washed thoroughly to remove any unbound enzyme. A color reagent is then added to the well following addition of the test serum. Any bound enzyme will catalyze a change in color which is read colorimetrically.

Rapid Tests

Varieties of rapid tests are available including particle agglutination, lateral flow membrane, through flow membrane and comb or dipstick—basal assay systems. Rapid tests are most appropriate for the smaller health institutions, where only a few samples are processed each day. Rapid tests are quicker and do not require specialized equipment. Most are dot-blot immunoassays or agglutination assays requiring no instrumentation or specialized training and take 10 to 20 minutes to perform. Most rapid test have sensitivities and specificities equal to ELISA test, which has sensitivity equal to almost 100% and specificity to 99% or more respectively.

Western Blot

The HIV antibodies in the test serum are detected by reacting to a variety of viral proteins. Viral proteins are initially separated into bands according to their molecular weight on an electrophoresis gel. These proteins are then transferred or "blotted" to nitrocellulose paper. The paper is then incubated with the patient's serum. HIV antibodies to specific HIV proteins bind to the nitrocellulose paper at precisely the point to which the target protein migrated. Bound antibodies are detected by colorimetric techniques.

The major advantage of the rapid HIV test is that it allows results to be given on the same day, thus reducing

the number of visits made by clients. There is also an increased likelihood of clients receiving test results on the same day.

Transfusion Safety

A single ERS (ELISA Rapid Simple) test is sufficient to ensure transfusion safely with the provision of simple test in places without electricity. The objective of the transfusion safety does not require identification of donor of the infected unit of blood and in low prevalence settings of HIV; single ERS would detect at least 56% samples falsely positive. However, the same test gives more than 99.9% surety that blood found negative is actually free of infection. Therefore, while we can label blood as safe, it is risky to label any donor HIV positive on such test result.

Goals of HIV Pre-test Counseling

- To help the patient make an informed choice
- To explore the patient's knowledge on HIV/AIDS and provide correct information
- To assess the patient's potential exposure to HIV
- To explain the process of testing
- To help patients prepare themselves for the test result and the issues that may arise after learning their HIV status
- To bring about behavioral change in order to prevent further transmission
- To refer patients for medical and nonmedical care and support, if necessary

Being diagnosed as "*HIV positive*" means that one has been exposed to the human immunodeficiency virus and that two HIV tests—a preliminary *enzyme immunoassay test* and a confirmatory *Western blot* test—have both come back positive for *antibodies* to HIV.

Aims of Post-test Counseling

- To help patient understand and cope with the HIV test results
- To provide the patient with any further information required
- To help the patient make immediate and short-term and long-term future plans to improve the quality of life
- To help the patient decide what to do about disclosing their test result to partners and others.

Reproductive Health Services

- Female patients who are pregnant or of child-bearing age should receive or be referred to reproductive health services. HIV-infected pregnant women should be referred to PPTCT (Prevention of Parent to Child Transmission of HIV) program.
- Transmission of HIV from parent to child can occur during pregnancy, at the time of delivery or through breastfeeding. There is a 25 to 30% chance that the child of an HIV positive mother will also be infected with HIV. Parent to child transmission of HIV (perinatal transmission) accounts for more than 2% of the country's HIV/AIDS cases. HIV transmission from parent to child can be prevented with a combination of low cost, short-term preventive drug treatment, safe delivery practices, counseling and support and safe infant feeding methods.
- **Susceptibility of HIV:** Fortunately, HIV is a very fragile virus. It is susceptible to heat, a temperature of 56°C for 30 minutes or boiling for a few seconds kills the virus. Most of the chemical germicides used in hospital/laboratories and healthcare settings kill HIV at much lower concentrations. Thus, 0.5 to 1% sodium hypochlorite, 70% ethanol, 2% glutaraldehyde, acetone, ether, beta propiolactone (1:400 dilutions) and sodium hydroxide (40 mmol/liter) inactivate the virus.

MANAGEMENT OF OCCUPATIONAL EXPOSURE AND POSTEXPOSURE PROPHYLAXIS

- In anticipation of accidental exposure of Health Care Workers (HCW), it is necessary to have a comprehensive program in place, for Postexposure Prophylaxis (PEP). The risk of infection varies with types of exposure and other factors such as:
  - The amount of blood involved in the exposure
  - The amount of virus in the patient's blood at the time of exposure
  - Whether postexpsoure prophylaxis was taken within the recommended time.
- Steps to be taken on exposure to HIV infected blood/body fluids and contaminated sharps, etc. immediately following exposure:
  - Needle stick injuries and cuts should be washed with soap and water
  - Splashes to the nose, mouth or skin should be flushed with water
  - Eyes should be irrigated with clean water, saline or sterile irrigants
  - Pricked finger should not be put into the mouth by reflex.

Reporting of the Exposure

Report the exposure to the appropriate authority and treat as an emergency. PEP should be started within 2 hours. Initiating treatment after 72 hours of exposure is not recommended.

Determination of HIV Status Code

- The main purpose of determining HIV status code (HIV SC) is to know the HIV status of source of exposure.
  - No PEP is required in case, the source was HIV negative.
  - If the source was HIV positive, but it was a low titer exposure, the status is HIV SC_1. If it was a high titer exposure then status is HIV SC_2.
  - If the status of the source is unknown or if the source is unknown, then the status is HIV SC unknown.

Basic Regimen

Zidovudine (AZT)—600 mg in divided dose (300 mg/twice a day or 200 mg/thrice a day for 4 weeks + lamivudine (3TC)—150 mg twice a day for 4 week).

Four weeks of drug therapy is usually sufficient to provide protection against HIV.

Expanded Regimen

Basic regimen + Indinavir—500 mg/thrice a day or any other protease inhibitor.

Testing and Counseling

Testing should be done at time of exposure, at 6 weeks following exposure and at 12 weeks following exposure.

Pregnancy and PEP

Antiretroviral therapy taken during 2nd and 3rd trimester usually does not cause serious side effects.

Side Effects of these Drugs

Most drugs are well tolerated except for nausea, vomiting, tiredness or headache.

RISK OF PATIENT TO HEALTH PROFESSIONAL TRANSMISSION

The likelihood of occupational transmission among health professionals is 0.3% after percutaneous exposure to infected blood and 0.09% after exposure of mucosa.

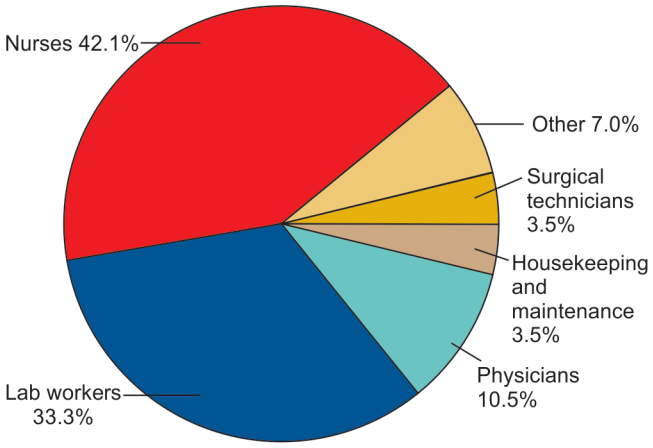


Fig. 3.1: Risk groups: Healthcare professionals

There has been no documented case of transmission after exposure of intact skin to infected blood. The risk of patient-to-healthcare professional transmission is greater than the risk of healthcare professional-to-patient transmission **(Fig. 3.1)**.

PROTOCOLS FOR TREATING HIV POSITIVE PATIENTS

- Two of the main considerations in the dental treatment of the HIV patient are the count/percentage of CD4 T lymphocytes and the viral load in the blood. The CD4 T lymphocyte count has proven to have greater predictive value than the clinical stage of the infection in the evaluation of complications derived from dental treatments.
- Asymptomatic HIV positive patients with a CD4 count/percentage of more than 500 cells/mm can undergo any dental treatment including oral or implant surgery. It is recommended that symptomatic patients with CD4 counts of less than 200 cells/mm should only undergo emergency surgery after antibiotic prophylaxis with assessment of the state of hemostasis, opportunistic infections present, and drugs being taken. Consultations with their physician are mandatory in these cases.

Patients with AIDS [<200/14% CD4-(clinical categories, C1, C2, and C3)]

- Periodic examination of patient
  - Bacterial plaque control and phase 1 periodontal treatment every 3 to 6 months.

- Dental treatment
  - Caries removal and restoration of carious surfaces
  - Regular fluoride applications
  - Simple prosthetic treatment (removable partial denture or complete denture)
  - Supra- and subgingival scaling—postpone complex periodontal treatment (bone regeneration).
- Evaluate hemostasis status
  - If there is a history of thrombocytopenic purpura or hepatic problems, postpone oral surgery.
- Assess the risk of septicemia (antibiotic prophylaxis)
- Removal of septic foci, abscess, and cellulitis
  - Antibiotic prophylaxis
  - Consult with the patient's physician
- Diagnosis and treatment of oral lesions (mycotic, bacteria, and viral infections)
- Control of xerostomia and glossodynia
  - Dietary (greater liquid intake) and oral hygiene recommendations
  - Gentle manipulation of buccal tissues (lubricate lips, commissures) with damp rolls of cotton and gauze
  - Saliva stimulation with xylitol chewing gum; avoid tobacco and alcohol: fluoride applications
- Ulcers of viral origin
  - If recurrences occur, consult with the patient's physician
- Cleaning of removable dentures
  - Benzal chloride 1:7.5 + water + antiseptic soap + 1% hypochlorite
  - 0.1% chlorhexidine gluconate
- In terminal phases (<50 CD4)
  - Pain control, limitation of infection, removal of bacterial plaque, and cleansing of oral cavity when the patient is unable to do so. Do not carry out surgical treatment in emergencies, treat in the hospital setting
  - Treat acute infections of buccal or gingival origin using systemic antimicrobial and analgesic therapy
  - Consult with the patient's physician
- Consult with a psychiatrist, psychologists, or trained nurses for episodes of depression or anxiety.

WHO New Recommendations/Guidelines on the use of Antiretroviral Drugs for treating and Preventing HIV Infection—2013.

- Earlier, safer and simpler antiretroviral therapy will help people to live longer, healthier life, and substantially reduce the risk of transmitting HIV to others.
- This will help to prevent additional 3 million deaths and also prevent 3.5 million more new infections between now and 2025.
- Data showed that 9.7 million people were taking these life-saving drugs at the end of 2012.
- The new recommendations encourage all countries to initiate treatment in adults living with HIV, when their CD4 cell count falls to 500 cells/mm^3 or less when their immune systems are still strong.
- The new recommendations also include providing antiretroviral therapy irrespective of their CD4 count to all children with HIV under 5 years of age, all pregnant and breastfeeding women with HIV, and to all HIV positive partners, where one partner in relationship is uninfected.
- All people with HIV with active tuberculosis or hepatitis B, receive antiretroviral therapy.
- The new latest drug regimen is single fixed dose combination pill—combination of the 3 antiretroviral drugs—(1) tenofovir, (2) lamivudine (or emtricitabine) and (3) efavirenz, as a single pill, given once daily.

Posting of a HIV positive patient for surgery protocols are:

1. Theater
2. Personnel
3. Spillage
4. Instruments
5. Sharps
6. Laboratory specimens
7. Patients undergoing radiation therapy.

Theater

- The posting of the patient should be at the end of the operating list and to allow ample time for the theater and scrub room to clean after surgery. The patient should be induced GA in the theater and should recover fully in the theater, so that contamination is contained within that theater room.
- All nonessential items should be removed from the theater, but leave enough on trolley.
- The operating table should be covered with water-proof sheet.
- All equipment needed for observing precautions should be available within the theater before the case is started. This includes:
  - Adequate quantities of a suitable disinfectant, e.g. freshly prepared 2% glutaraldehyde, or 1% sodium hypochlorite solution **(Table 3.5)**.

Table 3.5: Disinfectants		
a.	Fresh sodium hypochlorite	1% for 30 min
b.	Glutaraldehyde	2% for 60 min
c.	Formaldehyde	5% for 60 min
d.	Ethyl alcohol	70% for 60 min
e.	Isopropyl alcohol	50% for 60 min
f.	Lysol	1% for 60 min
g.	Fresh hydrogen peroxide	5% for 60 min

  - Plastic apron to be worn under the gowns by all personnel.
  - Eye protective should be worn.
  - Specimen bottles to be labeled with "bio-hazard" and outer plastic bag for safe transport of specimen.
  - Linen and plastic bags for transporting linen and instruments.
- After surgery, the operating room and all equipment must be thoroughly cleaned with hot soapy water and sodium hypochlorite. (**Note**: Sodium hypochlorite must not be used on stainless steel).

Personnel

Nonessential personnel should not be admitted into the operating room during surgery and those inside should be kept to a minimum. This means that an extra nurse and technician will be required to be stationed outside the operating room door to fetch any equipment or drugs needed for the scrub nurse, surgeon or anesthetist during surgery. This is to prevent infection spreading to the rest of the theater block.

Spillage

If there be spillage of body fluids or blood, this should be dealt with as follows:

- The area should be covered with sodium hypochlorite 1% and left for 30 minutes.
- It should be mopped up by a knowledgeable person using gloves and old linen paper towels (newspaper) and sent for incineration (in plastic bag).

Instruments

All instruments must be thoroughly cleaned with hot soapy water and sodium hypochlorite, before handing over to sterilizing unit person.

- Procedure for autoclavable instruments:
  - These should be autoclaved before final rewashing
  - Allow to cool
  - Wash in soapy water
  - Rinse
  - Re-autoclave.
- Procedure for non-autoclavable instruments:
  - Immerse in glutaraldehyde 2% for 1 hour
  - Discard this solution
  - Instruments should be physically cleaned in warm water and detergent
  - Rinse in glutaraldehyde 2% and leave to soak for 3 hours.
- Procedure for suction bottles
  - After surgery, they should be carefully emptied and these should be filled with 30 mL of glutaraldehyde 2% or 60 mL of sodium hypochlorite 2%, then rinsed and autoclaved.
- Procedure for anesthetic equipment
  - Ventilator tubes/masks, etc. should be rinsed with running tap water for 5 minutes and subsequently immersed in glutaraldehyde 2% solution for 6 hours.

Sharps

Special care required when dealing with needles and sharps. Needles should be decontaminated before disposal.

Laboratory Specimens

These should be clearly labeled and double bagged in plastic bags for transportation.

Patients Undergoing Radiation Therapy

It is indeed essential to understand the dental and the oral complications of radiotherapy involving the oral cavity and salivary glands. The complications are as follows:

- **Mucositis:** Mucositis occurs when the radiation field involves oral mucosa. The degree of damage depends upon the type of radiotherapy, the dose and duration of the treatment. It causes considerable amount of discomfort and sometimes dysphagia. It usually subsides in 2 to 3 weeks' time.
- **Loss of taste (hypogeusia):** Hypogeusia occurs because of the damage to the taste buds due to irradiation. However, xerostomia alone can disturb taste sensation. Taste may start to recover within 2 to 4 months. If more than 6,000 cGy radiation is given, then the loss of taste is usually permanent.
- **Xerostomia and infections:** The area of radiotherapy to cancers of the head and neck often involve the major

salivary glands. Radiotherapy of tumors of naso and oropharynx can damage the salivary glands. Salivary secretion diminishes within a week of radiotherapy in practically all patients and the saliva becomes thick. Some salivary function may return after many months. Xerostomia predisposes to infections, particularly periodontal disease, caries, oral *Candida* infection and acute ascending sialadenitis.

- **Radiation caries and dental hypersensitivity:** Patients frequently take a softer, more cariogenic diet because of dryness and soreness of the mouth and loss of taste. There is a change towards more cariogenic oral flora. Irradiation may also directly damage the teeth, which become hypersensitive, thus making oral hygiene difficult.

  These factors combine to cause rampant dental caries, including areas such as incisal edges and cervical margins which are normally free from caries. The caries begins at any time between 2 months and 10 months after radiotherapy, and may eventually result in the crown breaking off from the root. A complete dentition may be destroyed within a year of irradiation.
- **Osteoradionecrosis and osteomyelitis:** Death of bone of the jaw, particularly the mandible, is a potentially serious complication of irradiation endarteritis. If the soft tissue covering the bone is healthy and undisturbed, there may be no obvious consequences, but infection, often resulting from dental extractions carried out after radiotherapy, can lead to intractable osteomyelitis.

  Irradiation associated osteomyelitis may occasionally be precipitated by mucosal ulceration caused by denture. As a consequence, some dental especialists refuse to permit patients to wear dentures, especially a full lower denture, after irradiation of the oral mucosa.

  Osteoradionecrosis is however, a less frequent problem now, as megavoltage radiotherapy has less effect on bone than orthovoltage therapy. Osteoradionecrosis appears to develop mainly in patients receiving more than 6,000 cGy, particularly to the floor of the mouth and mandible. Osteomyelitis may follow months or years after radiotherapy, but about 30% of cases develop within 6 months.
- **Trismus:** Progressive endarteritis of affected tissues, with reduction in their blood supply, follows radiotherapy. The results may be replacement fibrosis of the masticatory muscles. Fibrosis becomes apparent 3 to 6 months after radiotherapy and can cause permanent limitation of opening.
- **Dental defects:** Irradiation of developing teeth can cause hypoplasia and retarded eruption.

MANAGEMENT

Treatment Planning

The treatment has to be carefully planned. Oral hygiene measures should be taken. Preventive dental care instituted, and restorative procedures should be carried out. These measures can significantly reduce the caries incidence.

- **Before radiation:** It is not always necessary to extract all the teeth before radiotherapy. In any case, clearance before irradiation may not be practical, because the patient is too old or ill, or the prognosis is too poor. Sometimes the patient has very healthy teeth and good oral hygiene that dental complications after radiotherapy are unlikely.

  The time period between extractions and radiotherapy is a compromise because of the need to start irradiation at the earliest. No bone should be left exposed in the mouth when radiotherapy begins, since once the blood supply is damaged by radiotherapy, wound healing is jeopardized. Many authors advise an interval of at least 2 weeks between extracting the teeth and starting radiotherapy, but this is not always essential.
- **During radiotherapy:** Mucositis may be relieved by using warm normal saline mouthwashes and lignocaine viscous 2%. Smoking and alcohol should be discouraged. A 0.2% chlorhexidine mouthwash maintains oral hygiene and a benzydamine oral rinse or a saliva substitute such as carboxymethyl cellulose may provide some symptomatic relief. Trismus may be reduced by instituting jaw opening exercises with Heister's jaw stretcher three times a day. Antifungal drugs such as nystatin suspension, 100 000 U/mL, as a mouthwash or pastilles used four times daily may be required.
- **After radiotherapy:** Oral hygiene and preventive dental care should be continued and mucositis managed as outlined above. Dental extractions may precipitate osteomyelitis in the irradiated jaw but, if extractions are unavoidable, trauma should be kept to a minimum, raising the periosteum as little as possible and ensuring that sharp bone edges are removed. Careful suturing is needed and prophylactic antibiotics should be given in adequate doses and continued for 2 to 3 weeks.

Radiation caries and dental hypersensitivity can be controlled with daily topical fluoride applications (sodium fluoride mouthwash, stannous fluoride gel or acidulated fluoride phosphate gel). Occasionally full cover acrylic splints are used to protect the teeth (Coffin's caps). Patients should be advised to avoid sweets and sweet confectionery. Instead sugar substitutes such as saccharin or aspartane, may be used, wherever possible. Mouthwashes of sodium bicarbonate may help dissolve the stringy saliva that forms.

Mucosal trauma from dentures may predispose to osteomyelitis and some specialists therefore insist that dentures be abandoned. If dentures are required, they should be fitted at about 4 to 6 weeks after radiotherapy, when initial mucositis subsides and there is only early fibrosis.

Dental Management of Patient Undergoing Chemotherapy

These patients take immunosuppressant drugs and because of that there is leukocytopenia. Hence, all the procedures should be done under antibiotic coverage.

Pregnancy and Lactation

Every female patient in the child-bearing age must be asked for history of pregnancy or missed menstrual cycles. Great care must be taken when dealing with the pregnant patient, since the surgeon has to treat not only the mother, but also prevent any undue harm to the fetus. It is safe to perform procedures under local anesthesia in the second trimester. In the first trimester, there is a risk of stress related abortion as well as teratogenicity, while in the third trimester, there is a risk of stress induced early labor. General anesthesia is a contraindication in the third trimester, unless it is a life-saving emergency procedure. In the first and second trimesters care must be taken to avoid fetal anoxia.

Again, the risks and benefits must be outweighed prior to the procedure. The mother should be fully explained about the risks before performing any procedure. Teratogenic drugs such ae tetracyclines, salicylates, and chloramphenicol are best avoided. Amoxicillin, cloxacillin, ampicillin and paracetamol can be safely prescribed.

Food and Drug Administration (FDA) has categorized the potential for drugs to cause birth defects, providing

Table 3.6: FDA guidelines for the drugs to be prescribed during pregnancy

Drugs	*FDA category*	*Use in pregnancy*	*Use in nursing*	*Possible side effects*
Analgesics				
Acetaminophen	B	Yes	Yes	Not reported
Aspirin	C	Not in 3rd trimester	No	Postpartum hemorrhage
Ibuprofen	B	Not in 3rd trimester	Yes	Delayed labor
Naproxen	B/D*	Not in 2nd half of pregnancy	Yes	Delayed labor
Codeine	C	With caution	Yes	Multiple birth defects
Oxycodone	B	With caution	With caution	NRD**
Hydrocodone	C/D*	With caution	With caution	NRD**
Morphine	B	Yes	Yes	Respiratory depression
Propoxyphene	C	With caution	Yes	Not reported
Meperidine	B	Yes	Yes	Not reported
Pentazocine	C	With caution	With caution	Not reported
Antibiotics				
Amoxicillin	B	Yes	Yes	Not reported
Metronidazole	B	Yes	Yes	Not reported
Erythromycin	B	Yes	Yes	Not reported
Penicillin V	B	Yes	Yes	Not reported
Cephalosporins	B	Yes	Yes	Not reported
Gentamycin	C	Yes	Yes	Fetal ototoxicity

contd...

contd...

Clindamycin	B	Yes	Yes	Not reported
Tetracycline	D	No	No	Discoloration of teeth
Chloramphenicol	X	No	No	Maternal toxicity/fetal death
Chlorhexidine	B	No data	No data	Not reported
Antifungals				
Nystatin	B	Yes	Yes	Not reported
Clotrimazole	B	Yes	Yes	Not reported
Fluconazole	C	With caution	With caution	Not reported
Ketoconazole	C	With caution	No	Fetal toxicity
Local anesthetics				
Lidocaine	B	Yes	Yes	Not reported
Mepivacaine	C	With caution	Yes	Fetal bradycardia
Prilocaine	B	Yes	Yes	Not reported
Bupivacaine	C	With caution	Yes	Fetal bradycardia
Etidocaine	B	Yes	Yes	Not reported
Corticosteroids				
Prednisolone	B	Yes	Yes	Not reported
Sedative/Hypnotics				
Nitrous oxide	Not assigned	Not in 1st trimester	Yes	Spontaneous abortion
Barbiturates	D	Avoid	No	NRD
Benzodiazepines	D	No	No	Cleft lip/palate

Note:
- D* indicates caution: If used for prolonged period of time, or high doses.
- NRD** Neonatal respiratory depression.

definitive guidelines for prescribing drugs during pregnancy **(Table 3.6)**. They are as follows:

Food and Drug Administration Categories

- **Category A:** Controlled human studies indicate no apparent risk to fetus. The possibility of risk to the fetus is remote.
- **Category B:** Animal studies do not indicate risk. Well-controlled human studies have failed to demonstrate a risk.
- **Category C:** Animal studies show an adverse effect on the fetus, but there are no controlled studies in humans. The benefits from use of such drugs may be acceptable.
- **Category D:** Evidence of human risk, but in certain circumstances the use of such a drug may be acceptable in pregnant women despite its potential risk.
- **Category X:** Risk of use in pregnant women clearly outweighs possible benefits.

CONCLUSION

In conclusion, a few points need to be highlighted, which will define a basic protocol to be followed during the management of a medically compromised patient.

- A thorough knowledge of the patient's medical background must be obtained.

- The surgeon should also have knowledge about the medications taken by the patient and the regularity of the patient in taking the same.
- A written consent for the surgical procedure has to be obtained from a specialist in the field prior to the procedure.
- Adequate and necessary preoperative investigations must be performed.
- The patient should be explained about the risks and benefits of the procedure, with regards to his general condition and a witnessed written condition for the procedure, as well as high-risk consent should be obtained from the patient.
- The operation theater must be well-equipped with functional life-support systems and an updated emergency trolley in case of an emergency. The same applies to the postoperative recovery room.
- The decision of whether or not to operate lies with the surgeon, and he must make his choice judiciously weighing the pros and cons with respect to surgical benefits and anesthetic risks.

Points to Remember

- Classification of physical status of a patient
- Preoperative investigations, intra and postoperative manage-ment of patients with various medical conditions/disorders
- Dental management of patients undergoing chemo-therapy/radiation
- Precautions for pregnant patients
- HIV patient's diagnosis and management.

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CHAPTER 4 Armamentarium Used in Oral and Maxillofacial Surgery

INTRODUCTION

Surgeons have an access to a variety of surgical instruments that are designed to help them in the surgical treatment of various abnormalities and pathological processes. These instruments are used for a wide variety of surgical procedures, for both soft and hard tissues. A sound knowledge of these surgical instruments and their use is essential to perform routine basic or major surgical procedures. Surgeon must be well versed with the identification and indications for the use as well as the technique of using different instruments. Quality of the instruments chosen is also crucial. Handling/storing the expensive instruments is also equally important **(Table 4.1 and Box 4.1)**.

Table 4.1: Handling the instruments during surgery

- Know the name and use
- Free hand technique
- Handle carefully
- Watch the sterile field for loose instruments
- Use for intended purpose
- In between the surgical procedure, wipe the soiled instruments intermittently, clean with moist sponge, wipe blood, organic debris from instruments using a demineralized sterile distilled water. Rinse frequently.

Use hand signals

- Short instruments: Superficial surgery
- Long instruments: Deep surgery
- Pass instruments decisively/firmly

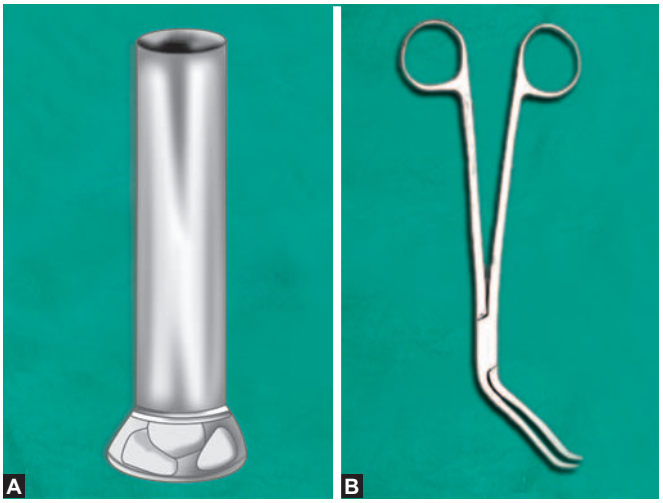
Box 4.1: Solutions that damage the surgical instruments

- ❑ Saline
- ❑ Betadine
- ❑ Peroxide
- ❑ Dish soaps
- ❑ Bleach
- ❑ Iodine
- ❑ Hand soaps
- ❑ Laundry detergents
- ❑ Long-term soaking in rust/stain remover
- ❑ Surgeon's hand scrub solution
- ❑ Household lubricants/powder cleaners
- ❑ Soaking for long time in water/saline

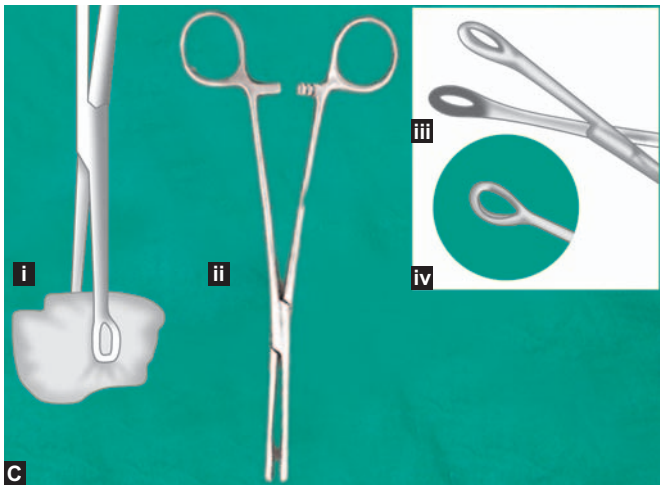
INSTRUMENTS USED FOR PICKING UP AND FOR TRANSFER OF STERILE INSTRUMENTS

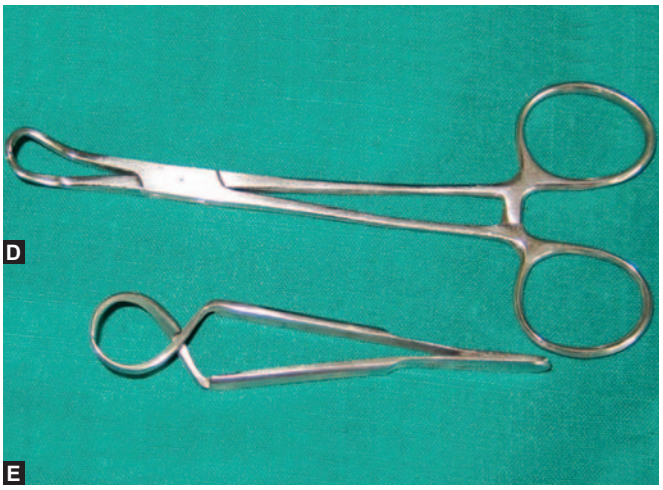
Cheatle's Forceps

It is also known as transfer forceps. It is an angulated instrument with long handle and angulated serrated beaks, that is used for picking up and transferring sterile instruments from a tray or linen/drapes from the drum to avoid direct touching. It has got no locking device and it is stored (kept) in a container containing an antiseptic or bactericidal solution like Savlon or glutaraldehyde. The solution must be changed everyday. The container should be thoroughly washed and autoclaved at least once a week **(Figs 4.1A and B)**.



Figs 4.1A and B: (A) Cheatle's forceps holder; (B) Cheatle's forceps





Figs 4.1C to E: (C) (i) Swab/sponge holding; (ii) Swab holder; (iii and iv) *Insets*—magnified view of the beaks; (D) The Pinchter type towel clip; (E) Backhaus towel clip

INSTRUMENTS USED FOR PREPARING THE SURGICAL FIELD

Swab Holder/Rampley's Sponge Holder

It is an instrument with long blades, expanded at the ends, forming an oblong tip. The blades have a central fenestration and transverse serrations **(Fig. 4.1C)**.

Uses

- To hold a swab/sponge and scrub/clean the skin/mucosa in the area of operative field.
- To swab the throat when there are profuse secretions in an unconscious patient or patients under general anesthesia.
- To press on the tonsillar bed to arrest hemorrhage.
- To hold the tongue and give anterior traction, thus preventing tongue fall and airway obstruction in an unconscious patient.
- To pick up gauze/cotton, etc.

INSTRUMENTS USED FOR HOLDING THE DRAPES (FOR ISOLATION OF SURGICAL FIELD)

Towel Clips

There are two types of towel clips:

1. The Pincher's type (the forceps type), (Mayo's towel clip/Moynihan's tetra towel clips, Schaedel towel clip) **(Fig. 4.1D)**.
2. Backhaus towel clip/Doyen's cross-section towel clip **(Fig. 4.1E)**.

The Backhaus type of towel clip has a spring joint and the forceps type has a box joint. The tips of the instrument are pointed, curved towards each other and overlap one another. These sharp, curved tips penetrate the towels or drapes and locked in place. Caution is taken not to pinch the patient's skin.

Uses

- To hold the corners of the draping sheets during an operation, to fix the drapes in position in order to isolate surgical field.
- To hold the tongue, while biopsy procedure is performed in the posterior part of the tongue. The tongue is held on the anterior dorsum and is pulled out and is taken on the contralateral side.
- To stabilize the suction tubes, motor cables and diathermy cables, other fiber-optic instrument cables to the drapes.

INSTRUMENTS USED FOR INCISING/DISSECTING THE SOFT TISSUES

Scalpel

The instrument used for making an incision is called a scalpel. The scalpel has two parts:

1. A blade and
2. A blade handle.

Bard-Parker Blade Handle

Various sizes of the handles are available. The most commonly used handle in oral surgery is no. 3, which is 12 cm long. No. 7 handle is longer and is 16 cm long. The handle has a receiving slot for the blade. While fitting the blade to the blade handle, it is held with the help of a needle holder or an artery forceps (hemostat) to prevent injury to the operator (loading and removal of the blade is always done with the help of a straight hemostat). The blade is then pushed into the slot till it fits or clicks snugly. The scalpel is always used with the pen grip. Blade is always disposable and used for a single patient. If in a single operation, several layer incisions are needed, then the blade may become blunt, which cannot make clean, sharp cuts. In that case, new blade is changed **(Fig. 4.2A)**.

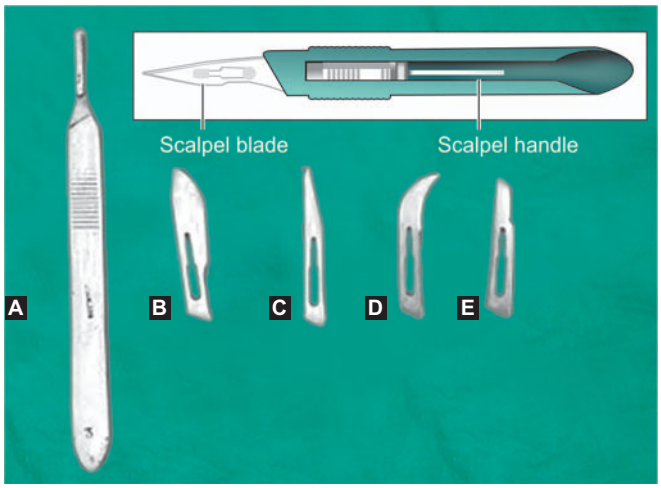
Surgical Blades

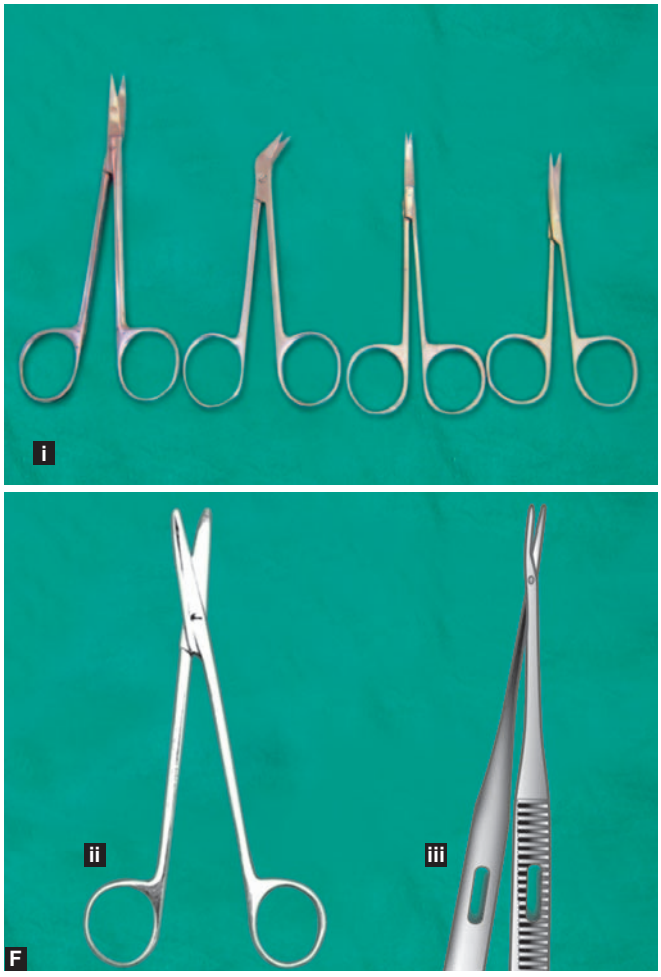
- **No. 10:** For making large skin incisions **(Figs 4.2B to E)**.
- **No. 11:** It is sharp, pointed blade used for making stab incisions (e.g., to drain an abscess).
- **No. 12:** It is hooked or curved. Useful for mucogingival procedures, especially in posterior region of the oral cavity.
- **No. 15:** For intraoral surgery, most commonly used blade for mucoperiosteal incisions.

Dissecting Scissors

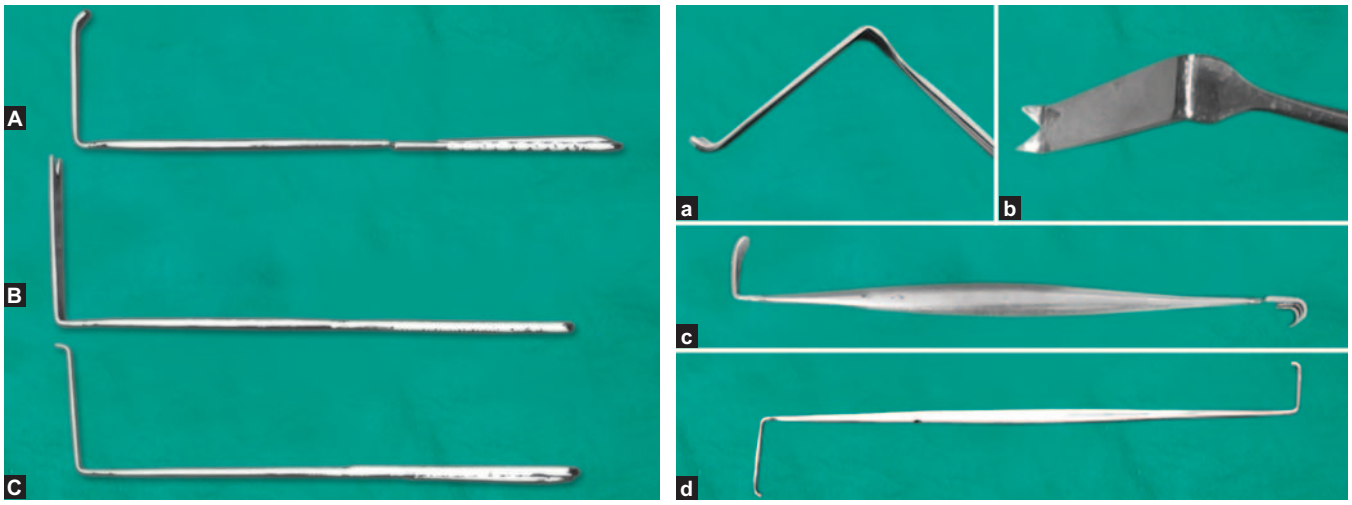
As the name suggests, dissecting scissors are used to perform soft-tissue dissection in the deeper layers. The dissecting scissors are available in different lengths and different combinations of blades and tips. They are also either straight or curved or angulated. The tips of the scissors can have various combinations such as sharp/blunt/blunt, sharp/blunt for straight and curved scissors. The mostly used dissecting scissors have a blunt nose for undermining the tissues and a side cutting edge for cutting the tissues **(Fig. 4.2F)**.

- **Iris scissors:** Small, delicate, 3–4 inches long with sharp pointed ends, designed for fine detail work. Available as curved or straight.
- **Mayo curved heavy duty dissecting scissors:** Both blades are slightly curved and have narrow tips with blunt ends. Used for cutting heavy, deep, tough tissues and to raise skin flaps by sharp dissection.
- **Metzenbaum curved on flat dissection scissors:** Used for plastic surgery. Dissecting out soft, delicate tissues or connective tissue planes. Microscissors are used for delicate and fine work.





Figs 4.2A to F: (A) Bard parker blade handle; (B) No. 10 blade; (C) No. 11 blade; (D) No. 12 blade and (E) No. 15 blade (inset: disposable scalpel); (F) Dissecting scissors—(i) Iris dissecting scissors; (ii) Mayo`s dissecting scissors; (iii) Microscissor



Figs 4.3A to C: (A) Toe in Obwegeser`s or Langenbeck's retractor; (B) Obwegeser's ramus retractors; (C) Toe out Obwegeser`s retractor. Inset—(a) Obwegeser`s ramus retractor; (b) V-shaped notch to hold the anterior border of the ramus; (c and d) Double ended Langenbeck's retractor

INSTRUMENTS USED FOR RETRACTING SOFT TISSUES

As the name suggests the retractors are used to hold back the tissue during surgery for atraumatic exposure of surgical field. There are different kinds of retractors, but the purpose is the same for each. Retraction provides good vision and good access in order to perform good surgery.

Langenbeck's Retractor

It has a long handle and an L-shaped blade. This retractor is most commonly used in oral surgery. It is available in different sizes and blade width. The instrument can be single or double ended. It is used to retract the soft tissues, incision edges, to allow visualization of the deeper structures. It can be used for retracting cheeks, tongue, mucoperiosteal flap, etc. **(Figs 4.3A to C)**.

Obwegeser's Ramus Retractor

The retractor is similar to the Langenbeck's retractor except that the edge of the retracting blade is forked, forming a V-shaped notch, so as to engage the anterior border of the ramus of the mandible and aid in good tissue retraction. Other modifications are toe in and toe out Obwegeser's retractors, depending on the direction of the end tip of the same **(Figs 4.3A to C, a and b)**.

Uses

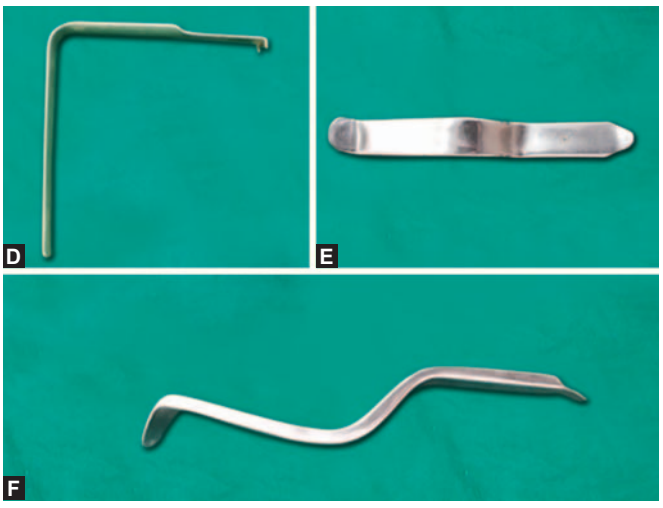
- To retract the soft tissues along the anterior border of the ramus during sagittal split or ramus osteotomy
- To retract the tissues from the anterior border of the ramus during coronoidectomy procedures.

C-shaped Retractor

This instrument also has a long handle but the blade is C- shaped. It is more commonly used in abdominal surgeries.

Austin's Retractor

It is a short right-angled L-shaped retractor used for retracting the cheek, tongue and the mucoperiosteal flaps **(Fig. 4.3D)**. It has got no handle, but one end is narrower with atraumatic teeth. Usually used during surgical



Figs 4.3D to F: (D) Austin`s retractor; (E and F) Minnesota retractor

removal of impacted 3rd molar. It can retract cheek and mucoperiosteal flap simultaneously.

Minnesota Retractor

It is S-shaped wide retractor, with slightly bent tips to engage mucoperiosteal flap. Usually used during surgical removal of impacted 3rd molars. It can retract cheek or lip and mucoperiosteal flap simultaneously **(Figs 4.3E and F)**.

Condyle Retractors

They are special retractors that have an appearance similar to the tongue depressor, but are much narrower and the tip of the blade has a C-shaped hook that is slipped under the ankylosed mass to retract and protect the medial soft tissues during release of the ankylosis **(Fig. 4.4A)**.

Weider's Tongue Retractor

It is a broad, heart-shaped retractor that is serrated on one side so that it can engage the tongue and firmly retract it medially and anteriorly. It should not be positioned too far posteriorly in order to avoid gagging **(Fig. 4.4B)**.

Volkmann's Cat Paw Retractor

As the name suggests, the instrument resembles a cat's paw. The blade has prongs that are curved at the tip. It is used to retract small amounts of soft tissue, skin, tough fascia, etc. Excessive force during retraction may lead to perforation or tear in the flap **(Fig. 4.4C)**.

Seldin's Retractor

It is similar to the periosteal elevator, but the leading edge is dull and not sharp **(Fig. 4.4D)**.

It is used only for retracting soft tissues and not for elevating the mucoperiosteal flap.

There are so many other retractors available such as army/navy retractors, Zen/Senn, Zerny, Shuman retractors. Depending on the surgical site and depth they can be chosen.

Tongue Depressor

The tongue depressor is an L-shaped instrument with a broad flat, rounded smooth blade for depressing or retracting the tongue **(Fig. 4.4F)**.

Uses

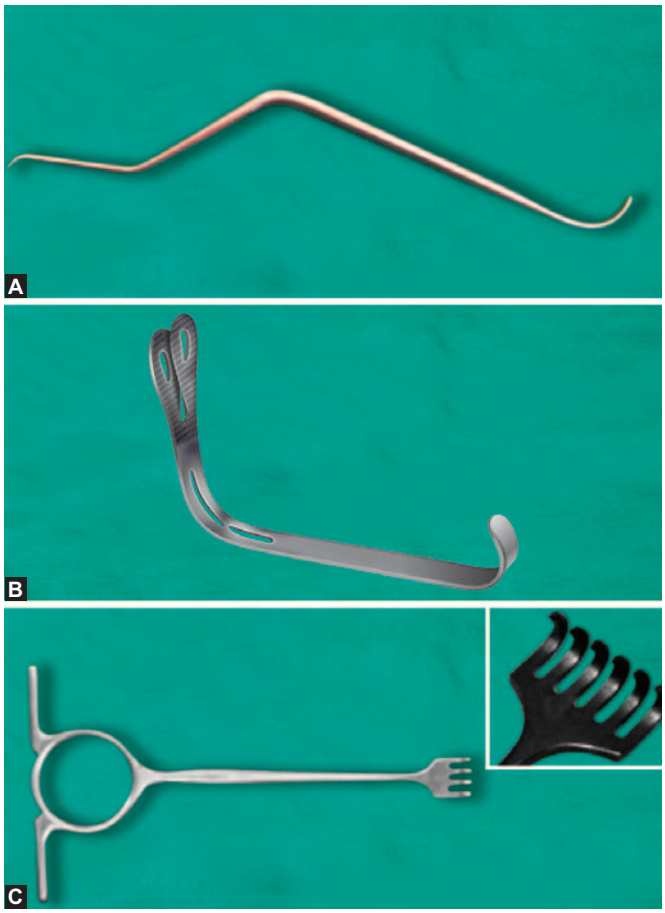
- To depress the tongue for visualization of the lingual side of the mandible, tonsils and the pharyngeal wall during inspection.
- To depress the tongue during endotracheal intubation and extubation.
- To depress the tongue and move it anteriorly to check for airway obstruction and to prevent tongue fall in an unconscious patient. It can be used for the removal of the throat pack at the end of general anesthesia.
- To retract the tongue during surgical procedures in the oral cavity.
- To retract the cheek.

Malleable Retractors

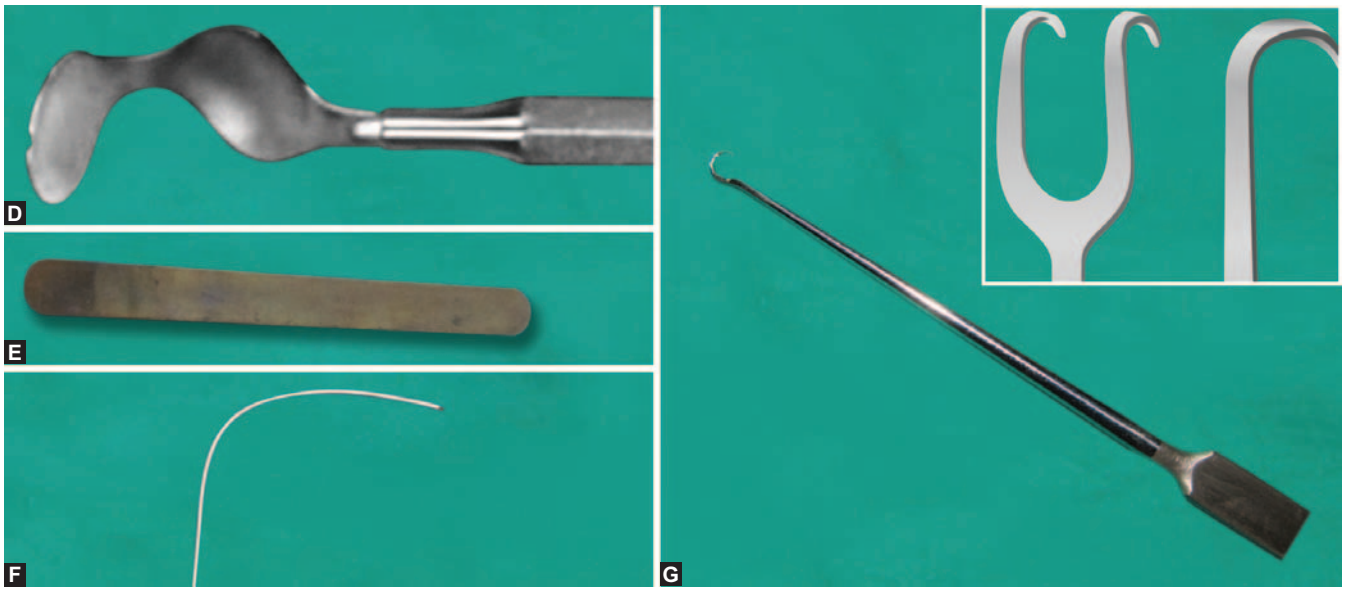
These are made up of brass or copper-malleable strips of various length and width. They can be bent as per the need to protect the soft tissues, nerves, vessels, etc. **(Fig. 4.4E)**.

Skin Hook

Skin hook is a thin, long instrument, with a delicate pointed curved tip. This tip engages the tissues **(Fig. 4.4G)**.



Figs 4.4A to C: (A) Condylar retractor; (B) Weider's tongue retractor; (C) Volkmann's cat paw retractor with Inset-magnified view



Figs 4.4D to G: (D) Seldin`s retractor; (E) Malleable retractor; (F) Tongue depressor; (G) Skin hook (Inset: Different tips of skin hooks).

Uses

- To stretch the edges of the skin incision during suturing to prevent dog ear formation
- To retract small amount of soft tissue or edges.

INSTRUMENTS USED FOR REFLECTING/ ELEVATING THE MUCOPERIOSTEAL TISSUE/ FLAP

Moon's Probe

It is a thin, flat instrument that has a small working tip at right angles to the handle. The tip is narrow and sharp **(Fig. 4.5A)**.

Uses

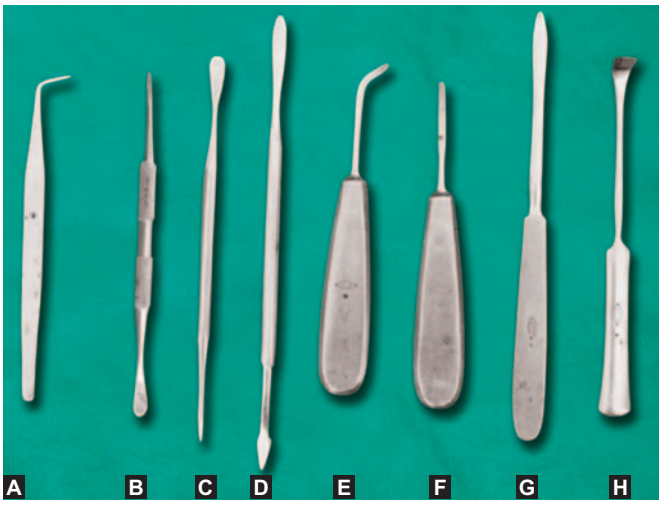
To elevate the attached gingiva around the tooth prior to extraction.

Periosteal Elevators (Molt's No. 9, Howarth's, Dial's)

As the name suggests, these instruments are used for reflecting or retraction of the mucoperiosteum. Most of the periosteal elevators have a broad, spatulate end with sharp edge on one side and a pointed or triangular or rugine end on the other (they an be single or double ended) **(Figs 4.5B to G)**.

Uses

- The pointed end is used to release the interdental papillae, clean separation of periosteal attachment from the bone.
- The broad end is used for elevating the mucoperiosteal flap from the bone, loosen soft tissues via gingival sulcus.
- The broad end can also be used as a soft tissue retractor.



Figs 4.5A to H: (A) Moon's probe; (B to G) Periosteal elevators; (H) Cleft palate raspatory

Methods of Reflecting the Periosteum from the Flap

- **Prying motion:** The pointed end can be used in a prying motion to elevate the soft tissue, e.g. reflecting the interdental papillae.
- **Push stroke:** It is given with the broad end of the periosteal elevator and is the most efficient stroke to reflect the periosteum from the bone
- **Pull stroke:** It is also called the scrape stroke and most likely tends to tear the periosteum.

Cleft Palate Raspatory

Raspatory is the term used for an instrument used to smoothen the edges of the divided bone (Latin: *Raspatorium*).

This broad, flat handled, curved tip elevator is specially used to elevate the palatal mucoperiosteum while mobilizing the flaps for cleft palate repair. It is also used to trim palatal bone to avoid laceration of nasal or palatal flap **(Fig. 4.5H)**.

INSTRUMENTS USED FOR ACHIEVING HEMOSTASIS: CONTROLLING HEMORRHAGE

When incisions are made through tissues, small arteries and veins are incised, causing bleeding that may require additional measures than simple pressure to control. For this purpose hemostat or hemostatic forceps is used. The term "artery forceps" is a misnomer, hence should not be used.

Hemostatic Forceps (Spencer Wells, Kelly's, Halstead's)

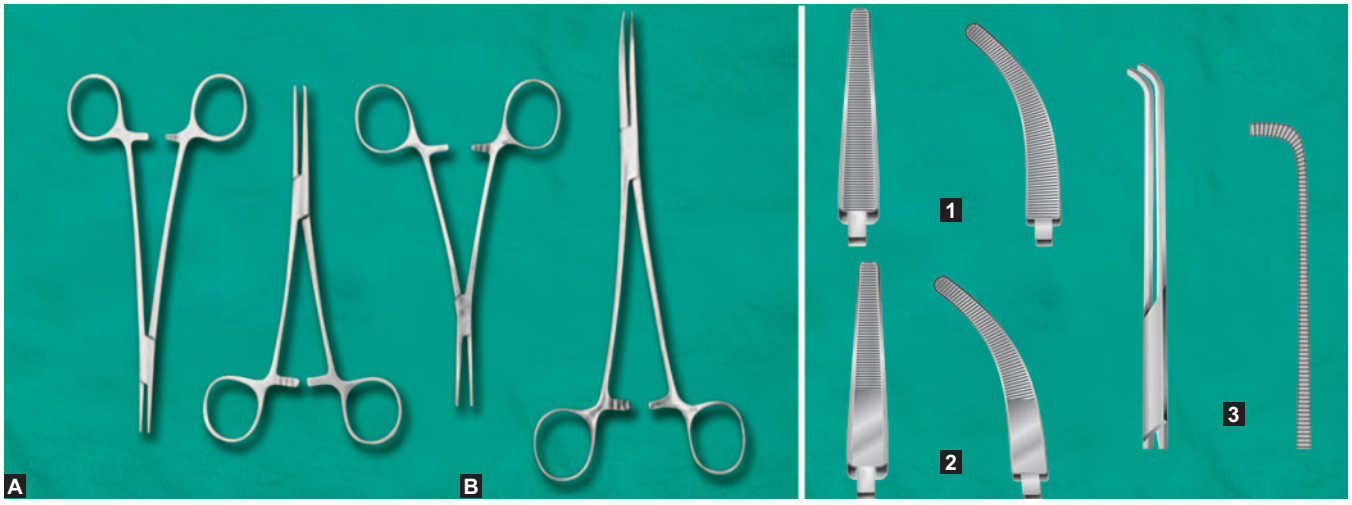
These forceps are better known as hemostatic forceps although they are used for catching both arteries and veins. They are used to catch hold of bleeding vessels. They have long beak to grasp the vessel and a locking handle. The unidirectional, transverse serrations on the blades of the hemostat prevent the vessel from slipping. The vessel is crushed between the blades and hemostasis is achieved. The handle has a catch and the vessel may be held and clamped for temporary occlusion. Small bleeders may be controlled by just crushing the vessel, whereas bigger vessels may be cauterized or ligated. These forceps allow easy placement of ligatures around the vessels. Right angled hemostat may be used to isolate and ligate vessels or ducts, especially in depths.

Types of Hemostats

- **Types:** Small—mosquito/halstead, medium—Spenser well and long—Bailey's forceps. Shapes—straight and curved **(Figs 4.6A and B)**.
- **Halstead's mosquito forceps:** A small, curved hemostatic forceps is known as a mosquito forceps.

Uses

- To achieve hemostasis by catching or temporary occlusion of blood vessels. Hemostasis may be achieved just by crushing the vessels or by grasping and ligating vessels or cauterizing them.
- To hold the ends of ligatures and allow easier placement of ligatures around the forceps.



Figs 4.6A and B: (A) Straight hemostats; (B) Curved hemostats [*Inset* (1) straight and curved mosquito forceps has serration along the entire tip, while; (2) Kelly's straight and curved hemostat has serrations only on some part; (3) right-angled tip hemostat]

- As tissue forceps for holding subcutaneous tissues, aponeurosis (but not skin or nerves)
- To drain an abscess by Hilton's method
- To pick up necrotic tissue, granulation tissue, foreign bodies, tooth or root pieces, small fragments of bone, etc.
- To carry out blunt dissection of the tissues.

INSTRUMENTS USED FOR HOLDING OR GRASPING THE SOFT TISSUES

Tissue Holding Forceps

As the name suggests these are used to hold or grasp the soft tissues during surgery.

Allis Tissue Holding Forceps

It is a short instrument with a catch and the blades have teeth that are delicate **(Fig. 4.7A)**.

Uses

- To hold delicate tissues like the peritoneum, aponeurosis, soft muscles, epulis fissuratum, etc.
- To retract and hold the tissue margins and skin edges, while raising a flap
- To provide tension/traction for tissue dissection.

Babcock's Tissue Holding Forceps

The instrument has fenestrated, smooth, non-serrated blades without teeth, so it is less traumatic **(Fig. 4.7B)**.

Uses

- To hold and pick up the organs and delicate structures, like peritoneum, fascia, etc.
- To hold the cyst lining, cut skin margins, etc.
- To hold enlarged lymph nodes or any glandular tissue.

Lane's Tissue Holding Forceps

It is a long and stout instrument with sharp teeth on the blades **(Fig. 4.7C)**.

Uses

To hold tough structures like the skin, coarse muscles or more bulky tissue can be held in its beaks. Tissue holding forceps will be described in detail later.

Tongue Forceps

The tongue forceps are of two types.

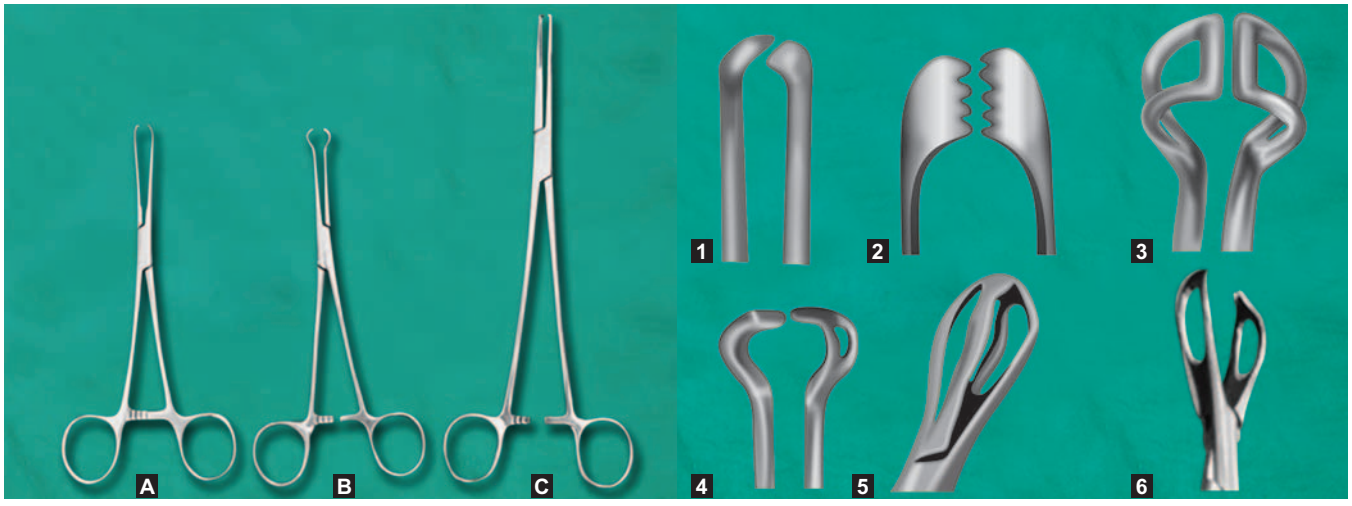
Swab Holder Variety

It is similar to the swab holder but for the fenestration on the blade which is triangular and the serrations on the blades coarser. It may cause damage to the tongue.

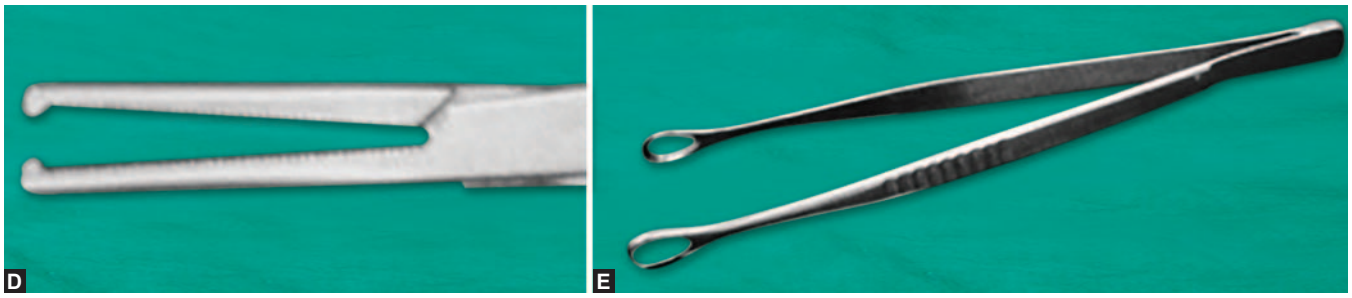
Towel Clip Type

It is similar to the forceps variety of the towel clip, except in the fact that the tip of one of the blades is expanded into which the tip of the other blade fits.

It is better than the swab holding variety as the tongue is traumatized at only one point.



Figs 4.7A to C: (A) Allis tissue holding forceps; (B) Babcock's tissue holding forceps; (C) Lane's tissue holding forceps (Inset 1 and 2–Allis`s working tips 3 and 4–Babcock`s working tips 5 and 6–Lane`s working tips)



Figs 4.7D and E: (D) Kocher`s type gland-holding forceps; (E) Swab holder type fenestrated gland-holding forceps

Uses

- To hold the tongue during any surgery of the tongue
- To arrest hemorrhage from the tongue (when the tongue is pulled forwards, the lingual artery is compressed between the tongue and the lower anterior teeth)
- To prevent tongue fall and airway obstruction in unconscious patients.

Gland Holding Forceps

Kocher's Variety

It is similar to the swab holder but there are two spikes in each blade that are turned to engage the tissues **(Figs 4.7D)**.

Uses

- To hold the salivary glands, especially the submandibular and the sublingual glands
- To hold enlarged lymph nodes
- To hold tumors during excision.



Fig. 4.7F: Alligator forceps for removal/grasping of foreign bodies (Inset: Magnified view of tips)

Swab Holder Variety

It differs from the swab holder in that there are no serrations on the blade **(Fig. 4.7E)**.

Alligator/Crocodile Forceps

It is an angulated instrument with serrated tips or jaws which grasp the tissues or foreign bodies at the depth **(Fig. 4.7F)**.

INSTRUMENTS USED TO KEEP THE MOUTH OPEN

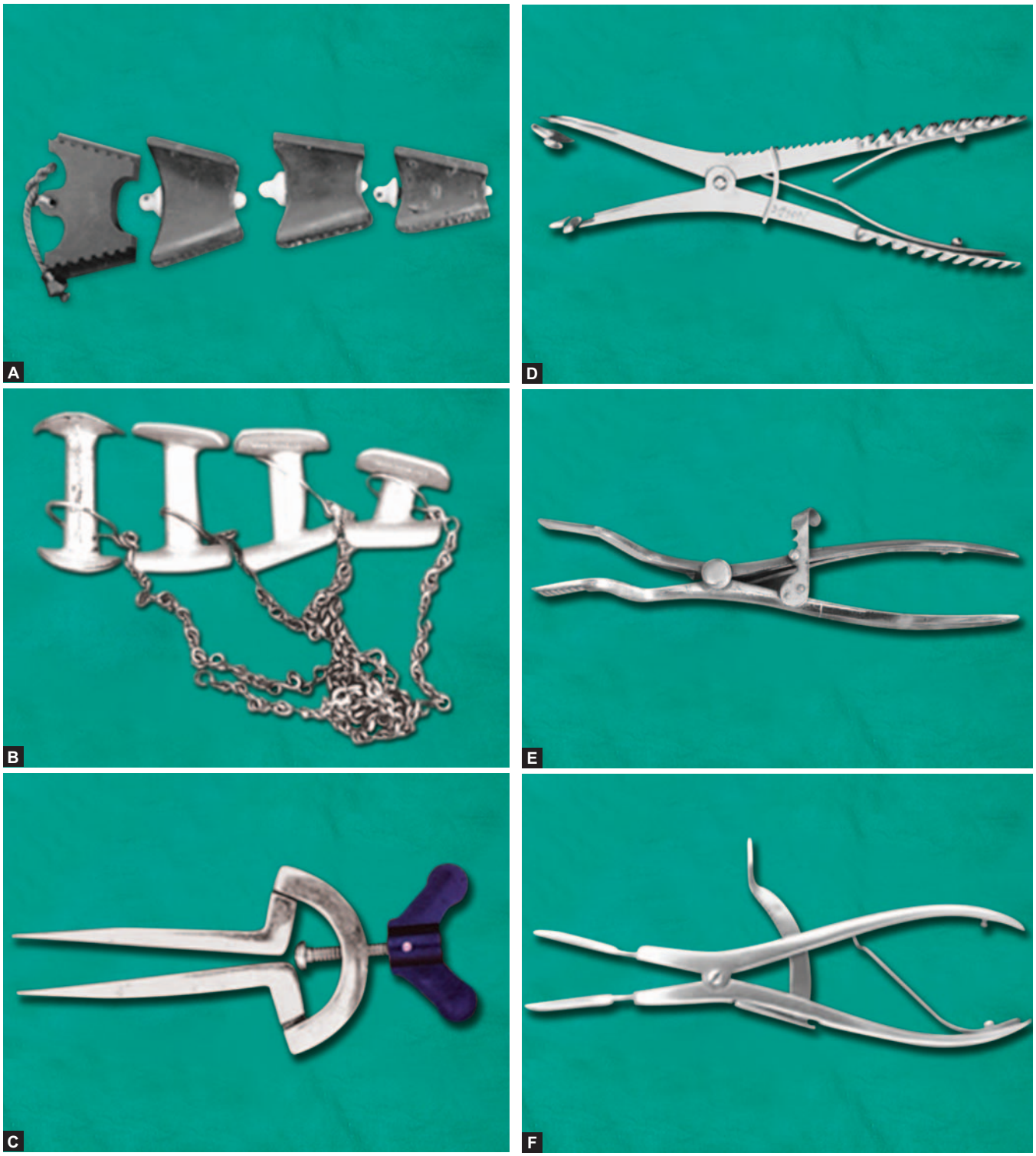
Mouth Prop-bite Blocks

Mouth props can be of two varieties (1) rubber and (2) metal **(Figs 4.8A and B)**.

The function of the mouth prop is similar to the mouth gag, i.e. to keep the mouth open during any surgical procedure performed in the oral cavity. The mouth prop consists of a vertical block having a concave surface on either of its ends to fit on the occlusal surfaces of maxillary and mandibular teeth. The block is placed between the mandibular and maxillary teeth to maintain the mouth open. Usually, there are three or four blocks of varying vertical heights arranged in an ascending order, and connected by a chain. The operator can choose the block according to the required extent of oral opening.

Heister's Jaw Stretcher

This instrument is used to forcibly open the mouth. The instrument has two flat blades that are applied between the maxillary and mandibular posterior teeth and are separated by turning a key that is positioned between the two blades. Slow gradual force is applied till desired oral opening is achieved and maintained in open position at least for 5 minutes to break the spasm **(Fig. 4.8C)**.



Figs 4.8A to F: (A) Rubber mouth props; (B) Metal mouth props; (C) Heister's jaw stretcher; (D to F) Fergusson's mouth gag



Fig. 4.8G: Doyen`s mouth gag

Uses

- To force the mouth open when there is trismus due to infection, muscle spasm, hemarthrosis of the temporomandibular (TM) joint following trauma
- To give postoperative active jaw physiotherapy after surgery for TM joint ankylosis, submucous fibrosis.

When using the above two instruments, care must be taken to prevent luxation of the teeth, especially the anterior teeth and dislocation of the TM joint.

Mouth Gag (Doyen's, Fergusson's, Ackland's)

This instrument is used to keep the mouth open in a patient under general anesthesia, during surgeries of the oral cavity, tonsils and the pharynx. The flat blades have serrations that rest on the occlusal surfaces of the maxillary and the mandibular teeth. The handle has a catch that is fixed at the required opening **(Figs 4.8D to G)**.

INSTRUMENTS USED TO DRAIN AN ABSCESS

Lister's Sinus Forceps

The instrument has long narrow/slender blades/beaks which are serrated transversely for only half an inch at the tip. The instrument does not have a catch or lock. The tip is rounded and bulbous. The shank and the tip are almost at equal length **(Fig. 4.9A)**.

Uses

- To open an abscess by Hilton's method, to break the pus loculi.

Hilton's method of drainage of an abscess: On the most dependent part of the abscess area, skin, subcutaneous tissues are incised. The deep fascia is not incised with blade, but pierced by thrusting a sinus forceps through the deep fascia and the beaks are opened up to enlarge the opening for easy drainage of pus.

- To hold a small piece of gauze between the blades to clean a cavity
- To dissect out sinus and fistulous tracts in soft tissues.

Hemostatic Forceps

As described earlier, it is used to drain an abscess by Hilton's method, when Lister's forceps are not available.

INSTRUMENTS USED TO REMOVE PATHOLOGICAL OR SOFT TISSUE FROM BONY CAVITIES OR DEFECTS

Surgical Curettes (Lucas)

The term "curette" comes from a French word *curer*, meaning "to cleanse". It is primarily an exploratory instrument. These are instruments used to scrape a bony cavity or a soft tissue tract in order to remove any pathological tissue present within them. A curette can be single or double ended. The working end may be in the same plane as the shank or at an angulation for adequate access to the pathologic cavity **(Figs 4.9B to D)**.

Uses

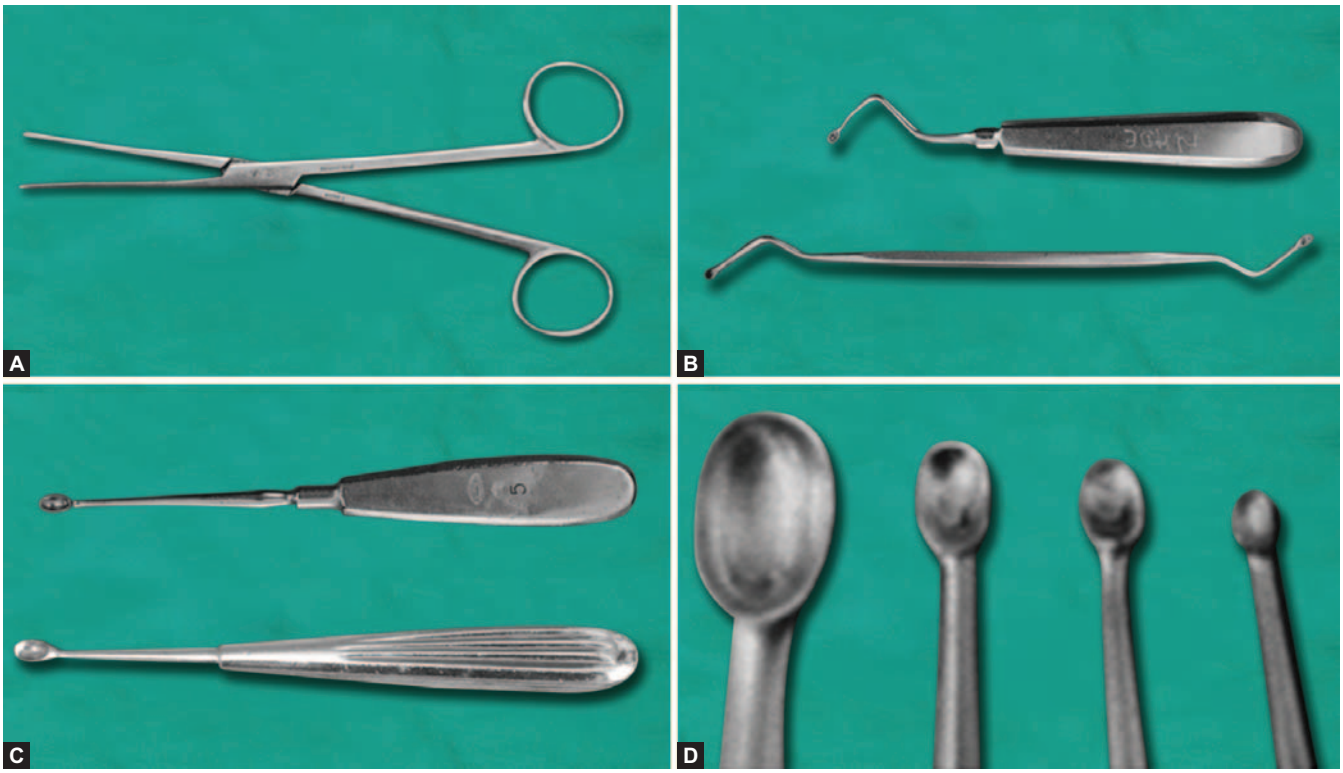
- It is used to remove tooth particles or debris from the extraction socket.
- To enucleate cysts, periapical granulomas, intraosseous tumors
- To remove small sequestra which may develop in healing sockets
- To remove proliferative or infected clot from the extraction socket.

Volkmann's Scoop or Molt's Curette

This instrument is used to scrape the contents of a cavity. It is similar to a curette, but the concavity of the working edges is more pronounced. It may also be used as a spoon **(Fig. 4.9C).**

Uses

- To collect the contents from a sinus tract, chronic abscess cavity or a fistula



Figs 4.9A to D: (A) Lister's sinus forceps; (B) Lucas curettes; (C) Volkmann's scoop/Molt`s curette; (D) (*Inset*: Different sizes of scoops)

- To scrape or curette bony cavities due to cystic/tumorous lesions or osteomyelitic lesions
- To scoop out the cancellous bone for grafting procedures
- To introduce graft material, antiseptic powder into the surgical area.

INSTRUMENTS USED TO HOLD OR GRASP THE BONE

Crocodile Bone Holding Forceps (Fergusson's Lion Jaw Bone Holding Forceps)

They are named so because of the appearance of the beaks sideways. The beaks have toothed margins to allow a good grip on the bone. The crocodile bone holding forceps has a catch to stabilize the instrument in the required position. In the absence of the above instruments, a "forceps type of a towel clip" may also serve the purpose **(Figs 4.10A to C)**.

Uses

To hold the bony fragments of the mandible during manipulation of the bony fragments, during fracture reduction, resection procedures, after osteotomy cuts, and during fixation of the bony fragments.

Kocher's Toothed Heavy Hemostat Forceps

This instrument is similar to a long heavy hemostat forceps, but it has toothed tip **[Fig 4.10 (2a and b)]** .

Uses

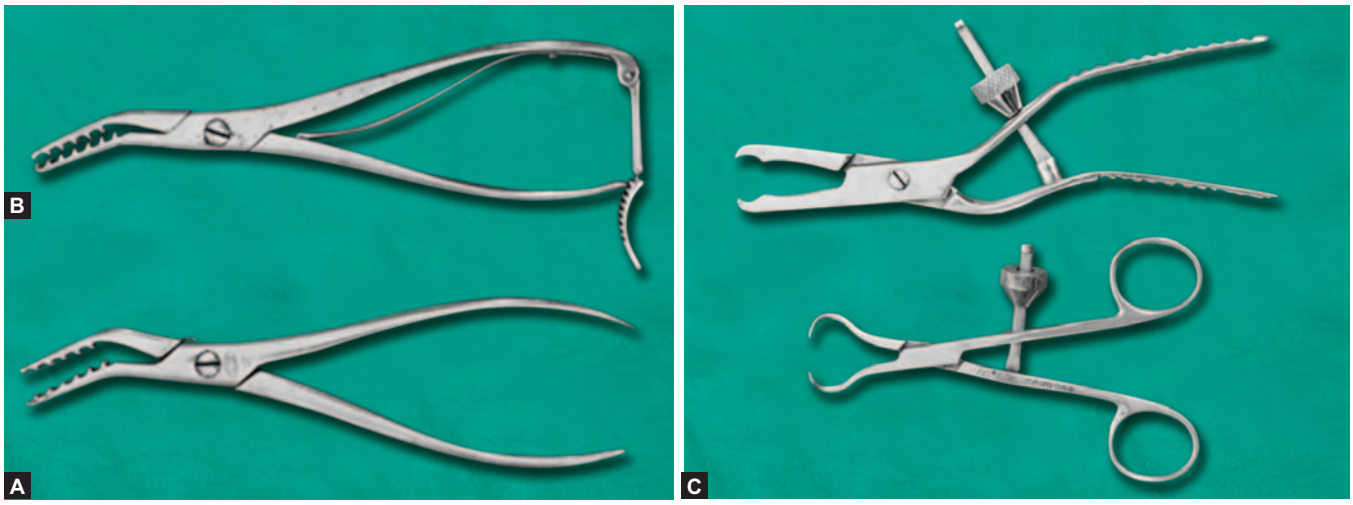
- The instrument is specially designed to hold the coronoid process during coronoidectomy procedure
- It can be used like the other bone holding forceps for stabilization of the bony fragment.

Sequestrum Holding Forceps

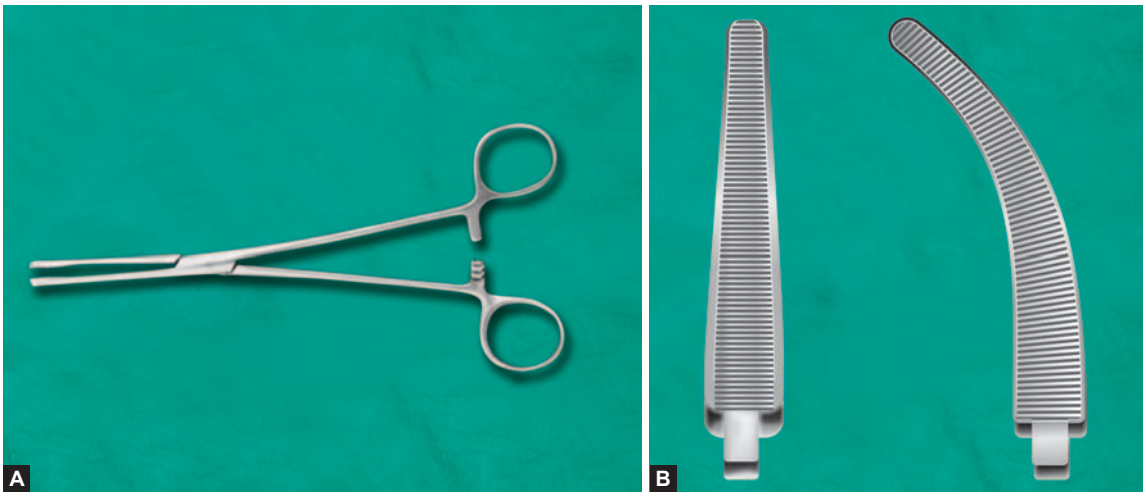
The instrument appears like the crocodile bone holding forceps, but does not have a catch to prevent crushing of the sequestrum.

Uses

To remove a sequestrum from a chronic osteomyelitic lesion.



Figs 4.10(1) A to C: (A) Crocodile bone holding forceps with lock; (B) Crocodile bone holding forceps without lock; (C) Other types of bone holding forceps with lock



Figs 4.10(2) A and B: (A) Kocher's heavy hemostat forceps; (B) Magnified view of straight and curved beaks

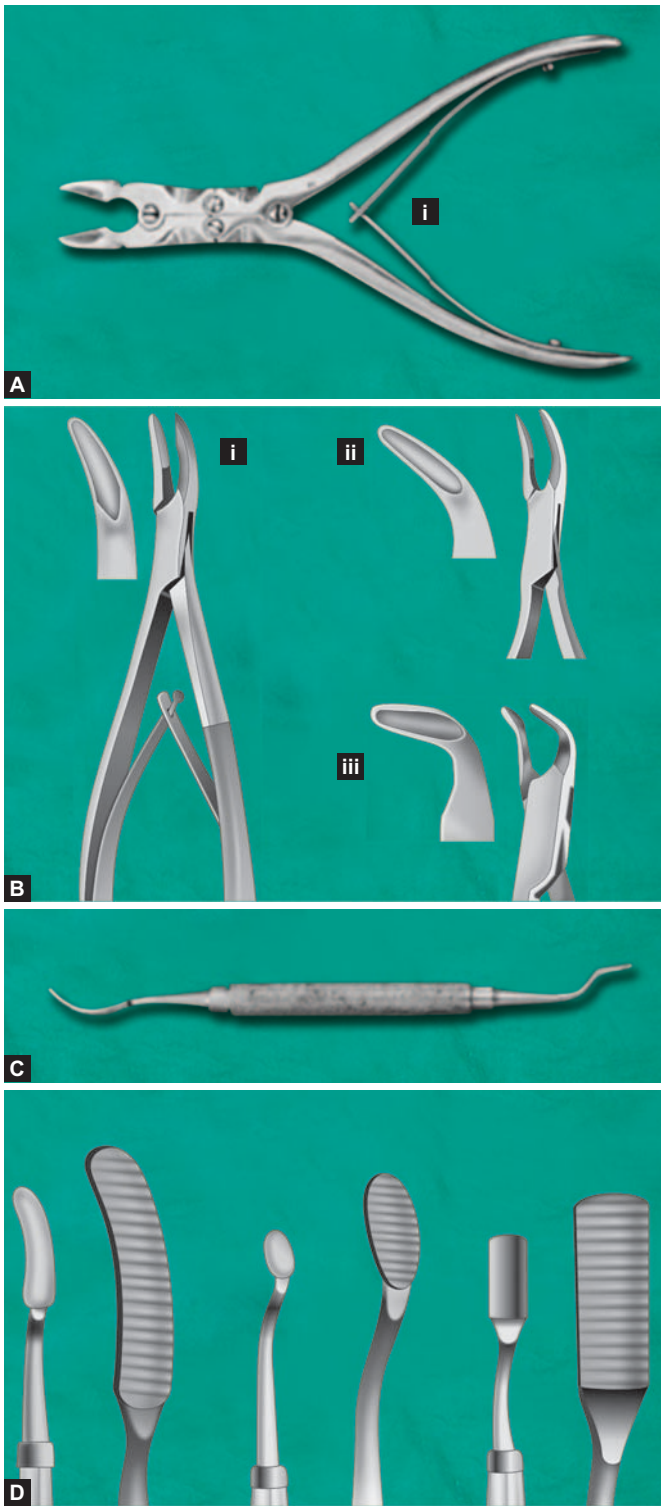
INSTRUMENTS USED TO CUT OR REMOVE BONE

Rongeurs Forceps (Blumenthal, Jensen Middleton)

The rongeurs forceps have curved handles that have a spring action. The leaf spring increases the force applied and hence efficiency of the instrument. There can be either one spring or a double spring (Jensen Middleton). When the handles are released, the instrument automatically opens up. This helps the surgeon to make repeated cuts without making efforts to open the handles. The tip is angulated forward to the handle and has a concave inner surface. The beaks are sharp. They can be either side cutting (Blumenthal for cutting and contouring the bone or both side cutting) for removal of large amount of bone and end cutting to cut the small amount of bone quickly. The instrument is used to remove large amounts of bone at a time using multiple, small bites **[Fig. 4.10(3 A and B)]**.

Uses

- To nibble sharp bony margins following simple or surgical extraction of teeth, surgical procedures
- To peel off thinned out bone present over cystic or tumorous lesions



Figs 4.10(3) A to D: (A) Jansen-Middleton Rongeurs forceps—(i) Tip cutting rongeurs; (B-i to iii): Side cutting rongeur; (C) Miller and Colburn bone file; (D) Different working tips of serrated bone files

- To trim sharp bony ridges during alveoloplasty/dentoalveolar surgical procedures
- To remove the interradicular septum by inserting the beaks into the sockets.

Miller and Calburn Bone File

As the name suggests, the bone file is used to smoothen any sharp bony margin present in the surgical field. The instrument has a long curved working end and a short oval working end—usually double-ended. The working ends have horizontal serrations. The instrument is used unidirectionally using a pull stroke. A push stroke usually causes burnishing and crushing of the bone. The working edges must be cleaned regularly to prevent clogging by bone debris, thereby reducing the efficiency of the instrument **[Fig. 4.10(3C and D)]**.

Bone Cutter

A bone cutter is similar to a Rongeur's forceps as far as the working principle is concerned. The instrument is activated by spring action. The edges of the blades are sharp and have a side-cutting action.

Uses

- To trim sharp bony margins following extractions, minor oral surgical procedures
- To trim sharp ridge projections during alveoloplasty procedure.

Chisel

Chisels are unibeveled instruments for cutting bone. They have a heavy round handle and a long flat working tip. The edge of the working tip has a bevel on one side. The working edge is sharp and flat. To plane the bone, the bevel is kept facing the bone. To cut the bone, the bevel is kept facing away from the bone **(Figs 4.11B to D)**.

Uses

- To remove chips of bone as in transalveolar extractions
- To split the tooth in difficult extractions.

Ochsenbein chisel—small, delicate chisel, used for removal of interproximal bone, elevating fractured root tip, etc.

Osteotome

- The osteotome is similar to a chisel, but the edge of the working tip is bi-beveled **(Fig. 4.11A)**.
- It splits bone rather than cut or chip the bone as with the chisel.

Uses

- Various osteotomy procedures
- Biopsy of bony lesions
- Removal or recontouring of the bone.

Bone Gouge

The bone gouge has a round handle and a blade that has a sharp working tip that is concave on the inner side. The working tip is half round and has a long working area **(Fig. 4.11E)**.

Uses

- To remove cancellous graft material during grafting procedures
- To make a window in the anterior wall of the maxillary sinus for access to the maxillary sinus during Caldwell Luc procedure.
- To remove irregular pieces of bone.

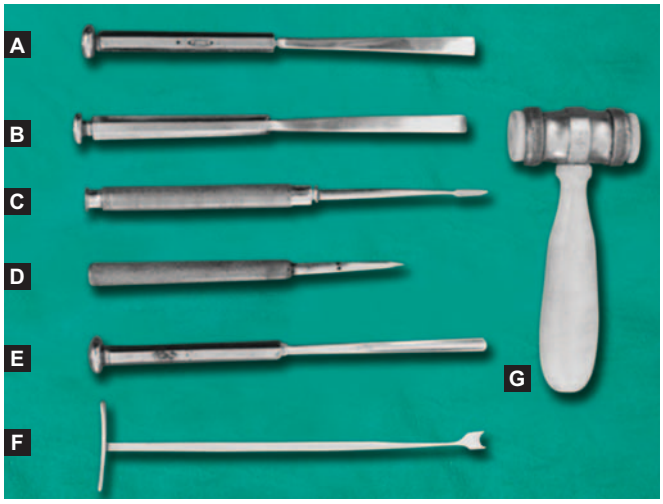
Nasal Rasp

It is used to fracture the anterior nasal spine and separate nasal septum from the maxilla during LeFort I or premaxillary osteotomy procedures. The instrument has a flat, thin blade with a sharp edge. The edge has a slit that engages the anterior nasal spine **(Fig. 4.11F)**.

Surgical Mallet

A mallet is made up of steel, lead or wood. It is similar to a hammer and is used for giving controlled taps on the chisel, bone gouge or osteotome. To be effective, the mallet should be used with a loose, free swinging movement of the wrist that gives maximum speed to the head of the mallet without introducing the weight of the arm or the body to the blow. The kinetic energy (KE) of a body is calculated as $KE = 1/2MV^2$, where KE stands for the energy possessed by the moving body, M stands for the mass of the body and V stands for the velocity of the body (tap-pull back action-force from the wrist); tapped with controlled force made to spring back from chisel or osteotome **(Fig. 4.11G)**.

Usually a 6-inch mallet is used for minor oral surgical procedures.



Figs 4.11A to G: (A) Osteotome; (B to D) Chisels; (E) Bone gouge; (F) Nasal rasp; (G) Mallet

Rotary Instruments: Handpiece, Burs and Saws

It is a quicker method of bone removal by drilling the bone at high speeds and also used for sectioning of teeth. Burs are rotary instruments that cut the bone and teeth. They are made up of either stainless steel or carbide. They are available in different lengths, shapes (fissure, round, tapering fissure) and sizes. Bur is used along with high-speed handpiece. No. 557, 703 fissure bur, and No. 8 round bur are usually used.

Uses

- To round off sharp margins after extractions, minor surgical procedures
- To aid in bone removal or splitting the tooth, during disimpaction procedure
- To round off sharp ridges during alveoloplasty procedures
- To perform osteotomy cuts
- To release bony ankylosis
- To make a bony window for access to cystic cavities, tumors
- To perform resection of the maxilla, mandible.

Gigli's Saw

The armamentarium for the use of Gigli's saw are:

- Gigli's saw
- Two handles
- Introducer
- Guide.

The Gigli's saw is made by twisting a few pieces of wires together so that it acquires a sharp, barbed, cutting edge when moved to and fro along its long axis. At the end there is a ring to which the hook of the handle can be fitted. In maxillofacial surgery, the saw was usually used to cut the mandible (hemimandibulectomy procedures).

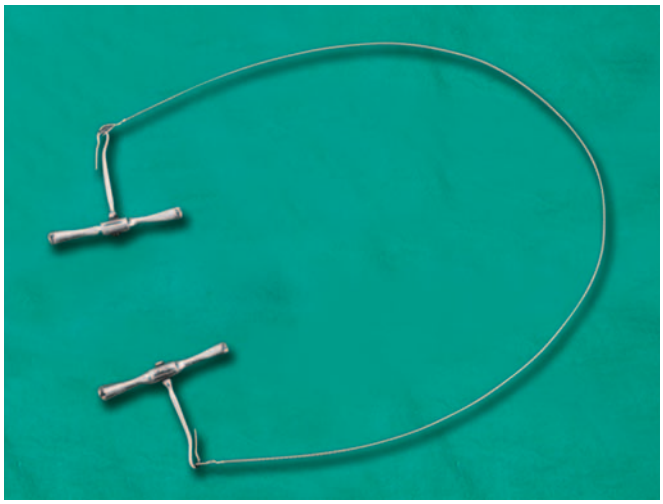


Fig. 4.12: Gigli's saw

Care must be taken to protect the soft tissues, while using this instrument **(Fig. 4.12)**.

INSTRUMENTS USED TO SUTURE THE SOFT TISSUES: SKIN, MUCOSA, ETC.

Mayo-Hegar Needle Holder

The needle holder is a straight instrument with a short, stout working tip. The blade of the needle holder is shorter and stronger than that of the hemostat. The working tip or beak has cross-hatched serrations with a single vertical serration to grip the needle. The cross hatching eliminates twisting/turning of the needle and holds the needle with positive grip and without damaging the needle. The length of the beaks is equal to the length of the box joint. The handle has a catch. Usually, a 6-inch or 15 cm needle holder is used in oral surgery. It is used to hold or grasp the curved suturing needle during suturing the tissues. The instrument is held between the ring finger and the thumb and the index and the middle finger support the needle holder **(Fig. 4.13A)**.

Suture-cutting Scissors (Dean's)

They are used for cutting the suture ends. They can be straight or curved, and angulated or nonangulated. The angulation may be at the joint or at the tip to facilitate access to the posterior areas of the oral cavity. They have long delicate handles and a short-cutting edge. Some needles have hook-shaped point on one blade, which is used to engage the suture before cutting it **(Fig. 4.13B)**.

Tissue Holding Forceps

Tissue holding forceps (Micro Adson, Gillie's, Adson's) **(Figs 4.13C and D)**.

- Plain
- Toothed.

They are used to hold the tissues during the process of dissection or suturing. Plain tissue holding forceps have serrations on the inner aspect of the tip to aid in a better grip.

Uses

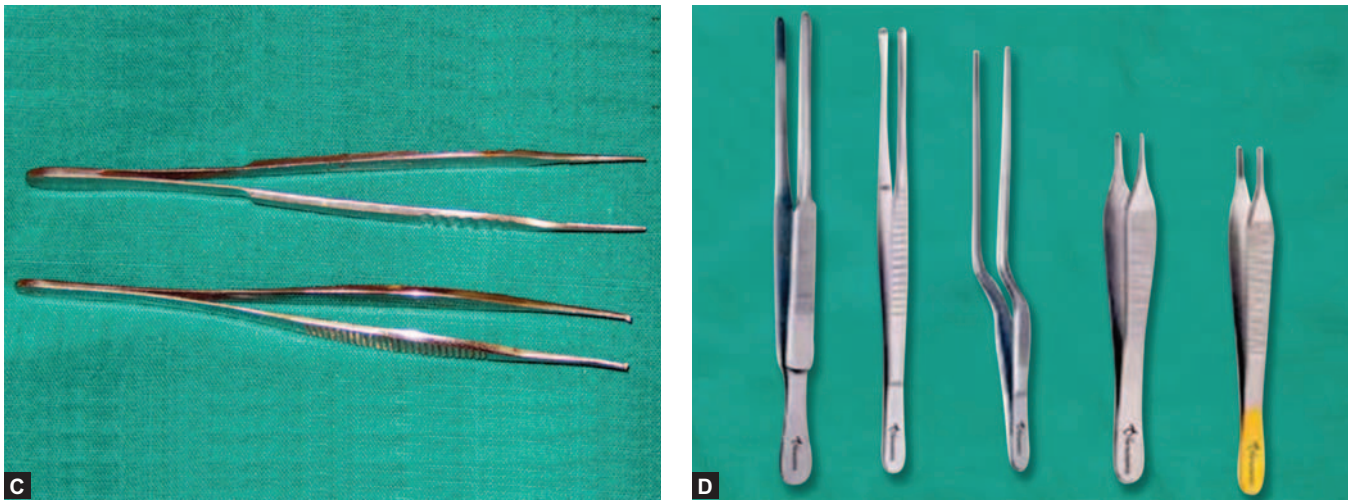
- The plain forceps having no tooth at the tip and are used for holding delicate structures, like the peritoneum, fascia, delicate muscles and facial skin.



Fig. 4.13A: (A) Mayo-Hegar needle holders (Inset: Serrations and slot created on the inner aspect of the tip to acquire proper grip of the needle)



Figs 4.13B: B-1. Dean's suture cutting scissors; B-2. Curved pointed tip on one blade of suture-cutting scissors



Figs 4.13C and D: (C and D) Adson's tissue holding forceps—without teeth and with teeth (*Inset*: Different designs of Adson's tissue holding forceps)

- The plain forceps are also used to hold blood vessels or nerves.
- The toothed forceps are used to hold tough structures, like the aponeurosis and coarse muscles, keratinized tissues. They are never used to hold the skin.

MISCELLANEOUS INSTRUMENTS

Lister Bandage-cutting Scissors

These scissors are designed in such a way that one blade is shorter than the other blade and the long blade is with blunt tip, so that when it is placed under the bandage, it does not hurt the patient. It is used to cut the gauze and bandages and adhesive tapes, while dressing the wound **(Figs 4.13E)**.

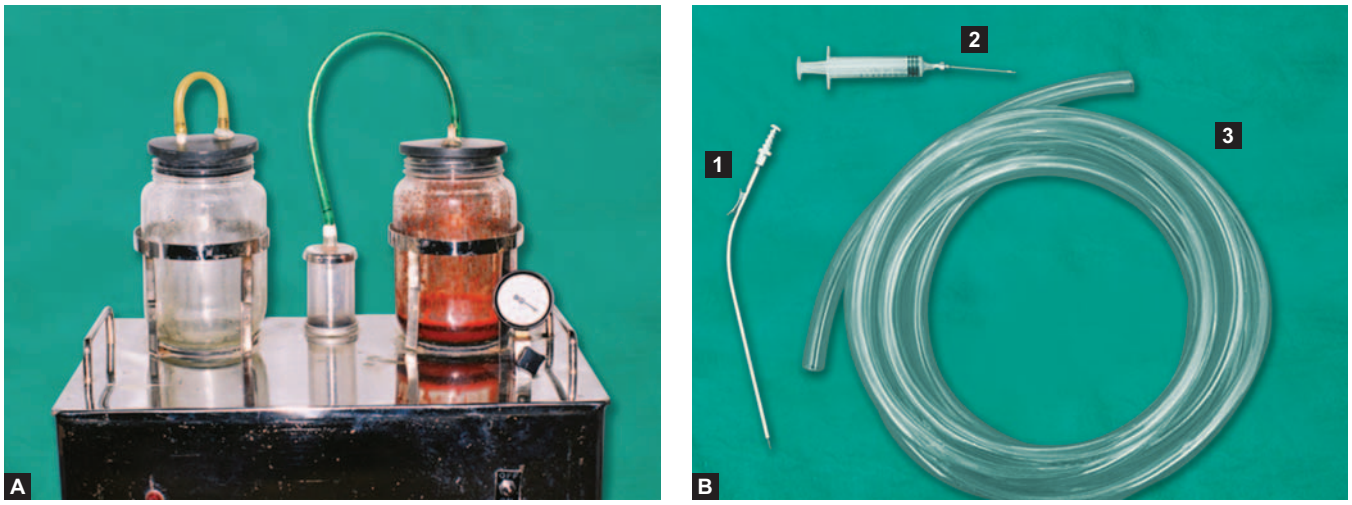
INSTRUMENTS USED TO MAINTAIN A CLEAN SURGICAL FIELD

Suction Apparatus

The commonly used suction apparatus is the vacuum pump suction apparatus. It is electrically operated with the help of a motor. It can be mounted on a trolley and moved around. A single or two bottles can be connected **(Fig. 4.14A)**.



Fig. 4.13E: Lister bandage-cutting scissors



Figs 4.14A and B: (A) Suction apparatus; (B-1) suction tip; (B-2) disposable syringe and needle; (B-3) rubber tubing for suction

Suction Tip (Frazier, Nuober) or Cannula

These are the instruments which are introduced into the surgical field for maintaining a clean field by sucking away blood, flushing solution, debris, cystic fluid, pus and secretions. Frazier suction tip has a blade in the handle for better control and a hole to control the suction speed. A stillet is provided to clean the lumen if there is clogging. The tip may be straight or angulated. A no. 4 or no. 5 tip is commonly used in oral surgery **(Fig. 4.14B-1)**.

Suction Tubing

It is connected to the suction apparatus at one end and the suction tip on the other end. It can be made up of India rubber or silicone polymer. The latter is better as it is transparent and can be autoclaved **(Fig. 4.14B-3)**.

INSTRUMENTS USED FOR THE TREATMENT OF FRACTURES OF THE JAW BONES: MAXILLOFACIAL TRAUMA CARE

Armamentarium for Performing Tracheostomy Procedure

Tracheostomy Set

A tracheostomy set consists of **(Fig. 4.15A)**:

- Tracheostomy tube
- Sharp hook
- Blunt hook
- Tracheal dilator.



Fig. 4.15A: Armamentarium used for performing tracheostomy: (a) Swab holder; (b) Suction tip; (c) BP blade; (d) Adson tissue-holding forceps; (e) Tissue dissecting scissors; (f) Hemostats (various sizes); (g) Blunt hook; (h) Tissue retractors; (i) Tracheal dilator; (j) Needle holder; (k) Metal tracheostomy tubes; and (l) Disposable tracheostomy tubes

Tracheostomy Tube

A tracheostomy tube (Jackson's tube) is a curved tube, which is inserted into the surgical opening made in the trachea (tracheostomy stoma) for airway management. The main function of this tube is to allow air/oxygen entry through a tracheostomy wound. There are different types of tracheostomy tubes available **(Figs 4.15A to C)** and can be broadly classified as: metallic or nonmetallic [Portex®, silicone and polyvinyl chloride (PVC) based]

- Reusable or disposable
- With cuff or without cuff.

A metal tracheostomy tube cannot be left in position for more than 48 hours. The Portex® tubes are disposable and can be maintained for indefinite periods. They have a cuff that can be inflated to stabilize the tube in position in the trachea, especially during the administration of general anesthesia. A cuff kept inflated for a long time may cause pressure necrosis of the trachea. The tube is withdrawn when there is no further evidence of airway obstruction.

A commonly used tracheostomy tube consists of three parts: (i) outer cannula with flange (neck plate), (ii) inner cannula, and (iii) an obturator **(Fig. 4.15B)**. The outer cannula is the outer tube that holds the tracheostomy open. A neck plate extends from the sides of the outer tube and has holes to attach ribbon ties or velcro strap around the neck. The inner cannula fits inside the outer cannula. It has a lock to keep it from being coughed out, and it is removed for cleaning. (If the inner tube is blocked, it can be removed and cleaned and the outer tube can be left in position). The curvature of the tube is such that it does not damage the trachea. There are rings at the base of the inner tube that can either be used to pull the inner tube or to stabilize the tracheostomy tube with loose cords tied around the neck. The obturator is used to insert a tracheostomy tube. It fits inside the tube to provide a

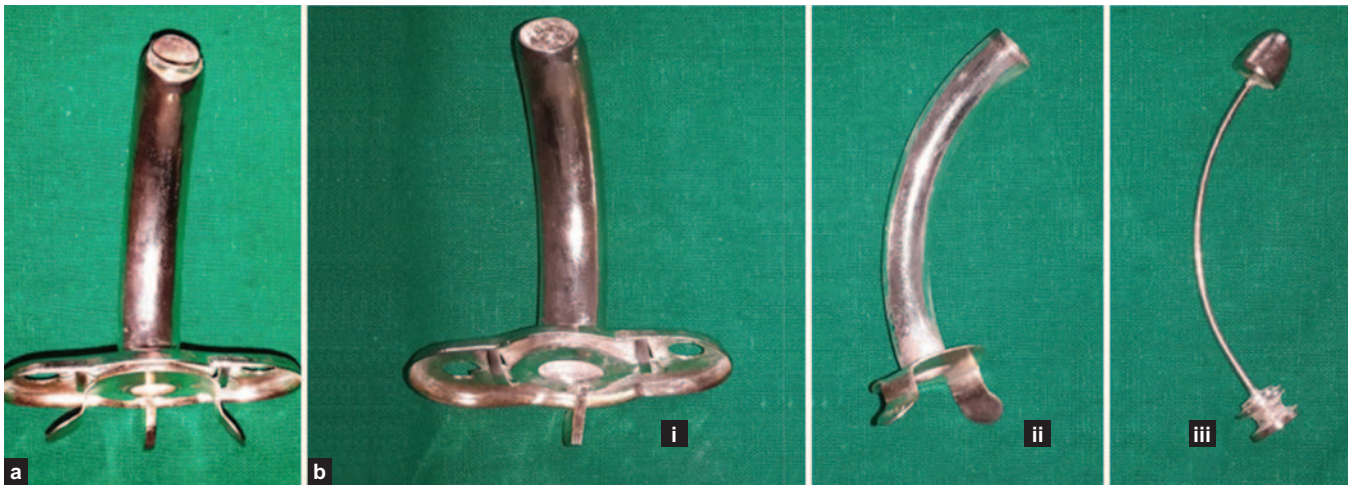


Fig. 4.15B: (a) Reusable metallic tracheostomy tube; (b) Parts of the tracheostomy tube; (i) Outer cannula; (ii) Inner cannula; and (iii) obturator



Fig. 4.15C: Disposable portex set

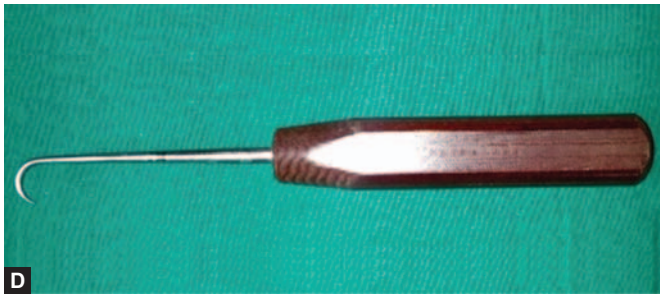


Fig. 4.15D: Sharp hook



Fig. 4.15E: Blunt hook

smooth surface that guides the tracheostomy tube, while it is being inserted.

Sharp Hook

This instrument is used for stabilizing the trachea, while making a stab wound on it, as during respiratory obstruction, the trachea tends to move rapidly up and down. The sharp hook is inserted just below the cricoid cartilage **(Fig. 4.15D)**.

Blunt Hook

The blunt hook is used for retracting the isthmus of the thyroid upwards while performing a tracheostomy **(Fig. 4.15E)**.

Tracheal Dilator

This instrument is meant for dilation of the stab incision given over the trachea to facilitate introduction of the tracheostomy tube. The blades of the instrument are opened when the handles are brought together **(Fig. 4.15F)**.



Fig. 4.15F: Tracheal dilator

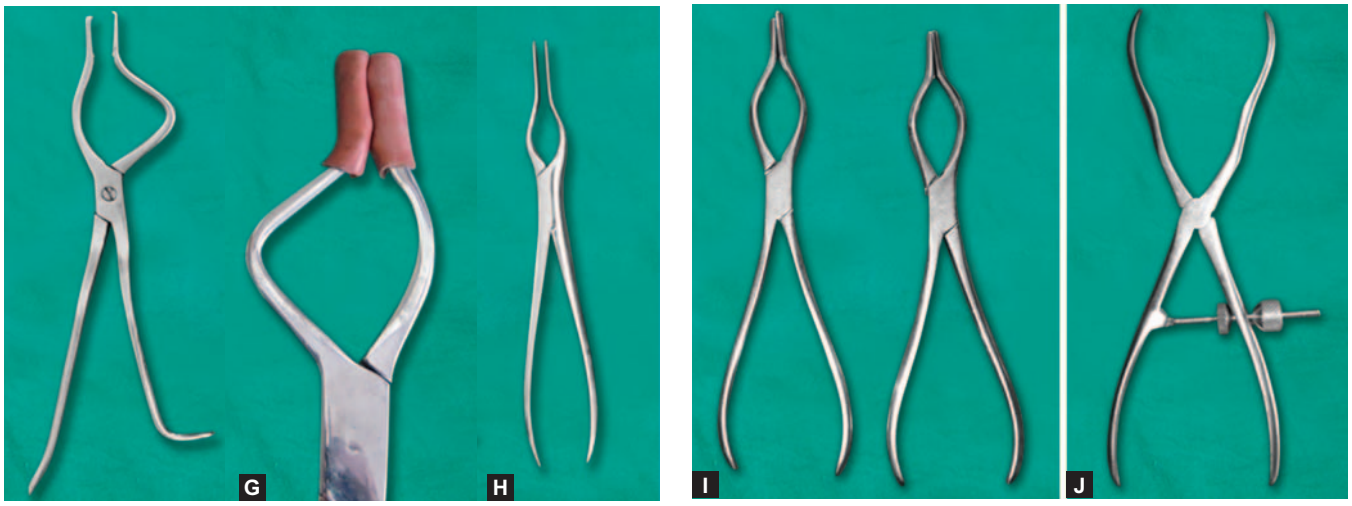


Fig. 4.15 G to J: (G) Rowe's Disimpaction forceps; (H) Asche's nasal bone reduction forceps; (I) Walsham`s forceps; and (J) Hayton William`s forceps

Rowe's Maxillary Disimpaction Forceps

A pair of Rowe's disimpaction forceps is used for disimpacting the maxilla in LeFort fractures. It consists of one straight and one curved blade. The blades are padded for atraumatic purpose. The straight blade is passed into the nostril and the curved blade enters the mouth and grips the palate. The V-shaped curvature on this curved blade accommodates maxillary anterior teeth. The operator stands behind the patient and grasps the handles of each of the forceps and manipulates the fragments into position **(Fig. 4.15G)**.

Uses

- To disimpact the maxilla in fresh LeFort fractures, malunited fractures
- To check for free movements of the maxilla after LeFort osteotomy procedure.

Hayton-William's Forceps

This forceps has two widely divergent curved beaks that engage the maxilla behind the tuberosity. It is usually used in conjunction with the Rowe's maxillary disimpaction forceps to mobilize the maxilla **(Fig. 4.15H)**.

Walsham's Forceps

It is used to manipulate the fractured nasal fragments. The forceps has a padded blade and an unpadded blade that are curved. The unpadded blade of the Walsham's forceps is passed up the nostril, and the nasal bone and the associated fragment of the frontal process of the maxilla are secured between the padded blade externally and the unpadded blade internally. The fragments are then manipulated in their correct position **(Fig. 4.15I)**.

Asche's Forceps

The Asche's nasal septal forceps has long and narrow blades. It is used to reduce the fractures of the nasal bone and to align the nasal septum. The blades are passed on either side of the nasal septum and the vomer and the perpendicular plate of the ethmoid is ironed out. If possible, the septal cartilage is then grasped and repositioned in its groove in the vomer. To reduce the nasal bone fracture, one blade is inserted in the nostril, holding the medial aspect of the nasal bone and the other blade is kept externally holding the lateral aspect of the nasal bone **(Fig. 14.15J)**.

Wire Holder

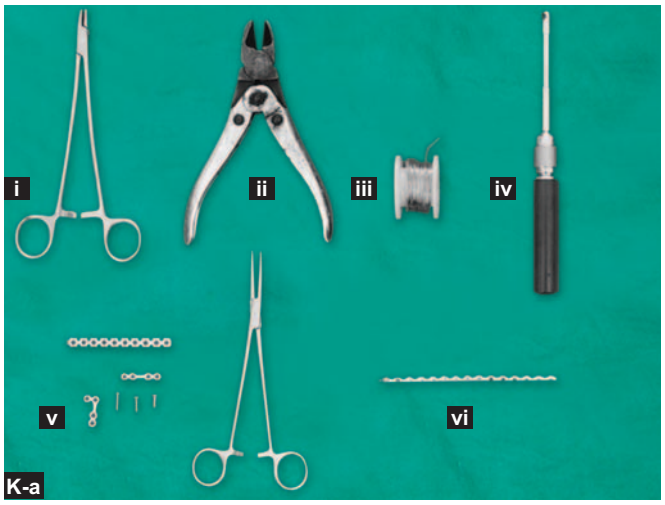
A wire holder is similar to a needle holder, except that it has a heavy tip, which may be devoid of the vertical serrations **(Fig. 4.15Ka-i)**.

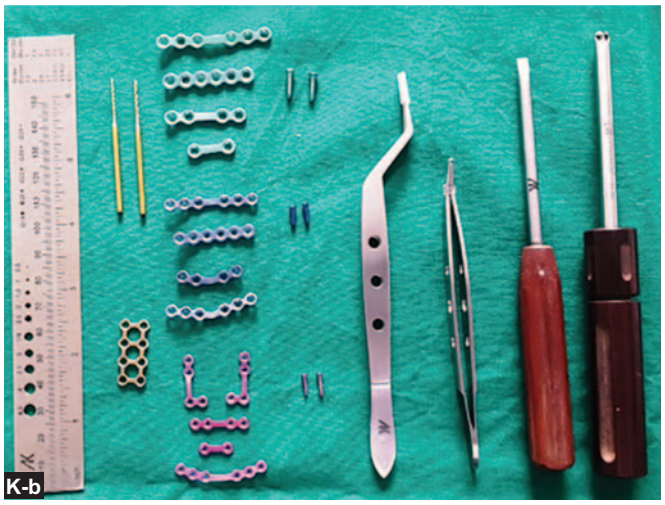
Wire Cutter

Usually a 26-G wire spool is used in oral surgical procedures **(Fig. 4.15Ka-ii)**.

Uses

- To stabilize dentoalveolar fractures







Figs 4.15K: (a) (i) Wire holder, (ii) wire cutter, (iii) wire spool, (iv) screw holder, (v) bone plates and screws, (vi) Erich's arch bar; (b) Ruler, drill bits, different bone plates, screws, screw holders; (c) Plate benders

- To perform intermaxillary ligation
- To splint the arch bar to the teeth
- Fixation of fractures by transosseous wiring
- Indirect fixation of fractures by suspension wiring.

Bone Plates

Bone plates are usually made up of stainless steel or titanium. They are available in various sizes, lengths and shapes. In oral surgery, the thickness of the plates varies from 1.5 mm to 2–2.5 mm. 2.5 mm plates are usually used for the mandible, whereas the former two are used for the maxilla. Depending on the requirement, they are available in different lengths, 2 holes, 3 holes, 4 holes, 6 holes, etc. and in different shapes—orbital, L-shaped, T-shaped, etc. **(Fig. 4.15Kb)**.

Erich's Arch Bar

It contains a thin stainless steel strip that has hooks incorporated on it. It is malleable and can be adapted to the contour of the maxillary or mandibular arch and fixed to the teeth by wires **(Fig. 4.15Ka-vi)**.

Uses

- To stabilize dentoalveolar fractures
- To stabilize mandibular or maxillary fractures that are to be treated by closed reduction
- To provide means for intermaxillary ligation.

Nerve Hook

Nerve hook is similar to a bone awl, except that it has a relatively blunt tip with a broad curve at the tip. The tip has an eye through which a suture can be passed **(Fig. 4.16A)**.

Uses

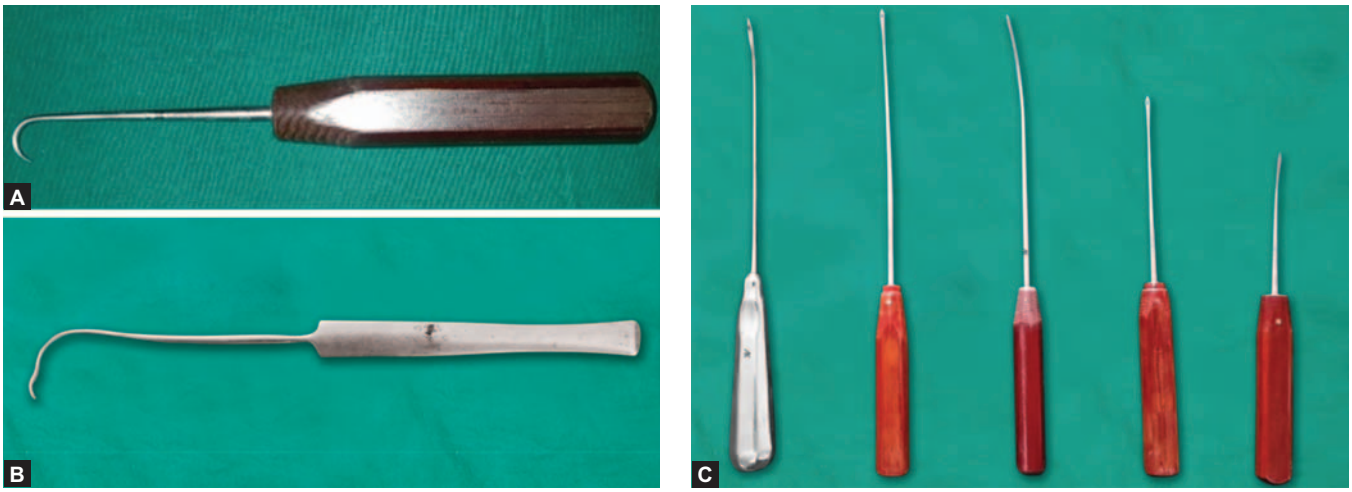
It is used in neurectomy procedures to tie the nerve for identification.

Aneurysmal Needle

Similar to the nerve hook, the aneurysmal needle has a blunt tip. The tip has an eye, through which a suture can be passed. The needle is used to pass a suture around a larger blood vessel and ligate it **(Fig. 4.16B)**.

Bone Awl

Bone awl is available in different lengths, straight or curved. It has got sharp, triangular tip for penetrating the skin.



Figs 4.16A to C: (A) Nerve hook; (B) Aneurysmal needle; (C) Bone awls

The tip has got eye, through which wire is carried for circumferential wiring or peralveolar, circumzygomatic wiring technique **(Fig. 4.16C)**.

INSTRUMENTS USED DURING ORTHOGNATHIC SURGERY

The instruments which are used in trauma care surgery are also useful in orthognathic surgery, as osteotomies are intentional sectioning of the jaw bones, and they need to be fixed just like fractured bone fixation. However, some of the dedicated instruments are designed for various osteotomy procedures.

Sigmoid/J-Hook/Sigmoid Retractors

They are useful in depressing the ramus during extraoral subsigmoid ramus osteotomy. It is placed at sigmoid notch to depress the ramus and also to stabilize it during osteotomy cuts **(Fig. 4.16D)**.

Ramus Stripper or Ramus Retractor

Ramus stripper or ramus retractor is used during intraoral osteotomies of ramus, coronoidectomy procedure, etc. The anterior border of the ramus is stripped off the temporalis attachment with the help of these instruments **(Fig. 4.16E)**.

Chin Retractor

The C-shaped blade is designed to engage the inferior border of the symphysis region, during genioplasty procedures **(Fig. 4.16E-ii)**.

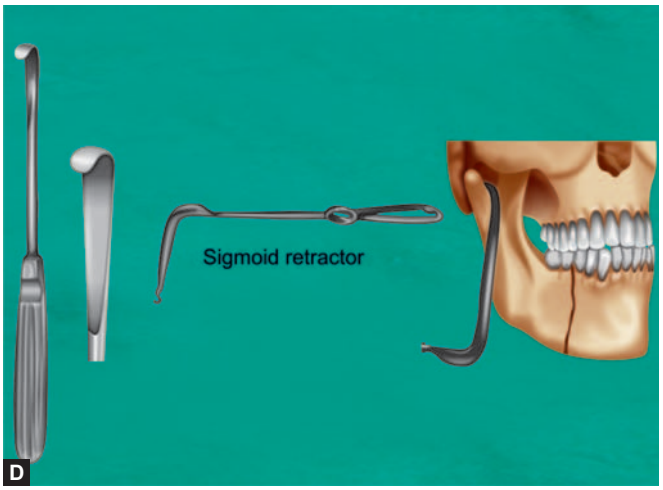


Fig. 4.16D: J-hook and sigmoid retractor to engage sigmoid notch

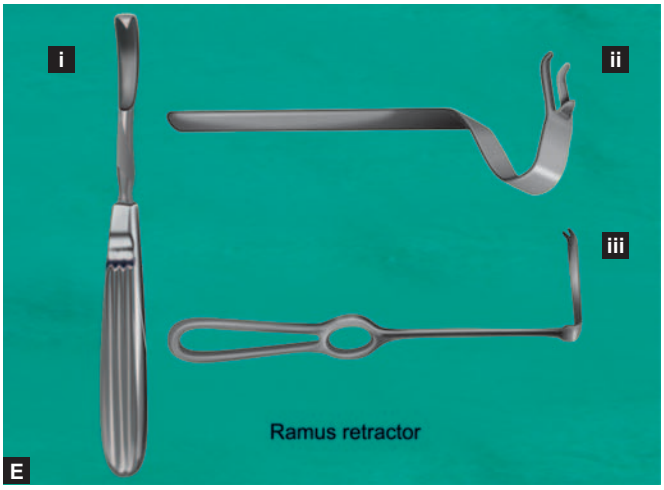


Fig. 4.16E: (i) Ramus stripper; (ii) Chin retractor; (iii) Ramus retractor

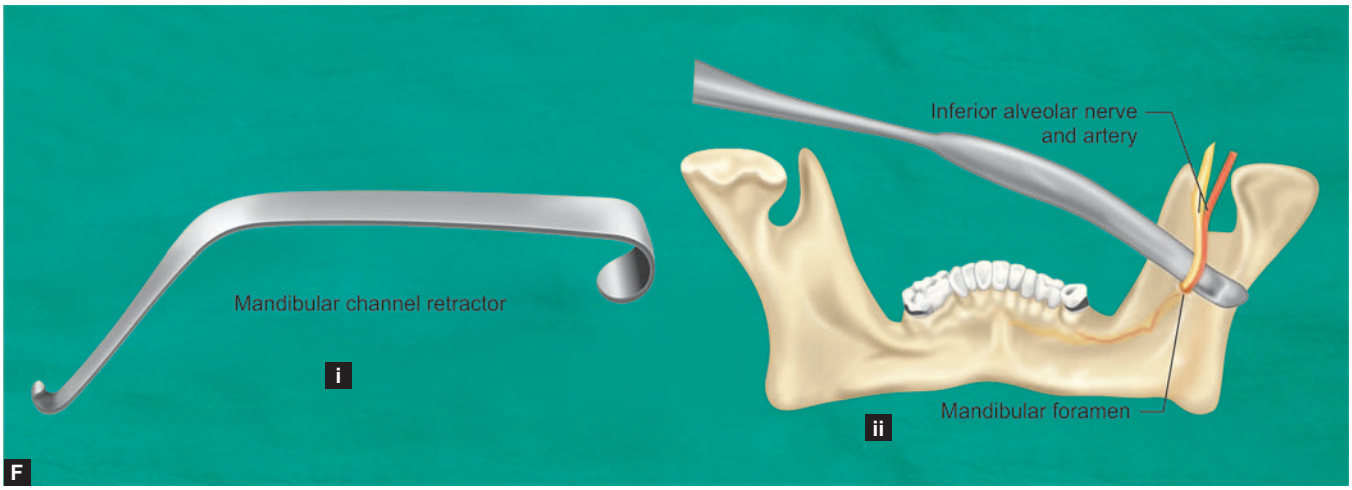


Fig. 4.16F: (i) Mandibular channel retractor; (ii) diagrammatic representation of use of channel retractor during sagittal split osteotomy

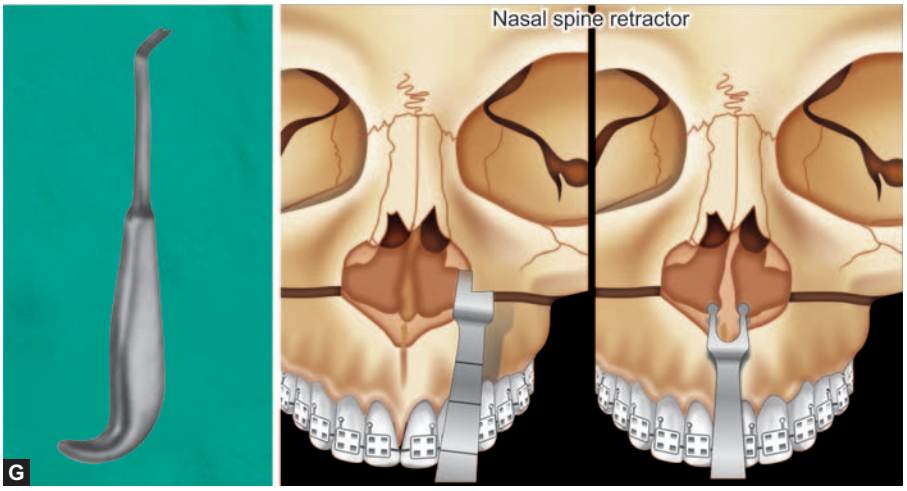


Fig. 4.16G: Nasal spine/septum/retractor separator

Mandibular Channel Retractors

These are double-ended retractors used during sagittal split osteotomy procedure **(Fig. 4.16F)**.

Nasal Septum Separator or Nasal Spine Retractor

Nasal septum separator or nasal spine retractor is used during LeFort osteotomy procedure to separate nasal septum or spine and base of the lateral nasal walls from the dentoalveolar segment **(Fig. 4.16G)**.

Bone Spreader

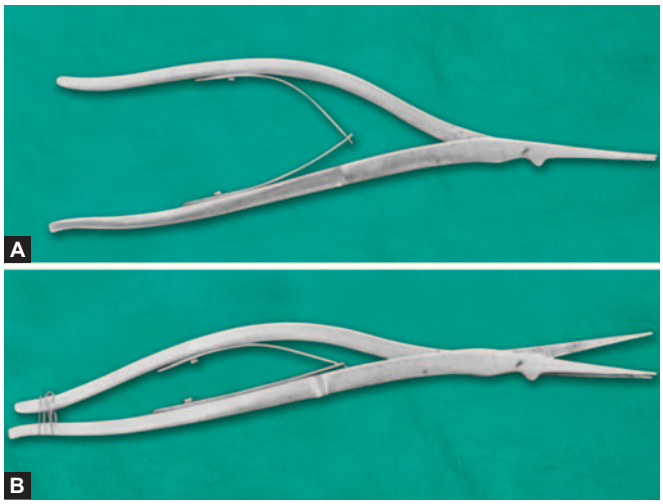
Smith's bone spreader has three blades that are separated by spring action when the handles are compressed. It is used to separate the bony fragments after completion of the osteotomy cuts, like in down-fracture of maxilla after LeFort I osteotomy or during sagittal-spilt osteotomy procedure **(Fig. 4.17)**.

SURGICAL DRAINS USED IN ORAL AND MAXILLOFACIAL SURGERY

Surgical drainage is the provision of removal of unwanted harmful contents—pus, blood or other fluids of body organs, cavities or tissues by mechanical means.

Need for Establishing Drainage

- Obliteration of dead space



Figs 4.17A and B: Smith's bone spreaders

- Removal of material which is foreign or harmful to the body tissues
- To evacuate fluid/blood/urine collection in any body cavity.

Indications for Drainage

- Abscess cavities with thick, shaggy walls that must collapse and heal from the deepest portions
- Surgical defects where postoperative collection of blood or inflammatory fluid is expected.
- Urinary retention
- Gastric lavage in case of poisoning, intraoperative ingestion of blood during general anesthesia
- Osteomyelitic lesions where drainage is established for inflammatory exudate and necrotic tissues.

Functions

- To allow for pus, fluid collection, blood to escape from the body cavities
- To allow for local introduction of antibiotics, antimicrobials.

Different Types of Tubings Which can be Used as Drains

- Simple rubber catheter (Penrose drain)
- Corrugated rubber drain
- Infant feeding tube
- Foley's catheter
- Nasogastric (Ryle's) tube **(Fig. 4.18A)**.

Penrose Drain

It is a simple rubber tube, open at both ends that can be used for drainage of abscess cavities, hematomas, etc. One end is inserted into the area to be drained and other end is left out on the skin and secured with sutures. It cannot drain against gravity and the drained fluid amount cannot be measured.

Infant Feeding Tube

Infant feeding tube is made up of nontoxic, radio-opaque, PVC. It is a long tube with a blunt tip with multiple openings for facilitating drainage. The other open end has a stopper that can be closed **(Fig. 4.18A-i)**.

The drain is inserted into the dead space and can be either removed externally through the incision line or through a separate incision away from the incision line. Most operators prefer the latter. A negative pressure can be established within the space by attaching and aspirating a 20 cc syringe to the open end. The syringe must be emptied at regular intervals. The drain is fixed to the skin by sutures. It can be removed in 3–5 days depending on the amount of drainage. It can also be used for local instillation of antibiotic solutions in deep wounds.

Corrugated Rubber Drain

It is a sheet of rubber with corrugations on its surface. It is usually used as a drain following abscess drainage. Multiple holes are usually made in the drain to prevent the drain from getting obstructed. The drain is inserted with one end in the cavity and the other end is kept out of the skin or mucosa. The drain is secured by sutures and is left in place for 3–5 days **(Fig. 4.18A-ii)**.

Foley's Self-retaining Catheter

It is a self-retaining catheter used for evacuating the bladder. The self-retaining mechanism is in the balloon near its tip. At the other end of the catheter two tubes are present. The wider tube is meant for draining the urine, while the narrower tube communicates with the balloon and is meant for inflating and deflating the balloon. The catheter is passed through the urethra in either sex, into the bladder. The position is confirmed by the free passage of urine through the wider tube. Then the catheter is anchored within the bladder by inflating the balloon via the smaller tube, by injecting 5 mL of distilled water. When the catheter is to be withdrawn, the water is aspirated through the narrower tube. The catheter is available in

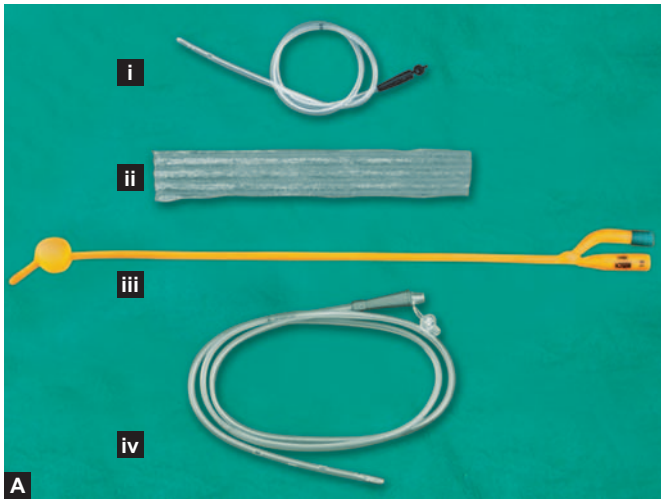


Fig. 4.18A: (i) Infant feeding tube; (ii) Corrugated rubber drain sheet; (iii) Foley's catheter; and (iv) Ryle's tube

various sizes. The commonly used size for males is no. 16 and for females is no. 14 **(Fig. 4.18A-iii)**.

Indications in Oral and Maxillofacial Surgery

- For evacuation of the bladder in long cases under general anesthesia
- For evacuation of the bladder in unconscious patients
- For patients with postoperative urinary retention
- For nonambulatory patients with multiple fractures
- Foley's catheter may also be used as a retention stent in comminuted zygomatic complex fractures. The balloon is inflated within the maxillary sinus to offer support to the bony fragments and left in position for 5–7 days till initial stabilization.

Nasogastric Tube (Ryle's Tube)

Nasogastric tube is a long hollow tube with one blunt end with multiple side openings for drainage and an open end. It is made up of Polyvinyl chloride (PVC). Length available is 105–110 cm. Four markings—(1) 40 cm at gastroesophageal junction, (2) 50 cm at body of stomach, (3) 60 cm at pyloric region and (4) 70 cm at first part of duodenum. Diameters indicating numbers can be 10, 12, 14 and 16. The blunt end is passed through the nostril into the stomach. To check the position of the tube, air is pushed into the tube with the help of a syringe and the air entry into the stomach is checked with the help of a stethoscope. Only after confirmation of the presence of the tube into the stomach, the feeds are started. The tube is fixed to the nose with the help of sticking plaster **[Figs 4.18Bi and ii]**.

Uses

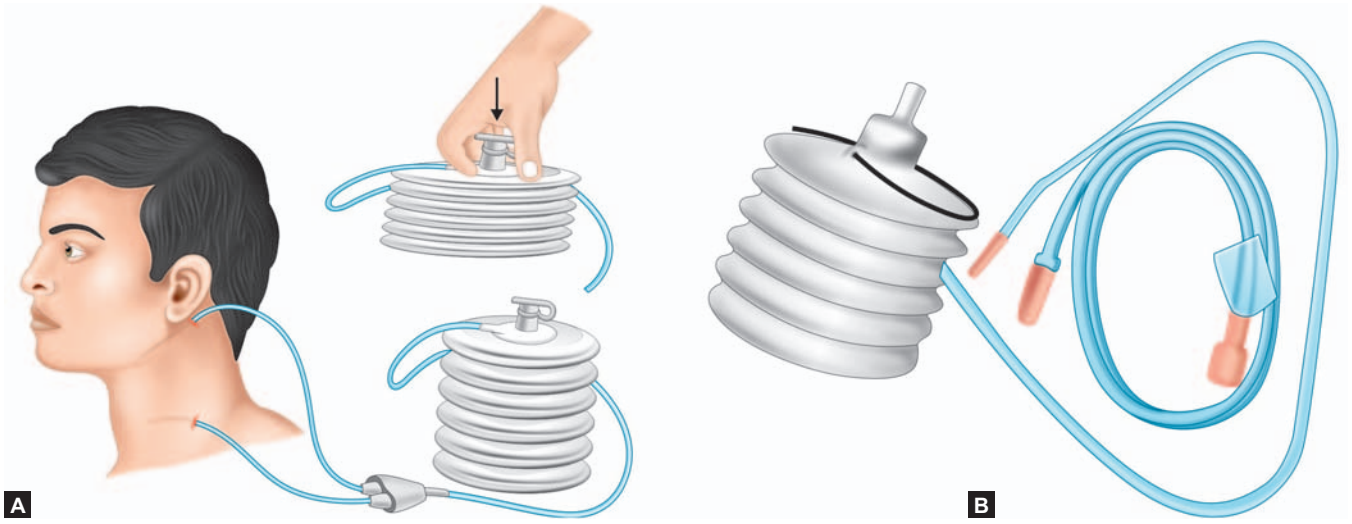
- To provide feeds to the patients who cannot take oral feeds
- To provide gastric lavage postoperatively to flush out blood, fluids ingested intraoperatively
- To provide gastric content aspiration and lavage in case of poisoning.

Hemovac/Romovac/Readyvac (Closed Wound Suction System)

It is a negative pressure self-suction drain, which has got following parts—suction bag-capacity 800 mL, tubing system, clamp and perforated catheter with number of holes. A continuous current of air activated by suction bag



Fig. 4.18B: (i) Nasogastric tube; (ii) Patient with nasogastric tube (Ryle's tube)



Figs 4.19A and B: (A) Hemovac; (B) Romovac/Readyvac

passes up through the tube, any fluid collected near the catheter is immediately sucked away. It is placed in the wound, where blood or inflammatory fluid collection is expected in the postoperative period. Patient can be sent home with the drain still in place. For emptying the drain, the stopper or plug is removed from the spout, the hemovac container will expand and all the collected fluid from the container is poured into the measuring cup. The container is turned 2–3 times over, so that all the fluid comes out. The container is pressed till it becomes flat and stopper is placed back. This is one of the newer types of wound healing drain device which promotes faster tissue granulation, often used for large surgical/trauma/nonhealing wounds **(Figs 4.19A and B)**.

SURGICAL DIATHERMY (CAUTERY, ELECTROCAUTERY)

There are two basic types of cautery **(Fig. 4.20):**

1. Mono or unipolar
2. Bipolar.

Monopolar Diathermy

It basically consists of:

- High frequency AC generator (over 20,000 Hz)
- Regulator
- Foot control
- Indifferent electrode
- Active electrode.

The AC electrode generates a high frequency alternate current, the intensity of which is controlled by the regulator. The indifferent electrode is a flat steel plate which is put in contact with the patient's back, thigh or buttocks. The contact between the patient's skin and the indifferent electrode may be improved by either shaving that area or by using a conductive jelly. The electrode is usually wrapped with a wet cloth to improve conduction.

The active electrode or the tip touches the hemostat in which the bleeder is held. When the foot control is pressed, current is generated and discharged through the active electrode.



Fig. 4.20: Surgical diathermy (electrocautery machine): (i) Indifferent electrode plate; (ii) Active electrode tip

Principles

The large, flat steel plate or the indifferent electrode acts as the earth. The active electrode is a fine tip. Due to the large difference in the size of the two electrodes, a high current density is generated around the active electrode, resulting in a heating effect. By changing the intensity of the current, various functions are possible:

- Coagulation
- Cutting
- Fulguration.

Coagulation: Bleeding from the small vessels, viz. the capillaries, arterioles, can be controlled. The subcutaneous bleeders and oozing vessels from the incision lines are first clamped with a hemostat and then the cautery is applied. Bleeding from thin-walled veins and large arteries cannot be controlled by cauterization. They have to be ligated and then divided.

Cutting: An incision can be made by increasing the current and using a cutting tip. It is used for incising soft tissues with diffuse capillary network so that the small bleeders get coagulated as cutting occurs. It is never used for taking skin incisions.

Fulguration: Fulguration burns the tissue margins. This is useful in resecting small growths, e.g. papilloma, leukoplakia, so as to prevent recurrence.

Precautions

- Care must be taken to ensure intimate contact between the patient and the indifferent electrode. Avoid point contact.
- Avoid placement of the indifferent electrode near bony ridge.
- If ether, cyclopropane are used for general anesthesia, risk of sparking is high.
- Operator using the tip should wear rubber footwear so as to avoid accidental burn.
- Avoid contact of the tip with retractors or other metal instruments which will conduct electricity.
- Do not use near isolated vascular pedicles or nerves.

Bipolar Diathermy

This consists of an AC generator foot switch. It does not have an indifferent electrode. The AC is of low power. The active electrode is in the form of forceps, the two tips of which serve as the two electrodes. As the current generated is smaller, the bipolar diathermy can be used only for coagulation, but not for cutting. When the two ends of the forceps are brought together, a circuit is created, producing a localized current. Bipolar diathermy reduces the risk of burns, and interference with other instruments such as electrocardiogram (ECG) units pacemakers. It also reduces the risk of spark ignition of anesthetic gases.

CRYOSURGERY

It is the technique of using extreme rapid cooling to freeze and thereby destroy tissues. Rapid cooling to temperatures below freezing point produces less localized destructive effect than slow freezing which causes generalized tissue necrosis **(Figs 4.21A to C).**

- The effects of rapid freezing on the tissues are:
  - Reduction of intracellular water
  - Cellular shrinkage
  - Increased concentration of intracellular solutes
  - Cell membrane damage

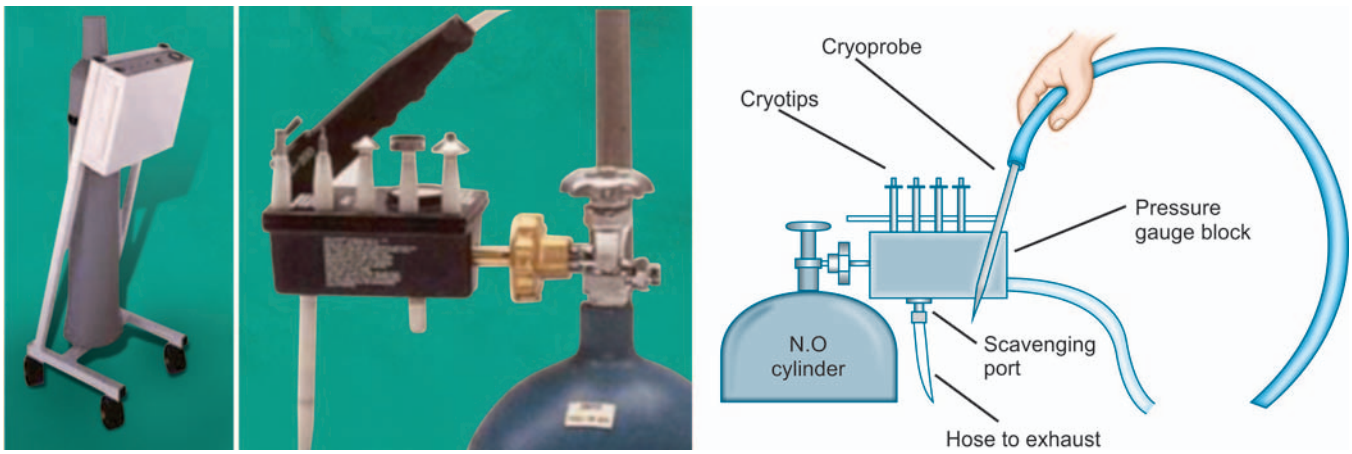
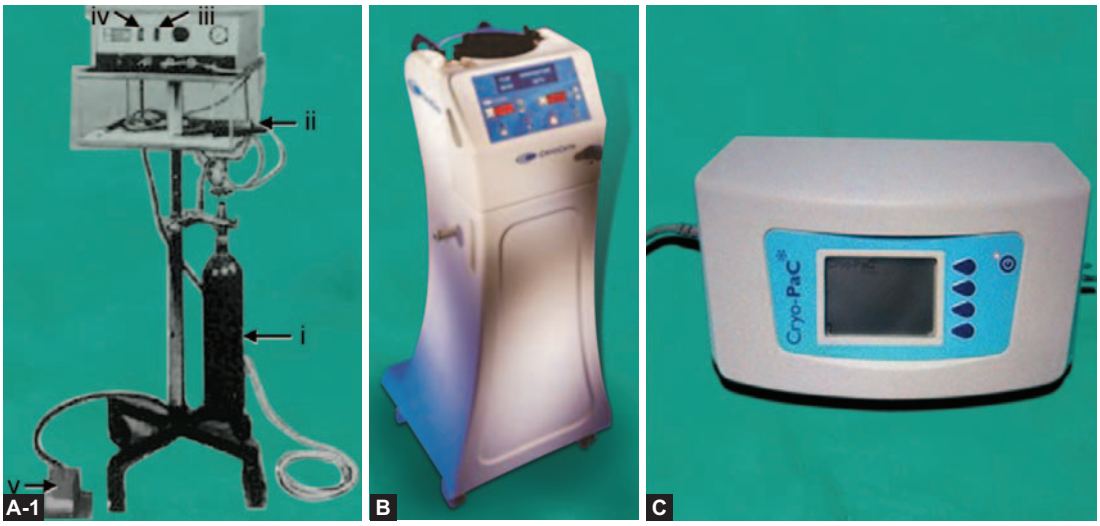


Fig. 4.21A:



Figs 4.21 A to C: (A) Old cryosurgery unit consists of: (i) Nitrous oxide cylinder; (ii) Cryoprobe, (iii) Warming cycle light, (iv) Freezing cycle light, (v) Foot switch; (B and C) New cryosurgical units

- Formation of intracellular ice crystals
- Formation of extracellular ice crystals.

- The apparatus consists:
  - Bottles for storage of pressurized liquid gases. Liquid nitrogen gives a temperature of –196°C, while liquid carbon dioxide, or nitrous dioxide give a temperature between –20°C and –90°C
  - A pressure and temperature gauge
  - A probe: The probe is connected to the bottles via tubing through which the pressurized gas can be directed at the tissue to be destroyed.

Following freezing, the tissues are thawed and refreezed. Alternate cooling and thawing destroys the tissues. The time and temperature for cryotherapy is determined by the depth and extent of the tumor.

It is applied in the treatment of malignancies, vascular tumor, and aggressive tumors, like ameloblastoma.

Points to Remember

- Instrument used for picking up and transfer of sterile instruments
- Instrument used for preparing the surgical field
- Instrument used for holding the drapes
- Instruments used for incising the soft tissues
- Instruments used for retracting the soft tissues
- Instruments used for reflecting the mucoperiosteal flap
- Instruments used for holding the soft tissues/ instruments used for achieving hemostasis
- Instruments used to keep the mouth open

Contd...

Contd...

- Instruments used to drain an abscess
- Instruments used to remove pathologic tissue
- Instruments used to hold the bone
- Instruments used to cut or remove bone
- Instruments used to suture the tissues
- Miscellaneous instruments
- Instruments used to maintain a clean surgical field
- Instruments used for the treatment of fractures of the jaw bones
- Drains used in oral and maxillofacial surgery
- Surgical diathermy (cautery, electrocautery)
- Cryosurgery
- Instruments used for the extraction of the teeth and root remnants.

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CHAPTER 5

Suturing Materials and Techniques

INTRODUCTION

Any surgical procedure involves the creation of a wound and subsequent closure by repositioning or reapproximating and securing the surgical flaps by suturing to allow optimum healing.

A suture is a strand or thread of material used to approximate tissues and also to ligate blood vessels. To suture is the act of sewing or bringing tissues or flaps edges together and holding them in apposition until normal healing takes place. Sutures also help the wound to withstand normal functional stresses and to resist wound reopening.

HISTORICAL BACKGROUND

The first description of sutures used in operative procedures is recorded by Edwin Smith Papyrus dated 16th century BC. The first great Arabian, Rhazes started his life as a story teller and later on he turned to medicine in 900 AD. He was credited with first employing "*kitgut*" to suture abdominal wounds, which was the natural material for a lute player to choose (the Arabic word *kit* means a dancing master's fiddle, the musical strings of which were made up of intestines of sheep). The word gradually evolved into "catgut" or "surgical gut." Many different materials have been used as ligatures and sutures through centuries, e.g. horse hair strands, pig's bristles, gold/silver wires, silk, silkworm gut, linen, cotton (flax) and the tendons and intestinal tissues of various animals.

By 1900, the catgut industry was firmly established in Germany due to the use of sheep intestine in their sausage industry. In 1902, Claudius established iodine sterilization of the suturing material. The development of synthetic absorbable sutures began in 1931 with the production of an absorbable synthetic fiber of polyvinyl alcohol.

Classification

Sutures can be broadly classified depending on their size, thickness, resorbability, number of filaments, making process, etc. into following types:

- **Absorbable:** All suture materials that are digested by the body enzymes or are hydrolyzed by the tissue fluids are absorbable. **They can be further classified into natural and synthetic**.
- **Nonabsorbable:** Sutures that cannot be digested by tissue enzymes and are encapsulated or walled off are nonabsorbable. **Nonabsorbable suture materials can also be classified into natural, metallic and synthetic.** These **can be further divided into monofilament and multifilament type in each category**.
  - **Monofilament type:** It is made up of a single strand, resists harboring microorganisms and ties smoothly. It is to be handled delicately without any damage to the strands to avoid breakage postoperatively.
  - **Multifilament type:** It consists of several filaments twisted or braided together into a single strand. This gives good handling and tying characteristics. As this type of suture can harbor bacteria, it is not suitable in the presence of contamination and infection. **They can also be classified as natural and synthetic (Table 5.1)**.
- **Coated or noncoated:** Some sutures like polyester sutures are usually coated with a biologically inert nonresorbable compound. This highly effective lubricant provides a thin coating, which dramatically reduces the surface friction of the braid, which aids the thread in passing more easily through the tissues. This coating, however, makes knot security an issue, as the material will easily untie if not secured with a surgeon's knot.

Table 5.1: General information about suture materials

Sl. No.	Suture	Classification	Raw material	Absorption rate	Tissue reaction	Contra-indication	Warnings	Uses
1.	Surgical gut	Natural, monofilament, absorbable	Collagen derived from sheep or bovine intestine			Being absorbable, it should not be used when prolonged approximation of tissue under stress is required		Suture subcutaneous tissues, ophthalmic surgery, oral surgery and can be used in the presence of infection
	Plain			70 days	Moderate		Absorbs quickly	
	Chromic			90 days	Moderate, but less in plain gut		Tendency to fray	
2.	Linen	Natural, multifilament, nonabsorbable	Staple flax fibers	Not applicable	Minimal	Poor tensile strength, cannot be used for suturing under tension	None	Ligation of superficial vessels. Mucosal suturing without stress
3.	Surgical silk	Natural, multifilament, nonabsorbable	Filament spun by the silkworm larva to form its cocoon	Not applicable	Moderate	Cardiovascular surgery	None	General, plastic and ophthalmic surgery, ligating body tissues
4.	Surgical cotton	Natural, multifilament, nonabsorbable	Staple Egyptian cotton fibers	Not applicable	Minimal	None	None	Most body tissues for ligating and suturing
5.	Surgical steel	Natural, nonabsorbable	Alloy of iron, nickel and chromium	Not applicable	Low	Should not be used with a prosthesis of another alloy	May corrode and break at points of bending, twisting and knotting	Abdominal wall and skin closure, sternal closure, retention, tendon repair, orthopedic and neurosurgery
6.	Coated VICRYL (polygalactin 910)	Synthetic, monofilament/ multifilament, absorbable	Copolymer of lactide and glycolide coated with polygalactin 370 and calcium stearate	60–90 days	Mild	Being absorbable, it should not be used when prolonged approximation of tissue under stress is required	Safety not proved in neural and cardiovascular tissues	Ligate or suture tissues where an absorbable suture is desired
7.	Poly-dioxanone	Synthetic, monofilament, absorbable	Polyester polymer	210 days	Slight	Being absorbable, it should not be used when prolonged approximation of tissues under stress is required	Absorbs slowly	Abdominal and thoracic closure, subcutaneous tissue, rectal and colon surgery, orthopedic and plastic surgery. It can be used in the presence of infection

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8.	Nylon	Synthetic, monofilament or multifilament, nonabsorbable	Polyamide polymer	Degrades at a rate of 15–20% per year	Extremely low	None	None	Skin closure, retention plastic, ophthalmic surgery and microsurgery
9.	Polypropylene	Synthetic, monofilament, nonabsorbable	Polymer of propylene	Not applicable	Minimal transient acute inflammatory reaction	None	None	General, plastic, cardiovascular surgery, skin closure ophthalmology
10.	Collagen	Natural, monofilament, absorbable	Homogeneous dispersion of pure collagen fibrils from the flexor tendons of beef	56 days	Minimal	After 10 days, only 10% of the tensile strength remains, hence cannot be used where tissue healing is slow	None	Ophthalmic surgery

- **Surgical threads are also classified by the thread diameter.** Thread materials range in diameter or thickness from 1-0 to 10-0, with the higher number of zeros, corresponding to the thinner, more delicate thread.

In dentistry, a 3-0 thread diameter is usually used to secure flaps, when a mattress suturing technique is used and then a 4-0 thread is used closer to the flap edges to coapt tension free flap edges. Thicker sutures are used for approximation of deeper layers, wounds in tension prone areas and for ligation of blood vessels.

Requisites for Suture Materials

- **Tensile strength:** In selection of a thread "tensile strength" is an important quality. Depending on the elasticity of the material, the strength will vary. Flexible materials will have a greater ability to stretch and bear stress. Adequate material strength will prevent suture breakdown and the use of proper knots for the material used will prevent untying or knot slippage.
- ***Tissue biocompatibility, low tissue irritation and reaction:*** Sutures made from organic material will evoke a higher tissue response than synthetic sutures. Tissue reaction is also directly proportional to the amount and size of the suture material used.
- **Low capillarity:** Multifilament type suture materials soak up tissue fluid by capillary action providing a rich medium for proliferation of microbes, and in turn, increasing the chances of inflammation and infection.
- **Good handling and knotting properties:** Ease of tying and a thread type that permits minimal knot slippage also influence the thread selection.
- **Sterilization without deterioration of properties:** Most of the suture materials available in packages are sterilized by dry heat and ethylene oxide gas.

PRINCIPLES OF SUTURE MATERIAL SELECTION

The selection of suture material by a surgeon must be based on a sound knowledge of the healing characteristics of the tissues which are to be approximated, thickness of the tissues to be sutured, the physical and biological properties of the suture materials, the condition of the wound to be closed as well as the biological forces exerted on the healing wound (e.g. muscle pull, swelling) and the probable postoperative course of the patient, and the interaction between the suture material and the tissues.

- **Rate of healing of tissues:** When a wound has reached maximal strength, sutures are no longer required. Therefore:
  - Various suture materials can be chosen for intraoral and extraoral use. The surgeon should select a suture that will lose its tensile strength at about the same rate that the tissues gain strength.
  - Tissues that ordinarily heal slowly such as skin, fascia and tendons should usually be closed with nonabsorbable sutures.

  - Tissues that heal rapidly, such as muscles, periosteum, may be closed with absorbable sutures.
- **Tissue contamination:** Foreign bodies in potentially contaminated tissues may convert contamination to infection. Therefore, monofilament absorbable or nonabsorbable sutures are used in potentially contaminated wounds.
- **Cosmetic results:** Where cosmetic results are important, close and prolonged apposition of wounds and avoidance of irritants will produce the best results. Therefore:
  - Use the smallest, inert monofilament suture material such as polyamide or polypropylene.
  - Avoid skin sutures and close subcuticularly wherever possible with Monocryl or Vicryl or Prolene.
  - Under certain circumstances, to secure close apposition of skin edges, skin closure tape may be used.
  - Dermabond liquid stitches provide a quick, effective and sutureless approximation of skin. It also acts as a barrier to prevent external microbial infection and gives excellent cosmetic results.
- **Microsurgical procedures:** The tissues most commonly approximated under microscope are arteries, veins, nerves, tendons, etc. The most commonly used suture is 10-0 polyamide monofilament.
- **Cancer patients:** Hypoproteinemia and chemotherapy can breakdown the wound. Synthetic nonabsorbable sutures are used. If the patient is to be irradiated in the postoperative period, monofilament polypropylene should not be used; instead, polyester should be used.
- **Wound repair in patients following irradiation:** In these patients, not only the normal healing process is delayed, but the tolerance to trauma of irradiated tissues is markedly reduced.
  - Use extremely careful and gentle surgical technique.
  - Avoid tension sutures and mattress sutures as they further increase the degree of ischemia.
  - Plan closure in layers.
  - Avoid continuous and constant pressure in irradiated tissues.
  - For fascial layer use nonabsorbable sutures, polypropylene is ideal.
- **Nutritional status:** When a patient is undernourished and hypoproteinemic, nonabsorbable sutures should be used, as tissues need to be kept in approximation for a longer period. Use of absorbable sutures may result in wound dehiscence.
- **Suture size:** The size of the suture material should be properly selected depending on the tensile strength of the tissues to be approximated and whether or not there will be flap tension or freely mobile tissues.

Biological Response of the Body to Suture Materials

The first response of the body as in any healing process is invasion of the tissue site by neutrophils. If uncomplicated by infection or trauma, the acute cellular tissue response to the suture material changes in about 3 days after implantation. The original population of neutrophils is replaced predominantly by monocytes, plasma cells and lymphocytes. Small sprouts of fragile vessels infiltrate the area, and eventually fibroblasts and connective tissue proliferate. Enzyme histochemistry has demonstrated that all the cellular changes are accompanied by the presence of a variety of enzyme patterns. Cellular enzyme activity is an important factor associated with all foreign body reactions. The level of lysosomal enzyme synthesis and function in macrophages is associated significantly with their phagocytic activity.

Assuming the same technique, tissue and other relative factors, the tissue response to all the sutures is relatively the same for the first 5–7 days. After this the response is more related to the type of suture material. Plain catgut elicits a more intense response with macrophages and neutrophils, while all the nonresorbable materials show a less intense, relatively acellular response. All sutures passing through the mucous membrane or skin provide a "wick" or pathway through which bacteria can track down and gain access to the underlying tissues. The longer the suture remains, the deeper the epithelial invasion of the underlying tissues. When the suture is removed, the epithelial tract remains. These cells may eventually disappear or remain to form keratin and epithelial inclusion cysts. The epithelial pathway may also result in the typical "railroad scar" formation.

NONABSORBABLE SUTURES

These surgical threads are fabricated either from natural, metallic or synthetic materials.

Perma-Hand Silk Suture

It is derived from the cocoon of the silk worm larvae. It is basically a protein-like keratin of hair and skin and is covered initially by an albuminous layer. This layer is removed by a process of degumming prior to making of sutures. The suture is braided round a core and coated with wax to reduce capillary action. The material has high tensile strength, which is totally lost after 2 years. Silk being a foreign protein, tissue reaction is much greater than to the synthetic nonabsorbable sutures but is less in intensity than surgical gut. Encapsulation of the silk with a fibrous capsule usually occurs in 14–21 days. Handling properties are best of all suture materials, and it knots easily and securely. It is sterilized by gamma irradiation. It is the most universally used material in dentistry as it is relatively inexpensive.

Perma-Hand Silk Suture is available as eyeless needled sterile suture in sizes 7-0 to 1-0.

Reels as non-sterile sutures are available in sizes 5-0 to 3-0.

Linen

It is made from flax and is cellulose material. It is a natural cellulose polymer. It is twisted to form a fiber to make a suture. Tissue reaction is similar to silk and the material handles and knots well. It gains 10% in tensile strength when wet and is fairly unique in this respect. It is very extensively used for tying pedicles and as ligatures.

Cotton

It is derived from the hair of the seed of the cotton plant. Like linen, it is twisted to form a suture. Tissue reaction is like silk and linen and tends to be a polymorphonuclear cellular type. It is weaker as compared to linen. Handling is not as good as silk.

Polyamides

These are better known as nylon. They are chemically extruded, and generally available in monofilament form. Passage through the tissue is easy, because of low coefficient of friction and tissue reaction is minimal. Tensile strength loss after 1 year implantation is approximately 25%. The fiber tends to be stiff for handling, although this has been improved by the addition of fluid to the suture in the packet. Nylon has a memory and hence knot security is lower than Terylene. It can be available in the braided form also. Monofilament sutures are available in sizes ranging from 10-0 to 2-0.

Polyesters

These fibers are better known as Terylene and Dacron. They are chemically extruded from a polymer and braided to form sutures. They have extremely high tensile strength, which tends to be retained indefinitely; hence it has become the suture of choice in cardiovascular surgical procedures. Teflon or e-PTFE (expanded polytetrafluoroethylene) coating to these polyester threads reduces the tendency to cut through the tissues. However, this coating causes flaking in the tissues. Therefore, Ethicon introduced Ethibond sutures which are polyester coated with polybutylate. It provides excellent bonding and does not flake in the tissues and does not increase the suture diameter.

Polypropylene

This fiber is better known as Prolene. It is a monofilament and is chemically extruded from a purified and dyed polymer. It has an extremely high tensile strength, which it retains indefinitely on implantation and has an extremely low tissue reactivity. It can extend up to 30% before breaking and is useful to accommodate postoperative swelling and thereby helps to prevent tissue strangulation. It slides through the tissues readily and is sterilized by ethylene oxide. It is nonbiodegradable. It is available in sizes from 8-0 to 1-0. It can be used for dental implant surgery, bone graft procedures, etc.

Stainless Steel

Stainless steel has an enviable reputation among nonabsorbable sutures for strength and low tissue reaction. But it needs a very exacting technique, as it can pull or tear out the tissues and necrosis can result due to too tight a suture. Barbs on the end can tear gloves, breaking sterile technique or traumatizing surrounding tissues. Kinks in the wire can render it practically useless.

NATURAL ABSORBABLE SUTURES

Surgical Gut

It is a natural polymer built up from molecules of amino acids. It is derived from the submucosa of sheep intestines or the serosa of beef cattle intestines and is over 99% pure collagen. It is absorbed by a process of enzymatic digestion by proteolytic enzymes derived from lysozymes contained within polymorphs and macrophages. Absorption rate depends on size and also on the type of the gut, whether

it is plain or chromicized, and is usually completed within 60–120 days. Tensile strength loss of the suture material is however faster than absorption. Plain surgical gut loses its tensile strength in 15 days, while chromic surgical gut loses it within 30 days. Surgical gut is supplied in a sterile fluid to keep the gut hydrated and supple. It is sterilized by gamma irradiation. Allergic reaction to surgical gut is rare now and in olden days it used to be due to iodine sterilization or due to impurities such as mucopolysaccharides, which were found due to improper cleaning process of the animal intestines.

When used intraorally, it loses most of its tensile strength in 24–48 hours, unless it is coated with a chromic compound that extends absorption up to 7–10 days and extends loss of tensile strength for up to 5 days. Surgical gut sutures may break more rapidly in patients with a very low intraoral pH. A decrease in intraoral pH may be found in metabolic disorders, Sjögren's syndrome, chemotherapy, radiation therapy, some medications like antipsychotics, diuretics, antihypertensive agents, antipsoriasis medications and steroid inhalers. Surgical gut is contraindicated in these situations. It is available with eyeless needles as well as standard sutures, in sizes 5-0 to 2-0.

SYNTHETIC ABSORBABLE SUTURES

All these sutures are superior to natural absorbable sutures and more reliable in their performance. These sutures are manufactured in the laboratory and from carbohydrates. These are polymers. A polymer is made up of a large number of molecules, called monomers, linked together to form a chain. In synthetic absorbable sutures, the linkage is broken by hydrolysis. Therefore, allergic reactions are eliminated and early absorption in hypoproteinemic conditions is possible. These can be either monofilament or braided, coated or noncoated. They can be natural in color or can be colored violet or green after drugs and cosmetics clearance. They are twice as strong as compared to natural absorbable sutures and lose their tensile strength slowly; thus helping to hold the tissues together during the critical period of wound healing. Different synthetic absorbable sutures support the wound for different time periods. They do not leave behind any foreign body after total absorption, which is by a simple process of hydrolysis and evoke minimal tissue reaction. They have excellent handling characteristics, but require a special square knotting procedure. They are sterilized by ethylene oxide. Their shelf life is 5 years and should be stored away from heat. They can be suitably selected for different tissue layers in various surgical procedures, depending on whether they are required for short, medium or long-term wound healing. They are available in full range, in varying sizes from 10-0 to 1-0 and swaged to different types of needles.

COATED VICRYL: POLYGLACTIN-910 BRAIDED SUTURE MATERIAL

- **Polyglycolic acid:** It is formed by the monomer, glycolic acid and linking it together to form a polymer, polyglycolic acid; and this comes from the family of sugars
- **Polyglactin:** It is a copolymer of lactide and glycolide. Lactic acid belongs to the same family as milk products.

In Vicryl polyglactin 910, a lactic acid monomer has been introduced in a ratio of one part to every nine parts of glycolic acid. Coated Vicryl is twice as strong as chromic catgut and retains its tensile strength up to 28 days. Thus, it scores over natural absorbable sutures during the critical period of wound healing. The coating consists of 50% polyglactin and 50% calcium stearate. In polyglactin 910 suture, the formulation is 90% glycolide, 10% lactide, while polyglactin coating is 35% glycolide and 65% lactide. The chemical similarity between the two materials ensures that the coating will bond permanently on to the basic braiding. Calcium stearate is an absorbable organic lubricant. With Vicryl suture, knots do not "lock" prematurely and snug down as desired. Coated vicryl can be used wherever an absorbable suture or ligature is required. The sterilization is by ethylene oxide process. The shelf life is five years. It should be kept away from moisture and direct heat. Coated Vicryl is available as dyed violet and as undyed beige color, in sizes ranging from 10-0 to 2-0 on different types of needles.

- **Vicryl plus:** *(*Polyglactin 910 coated, braided synthetic absorbable antibacterial suture): Vicryl plus antibacterial suture is the world's first and only antibacterial suture, which offers protection against bacterial colonization of the suture. It contains Triclosan which is a broad-spectrum antibacterial agent and effective against the most common pathogens associated with surgical site infections. Its main advantage is that it provides defence against unwanted bacteria by a zone of inhibition that stops bacterial growth. It should not be used for ophthalmic, cardiovascular and neural tissues.

- **Vicryl Rapide—Polyglactin 910 coated: braided synthetic absorbable suture:** It is identical to coated vicryl suture. The rapid absorption quality is achieved by exposure of coated vicryl to gamma irradiation, resulting in material with low molecular weight than coated vicryl. This is available only undyed (beige). It loses all its strength between 10th and 12th days and gets totally absorbed within 42 days. These sutures are intended for use in closing mucosa and skin, where only short term wound support (less than 10 days) is required. Shelf-life of Vicryl Rapide sutures is five years. It is available in sizes 3-0 to 1-0.
- **Monocryl-Polyglecaprone 25—monofilament synthetic absorbable suture:** It is composed of a copolymer of 75% glycolide and 25% caprolactone and is available undyed as well as dyed violet. It is the most pliable, flexible monofilament suture with excellent handling properties. The major benefit of this material is its predictable loss of tensile strength over 3 weeks period. This is due to systematic hydrolysis of the suture material. It is absorbed in 9–120 days. It is sterilized with ethylene oxide and ideal for subcutaneous closure. Monocryl is available in natural golden color as well as in violet color and in sizes from 5–0 to 1–0.
- **Polydioxanone (PDS) and PDS II—Polydioxanone monofilament synthetic absorbable suture:** PDS (Polydioxanone) sutures are formed by polymerizing the monomer-para-dioxanone, in the presence of a catalyst to form a strong but soft, pliable filament, which is broken down by hydrolysis in the presence of moisture.

The PDS II sutures are an improved version of the initial PDS sutures, which give wound support beyond the 4 weeks period. Total mass is absorbed between 180 and 210 days. It is available in sizes 1–0 to 6–0.

Precaution: Adhesive should not be allowed to enter the wound, otherwise foreign body reaction will delay the wound healing.

SUTURE NEEDLES

The surgical needles are of two types **(Fig. 5.1A):**

1. Eyed and
2. Eyeless.

Suture needles usually are also classified according to their curvature, radius and shape **(Figs 5.1B and C).**

The surgical needle comprises of three parts:

1. Needle eye or swaged end (press fit)
2. Needle body
3. Needle point.

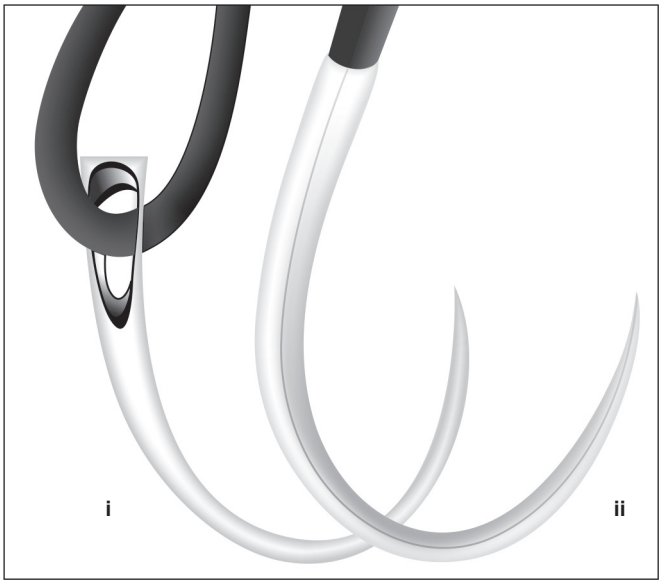


Fig. 5.1A: (i) Eyed suturing needle; (ii) Eyeless (swaged) suturing needle

Needle Eye

The eye can be closed or swaged. The closed eye is similar to the eye of the household needle. The shape of the eye may be round, oblong or square. Eyed needles must be threaded and present the disadvantage of pulling a double thread through the tissues and therefore are also known as traumatic needles. When the suture is attached to the needle via a hole drilled through the end of the needle, and the end is swaged during manufacture, it is called a swaged suture. These are also known as atraumatic needles.

Advantages of Eyeless Needles

- Less trauma to the tissues since a single strand of suture material has to be drawn through the tissues, and this creates a smaller hole **(Fig. 5.1D).**
- Each patient has the benefit of a new, sharp, guaranteed sterile needle.
- No chances of accidental unthreading of the needle and losing it while suturing.
- Faster and more efficient procedure.
- Needles are made up of high quality steel.
- Tru-tempering process gives uniform strength.
- By merely quoting the code number, the surgeon indicates the type, size, length of the suture as well as the details of the needle.
- Nurse working hours are saved; there is no need of ordering, cleaning, sterilizing and threading the eyed needles.

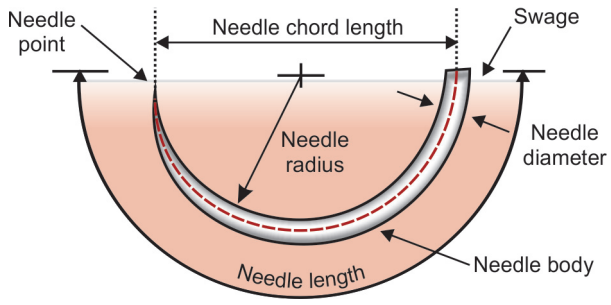


Fig. 5.1B: Anatomy of a surgical needle

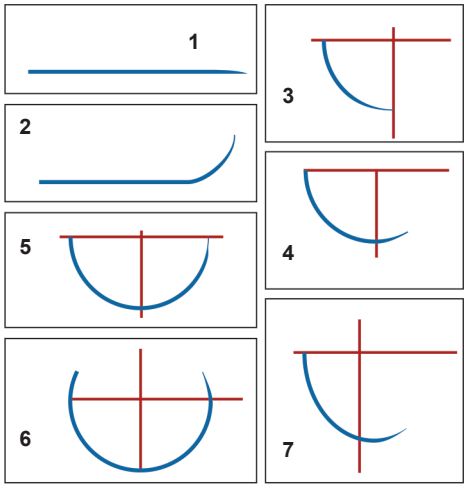


Fig. 5.1C: Suture needles: (1) Straight; (2) Half curve; (3) One-fourth circle; (4) Three-eighths circle; (5) Half circle; (6) Five-eighths circle; and (7) Compound curvature

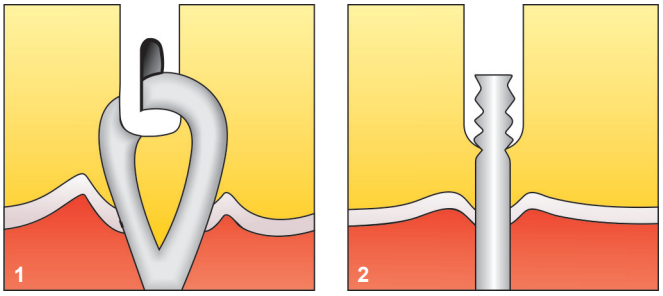


Fig. 5.1D: Advantages of eyeless needle: (1) Tissue disruption caused by double suture strand with eyed needle; (2) Minimum tissue disruption by single suture strand swaged to needle

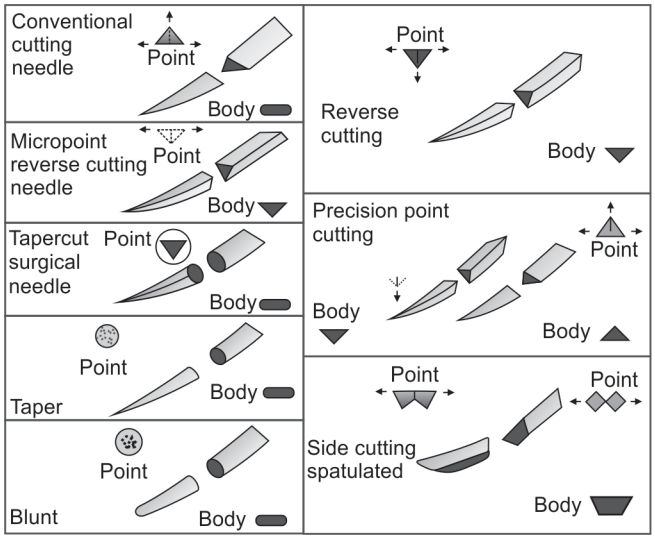


Fig. 5.2: Needle points and body shapes

Needle Body

The body or the shaft section is usually referred to as the needle grasping area. The cross-sectional configuration of the body may be round, oval, side flattened, rectangular, triangular or trapezoidal.

The longitudinal shape of the body may be straight, half curved, curved (one-fourth circle, half circle, three-eighths circle or five-eighths circle) or compound curved. The half circle curved needles are the most commonly used needles in oral surgical procedures **(Fig. 5.2).**

Needle Point

The point is the extreme tip of the needle to the maximum cross section of the body. The tip can be cutting, round or blunt. Cutting needles have at least two opposite cutting edges **(Fig. 5.2).** They are ideal for suturing keratinized tissues like the skin, palatal mucosa, buccal and alveolar mucosa. Cutting edges can be conventional, reverse or side cutting. They are triangular in cross section.

Round or tapered needles are used for suturing soft and nonkeratinized tissues like muscle, fascia, and neural sheath.

Principles of Suturing

- The needle should be grasped at approximately 1/3rd the distance from the eye and 2/3rd from the point.
- The needle should enter the tissues perpendicular to the tissue surface.
- The needle should be passed through the tissues along its curve.
- The suture should be passed at an equal depth and distance from the incision on both sides.
- The needle always passes from the movable tissue to the fixed tissue.

- The needle always passes through the thinner tissue to the thicker tissue.
- The needle always passes from the deeper tissue to the superficial tissue.
- Tissues must never be closed under tension. Undermining the tissues must be done prior to suturing in such cases.
- The suture should be tied only to approximate the tissues, not to blanch.
- The knot should never lie on the incision line.
- Sutures should be placed at a greater depth than the distance from the incision, so as to evert the wound margins.
- Sutures on the skin are usually removed in 5 days and intraoral sutures in 7 days. If there is tension while suturing, the sutures may be kept for 10 days.

Surgical Knot Tying

Surgical knot tying is vital to the art of suturing. It is essential for knot security and to prevent untimely knot untying, that the appropriate surgical knot be used for the specific suture material being secured. Knot security can be assessed by measuring the force required to slip or break a knotted loop of suture material. The type of knot that is used for each material is determined by the mode in which each type of thread is manufactured. A knot can be tied using an instrument, like the needle holder or with the hand.

Secure/Square Knot

Standard square or reef knotting method: It is a special knotting technique, once tied, the knots are secure. The first throw is placed in precise position for the knot, using a double loop. The second throw is tied using horizontal tension. Additional two throws are desirable. Totally there should be four throws and the ends should be cut long **(Fig. 5.3A).**

Surgeon's Knot

It is formed by two throws of the suture around the needle holder on the first tie and one throw in the opposite direction in the second tie **(Fig. 5.3B).**

Synthetic resorbabale and nonresorbable suture materials can be used to prevent untimely knot untying.

Granny's Knot or Slip Knot

When using silk, chromic catgut or plain catgut suture material, a slip (Granny's) knot can be used. It involves a tie in one direction followed by a second tie in the same direction and a third tie in the opposite direction to square the knot and hold it securely **(Fig. 5.3C).**

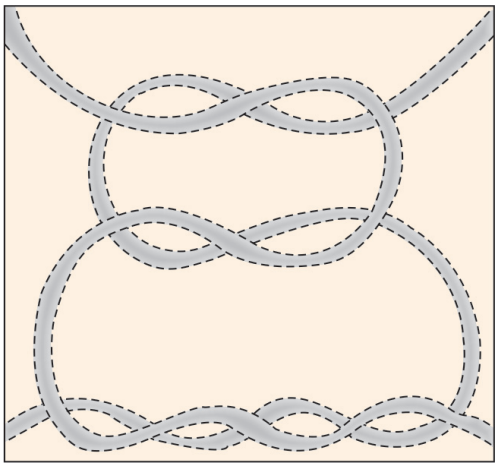


Fig. 5.3A: Square knot

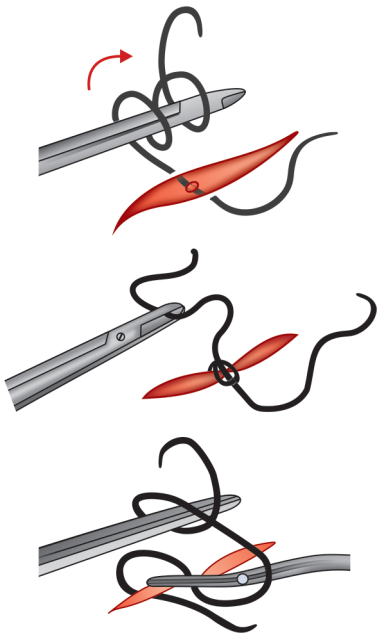


Fig. 5.3B: Surgeon's knot being tied

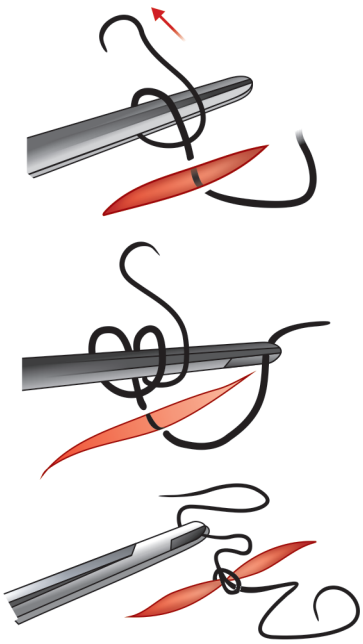


Fig. 5.3C: Granny's knot

SUTURING TECHNIQUES

Interrupted Suture-Sling Suture

The suture is passed through both the edges of the wound at an equal depth and distance from the incision, needle penetration should be 3 mm from the wound edges and the knot is tied. It is the most commonly used suture **(Fig. 5.4)**.

Advantages

- It is strong, and can be used in areas of stress.
- Successive sutures can be placed according to individual requirement.
- Each suture is independent and the loosening of one suture will not produce loosening of the other.
- A degree of eversion of the margins can be controlled.
- If the wound becomes infected or there is hematoma formation, removal of a few sutures may offer a satisfactory treatment.

Continuous Over and Over Suture

Initially, a simple interrupted suture is placed and the needle is then reinserted in a continuous fashion such that the suture passes perpendicular to the incision line below and obliquely above. The suture is ended by passing a knot over the untightened end of the suture. It provides a rapid technique for closure and distributes the tension uniformly over the suture line. It also offers a more water tight closure **(Fig. 5.5A).**

Continuous Locking Suture

This technique is similar to the continuous suture, but locking is provided by withdrawing the suture through its own loop. The suture thus passes perpendicular to the incision line. The locking prevents excessive tightening of the suture as the wound closure progresses **(Fig. 5.5B).**

Mattress Suture

These sutures may be horizontal or vertical. These are used in areas, where tension free flap closure cannot be accomplished. Mattress sutures are used to resist muscle pull, evert the wound edges and to adapt the tissue flaps tightly to the underlying structures (e.g. bone grafts, tissue grafts, dental implant, regenerative membrane, etc.)

Horizontal Mattress Suture

The needle is passed from one edge of the incision to another and again from the latter edge to the first edge in a horizontal manner and a knot is tied. The distance of needle penetration from the incision line and the depth of penetration of the needle is the same for each entry point, but horizontal distance of the points of penetration on the same side of the flap differs (needle penetration through the surgical flap should be at least 8 mm away from the

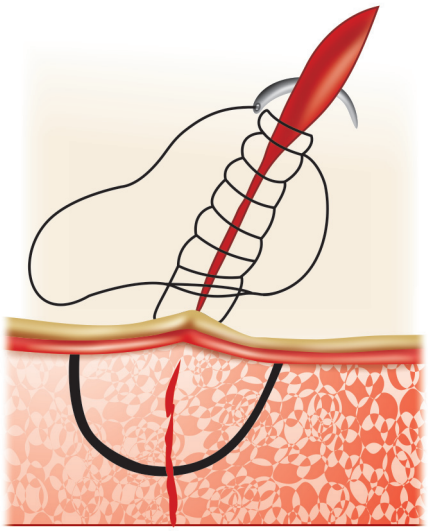


Fig. 5.5A: Continuous over and over suture

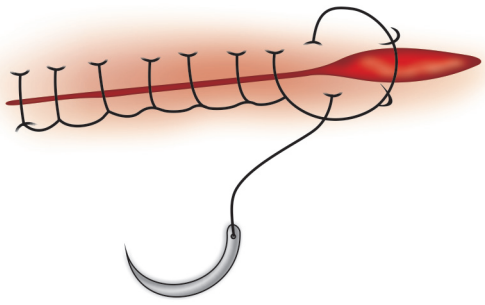


Fig. 5.5B: Continuous locking suture

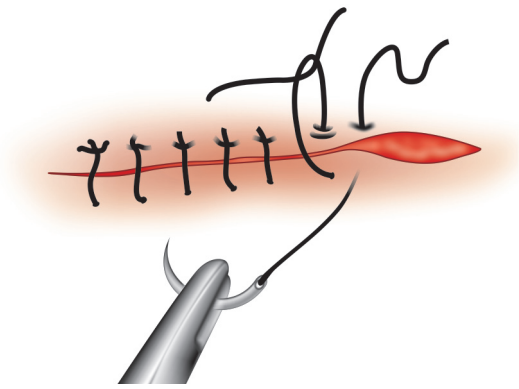


Fig. 5.4: Interrupted suture

flap edges). This suture provides a broad contact of the wound margins, e.g. closure of extraction socket wounds **(Fig. 5.6).**

Vertical Mattress Suture

It is similar to the horizontal mattress, except that, all factors remaining constant, the depth of penetration varies, i.e. when the needle is brought back from the second flap to the first, the depth of penetration is more superficial. It is used for closing deep wounds **(Fig. 5.7).**

Figure of 8 Suture

The figure of 8 suture can be used for the extraction socket closure as well as for adaptation of the gingival papilla around the tooth **(Fig. 5.8).**

Subcuticular Sutures

The subcuticular layer of tough connective tissue if sutured will hold the skin edges in close approximation when cosmetic results are desired. Continuous short lateral stitches are taken beneath the epithelial layer of the skin. The ends of the suture come out at each end of the incision and are knotted. This type of suturing leaves a cosmetic scar **(Fig. 5.9).**

SUTURE REMOVAL

The suture is grasped with an instrument and lifted above the epithelial surface. The scissors are then passed through one loop and transected close to the surface. The suture is then pulled out.

Skin sutures are usually removed after a period of 7–10 days depending upon the area, and mucosal sutures are removed between 5 and 7 days.

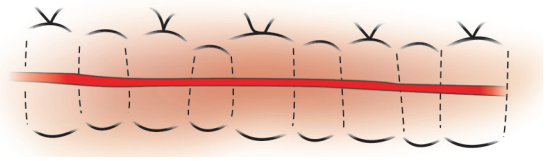


Fig. 5.6: Horizontal mattress suture

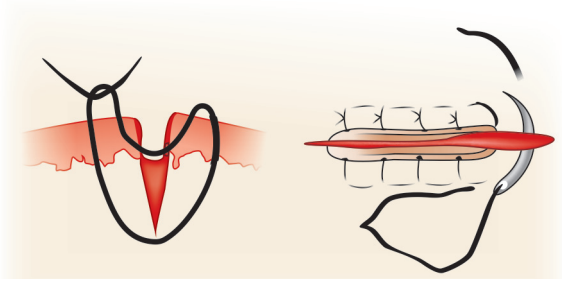


Fig. 5.7: Vertical mattress suture

MECHANICAL WOUND CLOSURE DEVICES

Ligating Clips

These can be resorbable or nonresorbable. Ligating clips are made from stainless steel, tantalum or titanium or polydioxanone. They are designed for the ligation of tubular structures.

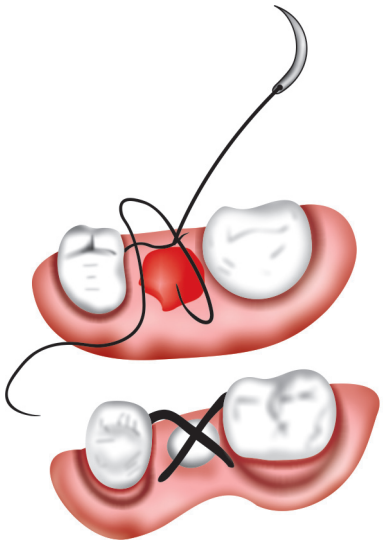


Fig. 5.8: Figure of 8 suture

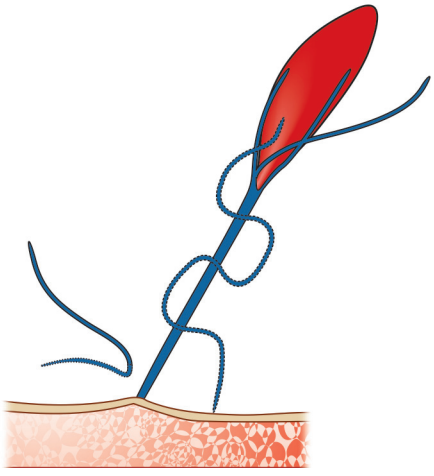


Fig. 5.9: Continuous subcuticular sutures

Surgical Staples

Surgical staples can be used for skin closure and closure of the abdominal layers. Skin staples are made up of stainless steel, and are placed uniformly to span the incision line. They have minimal tissue reaction. They can be used for routine skin closure anywhere in the body. Their use is contraindicated when it is not possible to maintain at least 5 mm distance from the stapled skin to the underlying bone and blood vessels.

Tissue Adhesives

After tight closure of the subcutaneous tissues, the skin layer can be closed with the help of tissue adhesive like N-butyl-cyanoacrylate, which on tissue contact polymerizes into a hard substance that keeps the wound margins together.

Dermabond Topical Skin Adhesive

It is a 2-octyl cyanoacrylate with a long carbon side chain structure that is combined with plasticizer—nontoxic, flexible, transparent bond. It has three dimensional strength and is 3–4 times stronger than N-butyl-cyanoacrylate. This adhesive is applied to the dry skin over the wound by a proper technique in multiple thin layers (at least three). It sets within three minutes and offers suture-less skin approximation. It has no length restrictions and wounds do not need to be linear. It provides a waterproof clear dressing resulting in excellent cosmetic result.

Points to Remember

- Principles of suture material selection
- Nonabsorbable sutures
- Natural absorbable sutures
- Synthetic absorbable sutures
- Coated vicryl - polyglactin-910 braided suture material
- Suture needles
- Suturing techniques
- Suture removal
- Mechanical wound closure devices.

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CHAPTER 6 Asepsis and Sterilization

INTRODUCTION

The concept of asepsis and its role in the prevention of infection was put forward nearly two centuries ago. The general principles for asepsis were laid down by Hungarian obstetrician, Ignaz Semmelweis, in Europe in early 1850s; and Oliver Holmes in USA. These principles were accepted after Joseph Lister's studies on prevention of wound infection, carried out in between 1865 and 1891. Lister, working on antisepsis, initially used phenol (dilute carbolic acid) for contaminated wounds, later applied it in all surgical wounds, also in operating room by nebulization of the solution. Further developments occurred, with the introduction of steam sterilization, surgical masks, sterile gloves, sterile gowns and sterile drapes, etc.

The studies showed that, despite employment of new methods of sterilization and aseptic techniques, microorganisms are introduced in surgical sites. These are implicated as the cause of many postoperative infections. However, as suggested by many clinicians, the most postoperative infections result from the following: faulty surgical technique, inadequate asepsis and disinfection. The success of prevention and control of infection in health-care areas is largely dependent on the aseptic technique of all personnel, who perform invasive procedures, the sterility of all items directly concerned in such procedures and the disinfection of all surfaces and items in the immediate vicinity.

DEFINITIONS OF VARIOUS TERMINOLOGIES

- **Cleaning:** It is a process, which removes visible contamination but does not necessarily destroy microorganisms. It is a necessary prerequisite for effective disinfection or sterilization.
- **Asepsis:** It is the avoidance of pathogenic organisms. It is the term used to describe methods, which prevent contamination of wounds and other sites, by ensuring that only sterile objects and fluids come into contact with them, and that the risk of airborne contamination is minimized.
- **Aseptic technique:** It aims at excluding all microorganisms. Surgical technique is aseptic when sterile instruments and clothing and "no touch technique" are employed. It is the term used to describe methods which prevent contamination of wounds and other sites by ensuring that only sterile objects and fluids come into contact with them, and that the risks of airborne contamination are minimized.
- **Antisepsis:** It is the procedure or application of an antiseptic solution or an agent, which inhibits the growth of microorganisms, while remaining in contact with them, but does not necessarily imply sterility. The examples are scrubbing up and preparation of operative sites.
- **Antiseptic:** It is a chemical applied to living tissues, such as skin or mucous membrane, to reduce the number of microorganisms present by inhibition of their activity or by destruction.
- **Disinfection:** It is a process, which reduces the number of viable pathogenic microorganisms to an acceptable level but may not inactivate some viruses and bacterial endospores.
- **Disinfectant:** It is a chemical substance, which causes disinfection. It is used on nonvital objects to kill surface vegetative pathogenic organisms but not necessarily spore forms or viruses.
- **Sterilization:** It is the process of destruction or removal of all microbial forms.

CLASSIFICATION OF INSTRUMENTS

- **Critical:** Instruments which penetrate mucous membrane or contact bone, the bloodstream or

other normally sterile internal tissues, e.g. surgical instruments, scalpel, blades, surgical dental burs, needles, periodontal scalers, etc.
    - Single use sterile disposable devices should be used whenever applicable.
- **Semicritical:** Instruments which contact mucous membrane but do not penetrate the soft tissues, e.g. mouth mirrors, dental handpieces, etc.
    - These are heat sterilized, or high-level disinfectant is used.
- **Noncritical:** Instruments, which contact intact skin. For example, X-ray heads, face bows, pulse oximeter, blood pressure cuff, etc.
- Clean and disinfect with low or intermediate level disinfectant.

Cleaning and Disinfection

Clearance of used instruments and equipment from the operatory and preparation for reuse is a process itself. It consists of five steps:

1. Transfer or transport of used items
2. Cleaning and disinfection
3. Preparation and packing
4. Sterilization
5. Storage.

Correct cleaning, packaging, sterilizer-loading procedures, sterilization methods or high-level disinfection methods should be followed to ensure patient safety.

TRANSPORT OF USED ITEMS

Disposable items should be discarded into suitable container, syringes are destroyed and needles burnt, cut and discarded into separate sharps container.

The rest of the used instruments should be transported in a separate tray from the operatory to the instrument cleaning area. Dental Health Care Workers (DHCWs) in charge of transport can be exposed to microorganisms from contaminated instruments and devices through percutaneous injury or contact with nonintact skin of the hands or contact with mucous membranes of the eye, nose or mouth due to water splash. Contaminated instruments should be handled carefully to avoid percutaneous injuries.

Instrument Processing Area

Dedicated separate area should be available. This helps in quality control and ensures safety. The instrument processing area should have following sections:

- Receiving, cleaning and decontamination
- Preparation and packing
- Sterilization
- Storage.

Ideally, partitions should separate the sections to control traffic flow and contain contamination generated during cleaning. Processing space should be adequate for the volume of work anticipated and the items to be stored. DHCWs should be provided with ongoing training and regular monitoring for quality control.

Receiving, Cleaning, Decontamination

The DHCW should wear puncture resistant, heavy-duty utility gloves, mask, protective eyewear or face shield and gown or apron, while handling or manually cleaning contaminated instruments and devices. Reusable instruments should be received, sorted, cleaned and decontaminated in one section of the processing area. Initial cleaning removes organic and inorganic contamination. Removal of debris and contamination is achieved by scrubbing with a detergent and water or by an automated process (e.g. ultrasonic cleaner or washer-disinfector) using chemical agents.

If visible debris is not removed, it will interfere with microbial inactivation and can compromise the disinfection or sterilization process.

If manual cleaning is not done immediately, the instruments should be placed in a puncture resistant container filled with detergent, a disinfectant or an enzymatic cleaner. Soaking them in this manner will prevent drying of blood and body fluids. Use of a liquid chemical sterilant or high-level disinfectant (e.g. glutaraldehyde) as holding solution is not recommended.

CLEANSING OF INSTRUMENTS

Cleansing Agents

Soaps and Detergents

They are commonly used for the removal of debris from the instruments. Soaps are salts of fatty acids and detergents are synthetic compounds. Both the groups act by reducing surface tension along the instrument surface leading to emulsification of contaminants, which are removed in the rinsing phase.

Soaps

They are effective at pH 9 or higher and even in a weak acidic environment, or in one containing soluble salts of calcium and magnesium, precipitation of soap will occur.

Detergents

They are compatible with calcium and magnesium ions and maintain their efficiency in neutral or slightly acidic solutions. Some detergents possess bactericidal activity against some specific Gram-positive organisms. For example, sodium lauryl sulfate is effective against *Streptococcus pneumoniae.* The spectrum of antibacterial activity of detergents is too narrow to classify them as disinfectants.

Other Fat Solvent Solutions

Such as acetone, ether and xylene are sometimes used in cleaning. These solutions are sometimes expensive, caustic to living tissues and probably less effective in overall cleaning ability than soaps and detergents. Some disinfectant solutions, such as aldehyde and phenols, are also used in cleaning of instruments. These solutions should be thoroughly rinsed from the instrument surface prior to their use as they are toxic to living tissues.

Lawrence and Block (1668) reported that proteins and other polymolecular structures, particularly when dry, serve as a protective covering for microorganisms and prevent penetration of sterilizing medium. All surgical instruments must be cleansed of the debris including blood, saliva and necrotic material. This debris prevents contact of the sterilizing medium with the instruments such as heat, chemicals or gas. Instruments, such as bone files and bone burs, should be thoroughly cleaned as solid particles are wedged into small crevices. The various methods by which it can be achieved are mentioned: (i) scrubbing by hand usually with a stiff wire brush, (ii) ultrasonic cleaning devices. Rubbo and Gardner (1965) reported that these devices act by converting electrical energy into vibratory sound waves, which pass through a soap solution containing the instruments.

In a nutshell:

- "Sterile" does not mean safe and clean.
- An item heavily loaded with microbiological material will be more difficult to sterilize than one lightly contaminated.
- Medical devices or instruments must be thoroughly cleaned to reduce organic material or bio burden before sterilization and as soon as possible after use. This is the most effective stage of any decontamination procedure, which should accompany or precede all disinfection procedures.
- Dried biological material is much more difficult to remove than fresh deposits. Blood with its content of iron, acid and sodium chloride is highly corrosive.
- Improperly cleaned instruments if sterilized may be free of living microorganisms, but they will be smeared with endotoxins—"the corpses of bacteria", which can trigger very strong inflammatory reactions in the body.
- Presoak the instruments after use in water or an enzyme solution. This prevents drying of saliva and blood.
- Manual scrubbing or washing in still or stagnant water increases the microbial count; hence, should be avoided.
- Automated washer disinfectors offer the safest, most reliable option, provided they are suitably monitored and maintained **(Fig. 6.1A)**.
- As an alternative to washer disinfectors (dishwasher), ultrasonic cleaning bath is recommended **(Fig. 6.1B)**.
- Use disposable items and equipment only once and discard, whenever possible.
- Consider items difficult to clean (endofiles, broaches and burs) as single use disposables and discard them after each use.

Mechanism of Action

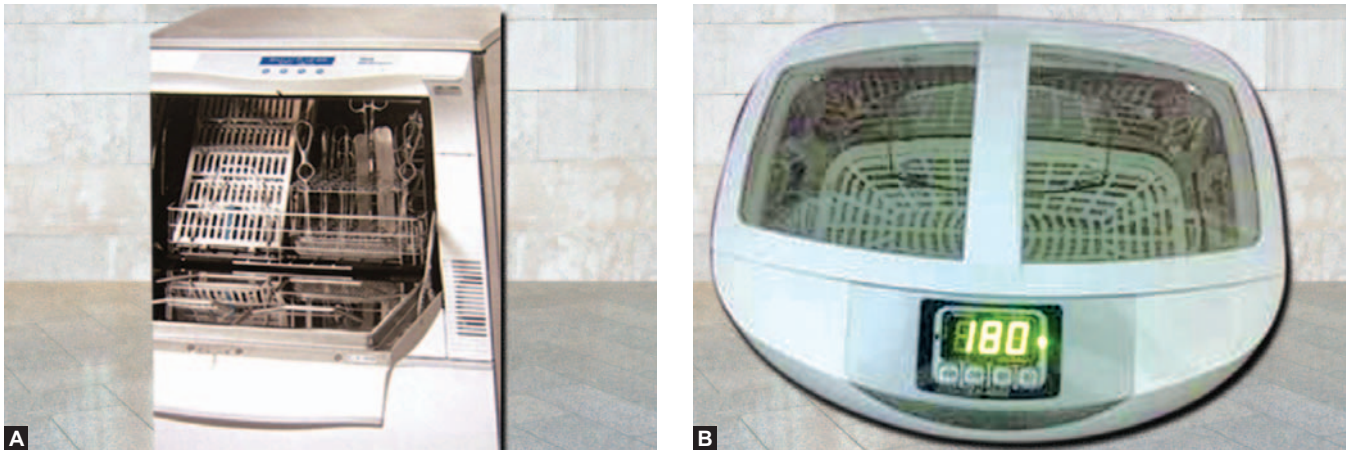
The disinfectant and antiseptics act on microorganisms by one or more of the mechanisms listed in **Box 6.1**.

Drug Concentration and Therapeutic Index

In general, antiseptic effect increases with a rise in concentration. Alcohol is an exception and shows maximum antiseptic activity in a 70% concentration. The potency of a particular concentration is meaningful only in relation to tissue toxicity (therapeutic index). The presence of debris and necrotic tissue reduces the penetration of these agents, thereby lowering their concentration. In the same way, tissue proteins reduce the concentration of halogen-containing and metallic antiseptics by adsorption, while anionic surfactants like soaps reduce the effective concentration of cationic surfactants by chemical neutralization.

Temperature and Duration of Contact

A limited rise in environmental temperature and prolonged contact can enhance antiseptic activity. A rise in temperature by 10°C generally doubles the antibacterial activity of chemical agents, whereas it increases that of moist heat a hundredfold.



Figs 6.1A and B: (A) Washer disinfector with air filter, spray facility; (B) Ultrasonic cleaners

Box 6.1: Mechanisms of action of disinfectants and antiseptics

- Coagulation of bacterial proteins
- Alteration in the properties of bacterial cell wall
- Binding of sulfhydryl groups essential for enzyme action
- Competition with essential substrates for the important enzymes in bacterial cell

PACKAGING OR WRAPPING INSTRUMENTS FOR AUTOCLAVING

Packing instruments before sterilizing prevents them from becoming contaminated after sterilization till it is opened and used. Instruments must be clean but not necessarily dry. Closed (nonperforated) containers (closed metal trays, capped glass vials) and aluminum foils cannot be used because they prevent the steam from reaching the inner sections of the packs. Cassettes, drums, trays with opening on all sides may be used **(Figs 6.2A to G).**

Packaging used for autoclaving must be porous to permit steam to penetrate through and reach the instruments. The materials used for packaging could be fabric or sealed biofilm/paper/muslin cloth pouches, nylon bags and tubing, sterilization wrap and paper-wrapped cassettes. The bag or wrap is heat sealed or sealed with tape. Pins, staples and paper clips are not advisable as they make holes in the wrap and may allow microorganisms to pass through subsequently.

The instruments are assembled into sets or trays and wrapped, packaged or placed into container system for sterilization. Hinged instruments should be processed open and unlocked.

An internal chemical indicator should be placed in every package; in addition, an external indicator (e.g. chemical indicator tape) should be used when the internal indicator cannot be seen from outside package. For unwrapped loads, an internal chemical indicator should be placed in tray or cassette with items to be sterilized **(Figs 6.3A and B).**

In case, the pack of instruments is to be stored and not used shortly after sterilization, the autoclave cycle should end with a drying phase. The instruments stored in damp conditions result in tarnish, corrosion or rusting.

Marking of Packs

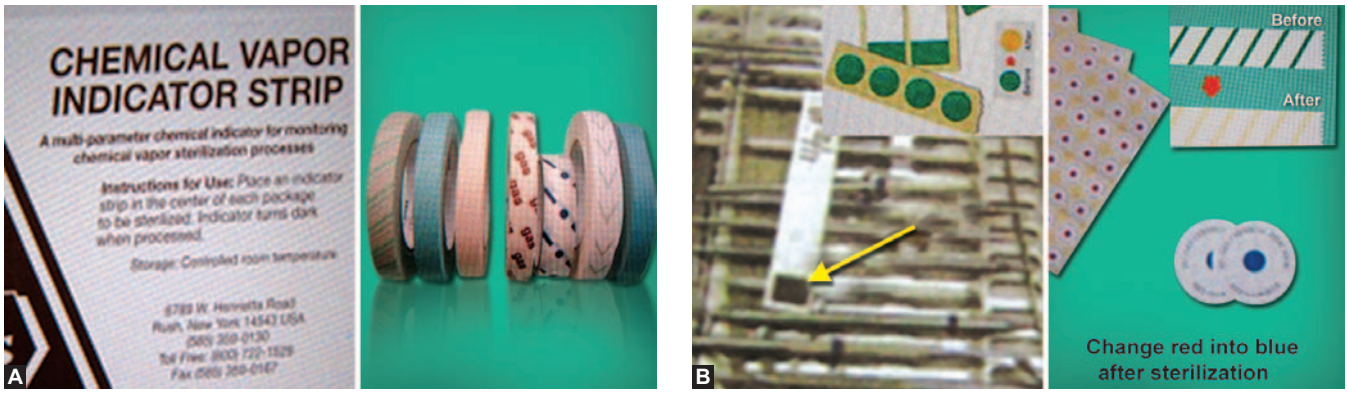
Packs should have some external indication showing that the pack has been processed. Autoclave tapes on packs change color after exposure to sterilization cycle. That does not prove sterilization; hence, it should be used in conjunction with the test for cycle sterilization. Each pack must be labeled with the contents, date of sterilization, autoclave number and load number. This will help in locating processed items in case of recall.

METHODS OF STERILIZATION

Sterilization can be defined as the use of a physical or chemical procedure to destroy all forms of microorganisms including bacteria, spores, fungi and viruses. The term sterilization can only be applied to instruments, and not to skin, where only antisepsis can be achieved. A general principle is that all items used to penetrate soft tissue or bone, enter into or contact the bloodstream or other normally sterile tissues should be sterilized and be sterile



Figs 6.2A to G: (A to C) Packaging exodontia instruments in a transparent pouch; (D) Packing of instrument in a sterilization pouch; (E) Assistant delivering the sterile instrument; (F) Instruments packed in a metal cassette; (G) Instruments packed in a metal tray and enclosed in a pouch



Figs 6.3A and B: (A) External chemical indicator strips are available in rolls or small label form; (B) Internal chemical indicator. After steam sterilization, the chemical indicator changes original color

at the point of use. A sterility requirement for medical products means that the theoretical probability that a living organism will be present on an object after the sterilizing process is equal to or less than one in a million, so-called sterility assurance level (SAL) = 10°.

There are several ways of achieving sterilization. Sterility may be achieved by: (i) heat, (ii) chemical and (iii) ionizing radiation. Most commonly used methods are as follows: (i) by steam or moist heat at a raised atmospheric pressure in an autoclave, (ii) by dry heat or hot air at normal atmospheric pressure in a dry oven, (iii) by use of ethylene oxide, (iv) by low-temperature steam and formaldehyde (LTSF) and (v) by irradiation.

Principles

- All used instruments should be thoroughly cleaned; all deposits of blood and debris should be removed before sterilization.
- It is essential for the sterilizing agent (heat, steam and/or gas) to be in contact with every surface of each item to be sterilized for the specified period of time at the specified temperature.
- All sterilizing equipment must be regularly serviced and maintained by suitably qualified engineers. Appropriate test must be applied to check temperature, humidity, pressure and gas content when appropriate and which proves the elimination of bacteria and spores.
- The manufacturer's instructions should be strictly adhered to for its operation and maintenance.

Heat is the most common and one of the most effective, simplest methods of sterilization. Heat may be transmitted through air, water or oil. Heat method can be utilized in two forms: (i) moist heat and (ii) dry heat.

Moist Heat Sterilization: Autoclave

Steam sterilization **(Figs 6.4A to D)** involves heating water to generate steam in a closed chamber (autoclave—in which drums and trays with the materials to be sterilized can be kept inside) producing moist heat that rapidly kills microorganisms. There is a mass heat transfer as the steam condenses. Use of saturated steam under pressure is the most practical, quickest, safest, effective and economic method of sterilization known for the destruction of all forms of microbial life because of its: (i) high penetrating capacity and (ii) it gives up a large amount of heat (latent heat) to the surface with which it comes into contact, and on which it condenses as water. The advantages are: (i) the results are consistently good and reliable, (ii) the instruments can be wrapped prior to sterilization, (iii) time efficient and (iv) good penetration. The main disadvantages are: (i) blunting and corrosion of sharp instruments and (ii) damage to certain rubber goods.

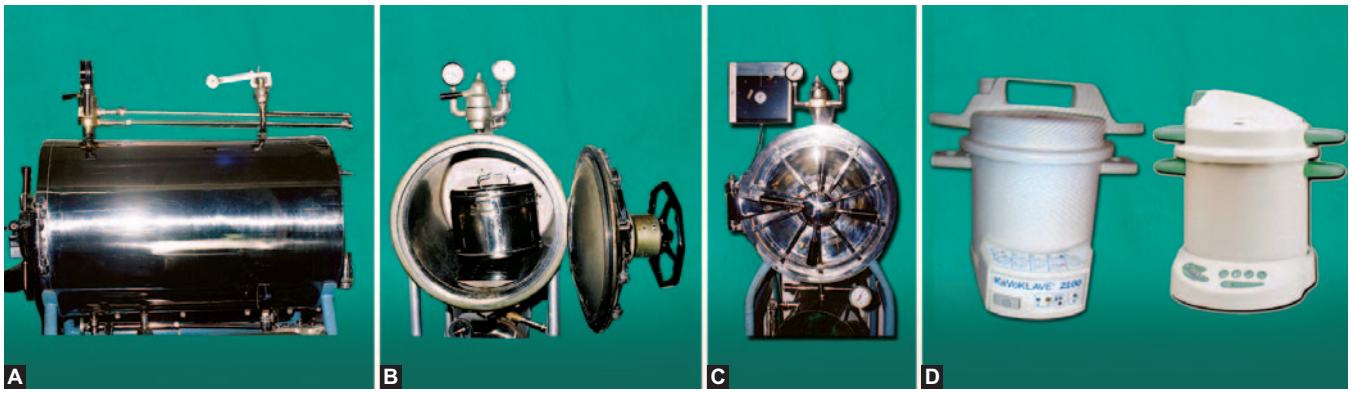
There are two types of autoclaves or steam sterilizers available:

1. Downward (gravitation) displacement sterilizer: This is nonvacuum type autoclave.
2. Steam sterilizers (autoclave) with pre- and post-vacuum processes: Class B type.

Steam Sterilizers (Autoclave)

The sterilization process is composed of three main phases:

1. **Pretreatment phase or heat up cycle:** All air is virtually expelled by a number of pulses (at least three) of vacuum and the introduction of steam, so that the saturated steam can affect the goods during second phase.



Figs 6.4A to D: (A) Horizontal autoclave for big institutes; (B) Autoclave with door open. Inside drums, trays can be kept with the material to be sterilized; (C) Front view of the big horizontal autoclave; and (D) Small autoclaves for the clinic

2. **Sterilizing phase or sterilization cycle:** The temperature increases sufficiently up to the degree at which sterilization is to take place. Actual sterilizing period, which is also called "holding time", starts when the temperature in all parts of the autoclave chamber and its contents (the load) have reached the sterilizing temperature. This should remain constant within specified temperature band throughout the whole sterilization phase (plateau/holding time).
3. **Post-treatment phase or depressurization cycle and drying cycle:** In this phase, either the steam or the revaporized condensed water is removed by vacuum to ensure that the goods are dried rapidly.

Precautions

Trapped air pockets in the load prevent steam penetration during sterilization of porous material such as textiles and hollow items with long narrow lumina. A single vacuum pulse is inadequate for wrapped/hollow/porous loads. Several (at least three) prevacuum pulses are needed to define preset vacuum level.

There are three major factors required for effective autoclaving: (i) pressure, (ii) temperature, and (iii) time.

- **Pressure:** It is expressed in terms of psi (pounds per square inch) or kpa (kilopascals) (kpa = 0.145 psi).
- **Temperature:** To achieve required pressure, the temperature must be reached and maintained at 121°C (250°F). With the increase in temperature and pressure, superheated steam is formed. The exposure to this superheated steam brings about the sterilization. This steam, which is lighter than air raises to the upper portion of the autoclave as more steam is formed, it eliminates air from autoclave. The purpose of complete elimination of air is to help superheated steam penetrate the entire load in the autoclave and remains in contact for the appropriate length of time.
- **Time:** Wrapped loads (paper wraps or a thin cloth) require a minimum of 20–30 minutes after reaching full temperature and pressure. By selecting the correct temperature and time cycle, a wide variety of materials can be sterilized by this method—dressing packs, surgical instruments, laboratory equipment, culture media and pharmaceutical products. Liquids can be sterilized by autoclave, provided the contents do not get inactivated by the high temperatures.

Higher temperatures and greater pressures shorten the time required for sterilization. At 15 psi pressure, the temperature of steam can reach 121°C. The time required to kill all living organisms at this temperature is 15 minutes. At 126°C for 10 minutes and at 134°C for 3 minutes, sterilization can be completed. The time required for sterilization for a particular item also varies with the amount of material and the thickness of the wrap. Perkins (1969) has discussed the instrument wrapping techniques and the placement of the packs in the autoclave.

The superiority of steam over hot air as a method of sterilization is due to the following: (i) moist heat acts by denaturation and coagulation of enzymes and proteins whereas dry heat acts by destructive oxidation of cell constituents. Moist heat kills more rapidly and at much lower temperature than dry heat. (ii) With the condensation of a large amount of latent heat to the surface. With steam condensation, besides emission of large amount of heat, there is a great contraction in its volume. This results in production of negative pressure and brings more steam to the site. Soon the temperature of the surface is raised to that of the surrounding steam. Thus, steam acts more quickly in heating exposed articles than hot air. (iii) Steam

penetrates better than hot air. This is partly due to its density, which is half that of air, and partly due to negative pressure.

Presently, two types of autoclaves are available:

1. Porous load autoclaves—to achieve complete sterilization, 121°C at 20 psi are maintained for 20 minutes. *The articles which can be sterilized by this method include:* towels used for draping, suture materials, cotton rolls rubber gloves. The articles which can be sterilized by this method include: towels used for draping, suture materials, cotton rolls ,rubber gloves etc.
2. small portable bench model type autoclaves—for complete sterilization, 136°C at 32 psi are maintained for 5 minutes. The steam entering the top of the chamber penetrates the material in a top to bottom flow.

Sterilization cycles that operate at a high temperature for shorter times are indicated for unwrapped and solid instruments, which need to be used immediately. Standard sterilizing conditions—3–10 minutes at 273°F. It invariably results in residual air in the autoclave chamber.

To avoid or minimize corrosive action of steam on metals, the use of following agents has been reported: Crawford and Oldenburg (1967) recommended the addition of ammonia to the autoclave. Accepted Dental Therapeutics (1977) recommends use of dicyclohexylammonium nitrate or cyclohexylamine and decylamine. Bertolotti and Hurst (1978) recommend 2% sodium nitrate.

Sterilization Monitoring

The mechanical, chemical and biological parameters are used to evaluate both the sterilizing conditions and the procedure's effectiveness.

Mechanical techniques for monitoring sterilization include assessing cycle time, temperature and pressure by observing the gauges or displays on the sterilizer and noting these parameters for each lot. Some tabletop sterilizers have recording devices that printout these parameters. Correct readings do not ensure sterilization, but incorrect readings can give first indication of a problem with sterilizer.

- **Spore testing:** Biological indicator—should be done once a week to verify proper functioning of the autoclave with the help of *Geobacillus stearothermophilus* strips or vials **(Fig. 6.5A).**
- **Thermocouple:** This is a thermometric testing, and a reliable gauge of efficiency. One recording is taken from a thermocouple placed inside a test pack of towels and a second one from the chamber drain. Comparison between the two recordings gives a good guide regarding the speed at which the steam penetrates the load.
- **Brown's test:** These are ampoules that contain a chemical indicator, which changes its color from red through amber to green at a specific temperature.
- **Autoclave tape:** This is a tape printed with sensitive ink that undergoes a color change at a specific temperature. This test forms the basis of the Bowie-Dick test for high vacuum autoclaves. Two pieces of strips are stuck onto a piece of square paper and placed in the middle of the test pack. With the application of temperature of 134°C for 3.5 minutes, there is a uniform development of bars throughout the length of the strips. This shows that the steam has passed freely and rapidly to the center of the load **(Figs 6.5B and C).**

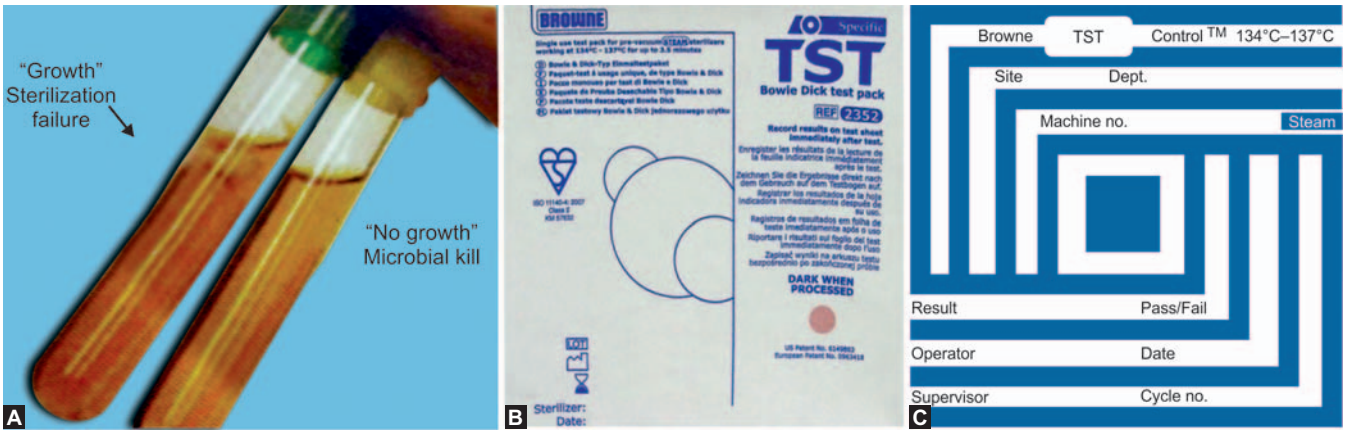
Dry Heat Sterilization

Dry heat sterilization involves heating air with transfer of heat energy from the air to the instruments. It is an alternative method of sterilization of instruments, particularly the sharp instruments. The basic action is dehydration and oxidation of microorganisms. Dry heat has less penetration and is less effective than moist heat. The advantage is that the instruments do not rust if they are dried prior to their placement in the sterilizer and there is relatively low cost of equipment. The disadvantage is that the process is time consuming and high temperature may damage the material to be sterilized. It is achieved by two methods:

1. **Dry heat oven type sterilizer (static air):** It has coils and heat rises within 60–120 minutes at 320°F or 160°C.
2. **Dry heat:** Rapid heat transfer (forced air) at high velocity within 12 minutes at 375°F/190°C. For wrapped items and within 6 minutes at 375°F for unwrapped items.

Hot Air Oven

It is used to sterilize items, which do not get damaged by high temperatures such as laboratory glassware, glass syringes and instruments. Hot air is a poor conductor of heat and has poor penetrating capacity. It does not penetrate grease, oil and powders, and equipment containing these substances should be sterilized by other methods. High temperature damages fabrics and melts rubber or plastic, hence should not be sterilized by this method **(Figs 6.6A and B).**



Figs 6.5A to C: (A) Biological indicator. If the repeat BI test is positive, the sterilizer should not be used, until it has been repaired, and declared as satisfactorily working, with BI tests in three consecutive empty chamber sterilization cycle; (B and C) Autoclave function testing strips

Temperature and time: This method of sterilization completely depends upon a combination of time and temperature. The sterilization is complete, if the two factors are achieved throughout the load. The following temperatures and times are used **(Table 6.1):**

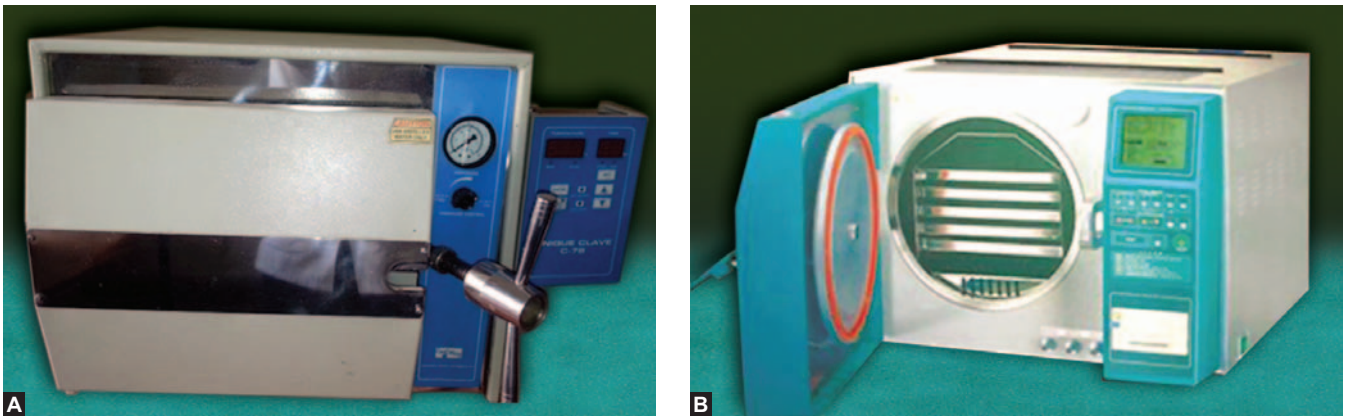
Kelsey (1969) reported that the long time required for sterilization is because of poor heat conduction by air and poor penetration of dry heat. The only advantage of this method is the maintenance of sharp edges of cutting instruments such as chisels. Hence, sharp instruments are preferably sterilized by exposure to dry heat. Autoclaving will reduce their sharpness and lead to rusting. Custer and Coyle (1970) found that carbon steel instruments could loose their hardness because of dry heat.

The instruments must be clean and dry prior to wrapping. The wrapping material must be heat resistant. Aluminum foil, metal and glass containers may be used in dry heat oven. The instruments should be loosely wrapped otherwise they may puncture the wrapping. Paper and cloth packs must be avoided because they may char. The instruments sterilized with wrapping should be kept or stored in sterile condition, if not to be used immediately.

Spore testing should be done once a week to verify proper functioning of the sterilizer with the help of *Bacillus atrophaeus* strips.

Glass Beads Sterilizer

This method employs a heat transfer device. The media used are glass beads, molten metal or salt kept in a cup or crucible. The temperature achieved is of 220°C. The method employs submersion of small instruments, such as endodontic files and burs, rotary instruments into the beads, and are sterilized in 10 seconds provided they are clean **(Fig. 6.7).**



Figs 6.6A and B: Hot air sterilizer with automatic control of temperature (0–200°)

Table 6.1: Relation of temperature and time

Temperature		*Time (minutes)*
°C	°F	
160	320	120/60
170	340	60
150	300	150
140	205	180

Oliet et al. (1958) reported that temperatures vary in different areas of the sterilizer. A warm-up time of at least 20 minutes is recommended to ensure uniform temperatures in these sterilizers. Grossman (1974) recommended the use of salt media sterilization because the accidental introduction of metal or glass clinging to the endodontic instruments into the root canal may cause blockage.

Some handpieces can be sterilized by dry heat. The handpieces should be carefully cleaned and lubricated with special heat resistant oils. Other handpieces, which have sealed bearings or which have been pressure lubricated with appropriate oils can be autoclaved. The instructions given by respective manufacturers regarding the cleaning, lubrication and sterilization are of importance and should be followed.

Ethylene Oxide Gas Sterilization

Ethylene oxide gas is an alkaline, noncorrosive agent, highly penetrative that infiltrates packaged medical devices to kill bacteria, spores and viruses. Ethylene oxide (ETO) is toxic and flammable or explosive at low temperatures (flash point of –20°C), so it is used on products that could get damaged or cannot withstand high temperature processes used to sterilize objects sensitive to temperatures greater than 60° such as plastics, optics and electricals. It destroys microorganisms by alkylation and causes denaturation of nucleic acids of microorganisms. It is highly toxic, irritant, mutagenic and potentially carcinogenic and should not be used where heat sterilization of an object is possible. It is highly flammable, but when mixed with carbon dioxide this danger is minimized.

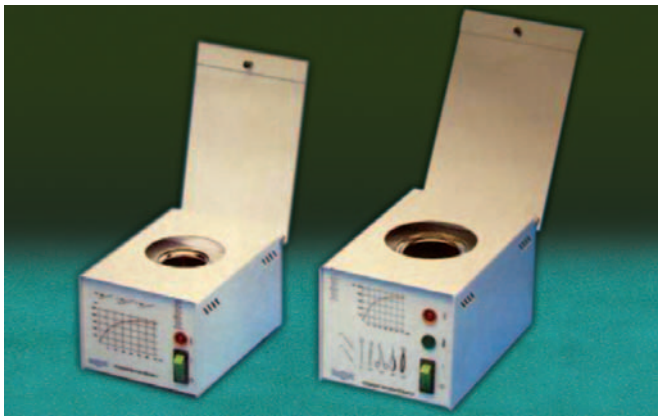


Fig. 6.7: Glass beads sterilizers

It is an excellent sterilizer of heat sensitive items. It is ideal for electric equipment, flexible fiber endoscopes and photographic equipment. As it is highly toxic, it causes blister on contact with living tissues. The duration that the gas should be in contact with the material to be sterilized is dependent on temperature, humidity, pressure and the amount of material.

Roberts and Rendell-Baker (1972) reported that once exposed to the gas, some objects such as plastic require 1–7 days to degas. This process may be hastened by warming the objects during the degassing phase. It is mainly used in industries for presterilizing single use medical devices.

The advantages are: (i) it penetrates extremely well, even through plastics, (ii) it can be used at a low temperature, (iii) it leaves no residue, (iv) it is a deodorizer, (v) it is comparatively nontoxic and (vi) many heat sensitive articles, e.g. plastic, rubber, can be sterilized. The disadvantages include: (i) high cost of the equipment and (ii) toxicity of the gas and the need for venting it, (iii) explosive and inflammable and (iv) longer period of aeration.

Chemical Vapor Sterilization

This method uses a combination of dry saturated steam and formaldehyde to kill bacteria, spores and most viruses. The destruction of microorganisms is due to the double action, by the heat and chemical (formaldehyde). Formaldehyde acts by alkylation of the nucleic acids, which are responsible for synthesis of proteins. It takes longer time than an autoclave and shorter time than dry heat method. The required combinations of temperature and pressure are 127–132°C/270°F at 20–40 psi for 30 minutes. The advantages of this method are: (i) lack of corrosion of instruments, (ii) shorter duration of sterilization cycle and (iii) the sterilization is achieved at a low temperature (73°C); hence, it is suitable for heat sensitive equipment and items with plastic components, which might get damaged by other processes. The disadvantage is that it requires provision of adequate ventilation to expel chemical vapors released from the chamber at the end of the cycle. This type of chemical

sterilizer is also called Harvey sterilizer or Chemiclave. It uses chemical solution containing 0.23% formaldehyde, 72.38% ethanol (ethylmethyl, ketone solution), acetone, ketone, water and other alcohols. It is suitable for handpieces, burs—carbon steel and diamond, orthodontic wires, bands, pliers, etc.

Irradiation

Radiation used for sterilization is of two types: (i) ionizing radiation, e.g. X-rays, gamma rays and high speed electrons and (ii) nonionizing radiation, e.g. ultraviolet light and infrared light. These forms of radiation can be used to kill or inactivate microorganisms.

Ionizing Radiation

It is effective for heat labile items. Bellamy (1959) reported that it has great penetrating properties. It is commonly used by the industry to sterilize disposable materials such as needles, syringes, swabs, culture plates, catheters in bulk, suture material, cannulas and pharmaceuticals sensitive to heat and various types of plastic materials including disposable plastic heart-lung machines. The lethal action of this radiation is believed to be due to its effect on the DNA of nucleus and on the other vital cell components. There is no appreciable rise in temperature. High-energy gamma rays from cobalt-60 are used to sterilize such articles.

Nonionizing Radiation

Two types of nonionizing radiations are used for sterilization: (i) ultraviolet and (ii) infrared.

- **Ultraviolet rays:** It is absorbed by proteins and nucleic acids and kills microorganisms by the chemical reactions. It sets up in the bacterial cell. It has low penetrating capacity and its main application is purification of air in operating rooms viz. to reduce the bacteria in air, water and on the contaminated surfaces. All forms of bacteria and viruses are vulnerable to ultraviolet rays below 3,000 atmospheric pressure. Excessive exposure of skin can produce serious burns. Care must be taken to protect the eyes while using UV radiation for sterilization. Now, UV chambers are available for storage of sterilized packages **(Fig. 6.8).**
- **Infrared rays:** It is another form of dry heat sterilization. It is a convenient method of sterilizing a large number of syringes sealed in metal container, within a comparatively short span of time.

It is most commonly used to purify air such as in the operating room. Infrared is effective, however, it has no penetrating ability. It is largely limited in medical field to air sterilization and the preparations of immunizing agents by bacterial or viral attenuation.

Boiling Water

Water maintains and conducts heat extremely well. Boiling water produces a temperature of 100°C at normal atmospheric pressure. It requires 10 minutes exposure to this temperature, to kill many bacteria and some viruses (including Human Immunodeficiency Virus- HIV and Hepatitis B Virus-HBV). However, prolonged time of 24 hours is required to kill bacterial spores, and even this prolonged time will not kill many viruses. Hence, boiling water is not recommended for sterilization of tissue penetrating instruments. Cutting instruments should not be sterilized by boiling as they loose their sharpness.

Oil

Hot oil baths have been used for sterilization of metallic instruments. At a temperature of 175°C, submersion for 15 minutes is required for sterilization. The disadvantages of using oil include poor penetration, poor sporicidal activity, presents a fire hazard and is difficult to remove from instruments such as handpieces without recontamination. It should not be used for hypodermic syringes or needles because of the danger of oil embolization.



Fig. 6.8: UV ray chamber

STORAGE OF STERILE GOODS

Crump (1966) reported that the storage of instruments is also a problem. The pattern of storage varies from place to place. They are either stored in drawers or in containers, in packs or sterile trays. The maintenance of sterility during transportation and storage is of utmost importance.

Packs should be stored with the following considerations:

- Instruments are kept wrapped until ready for use.
- To reduce the risk of contamination, sterile packs must be handled as little as possible.
- Sterilized packs should be allowed to cool before storage; otherwise, condensation will occur inside the packs.
- To prevent contamination from rodents, ants and cockroaches, the store must be subjected to adequate pest control.
- Materials should be stored at least 8" off the floor and 18" from the ceiling.
- Sterile packs must be stored and issued in correct date order. The packs, preferably, are stored in drums which can be locked. Preset trays and cassettes are useful, as the instruments can be organized as per the procedure.

DISINFECTION

Disinfection (high-level disinfection) is the term used for destruction of all pathogenic organisms, such as vegetative forms of bacteria, mycobacteria, fungi and viruses, but not bacterial endospores, from inanimate surfaces such as walls, furnishings and equipment; and antisepsis is the term applicable to living tissues such as skin and mucous membrane.

Methods of Disinfection

Cleaning

Cleaning with a detergent and clean hot water is an excellent mode of disinfection. It removes almost all pathogens including bacterial spores.

Disinfection by Heat

Heat is a simple and reliable disinfectant for almost anything except living tissues. The hot water used in the process of physical cleaning greatly enhances the quality of disinfection. Mechanical cleaning with hot water provides an excellent quality of disinfection for a wide variety of purposes.

Low Temperature Steam

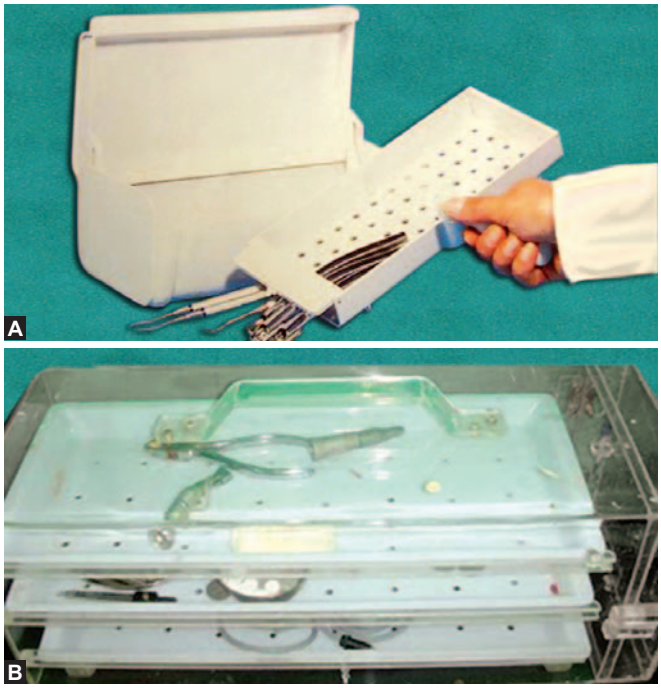
This method kills most vegetative microorganisms and viruses by exposure to moist heat. The typical conditions are exposure to steam at a temperature of 73°C for a period of 20 minutes below atmospheric pressure. By this method, items can be easily cleaned as the coagulated protein residues can be easily removed. This makes it a useful procedure to render dirty instruments safe to handle prior to sterilization.

Chemical Agents

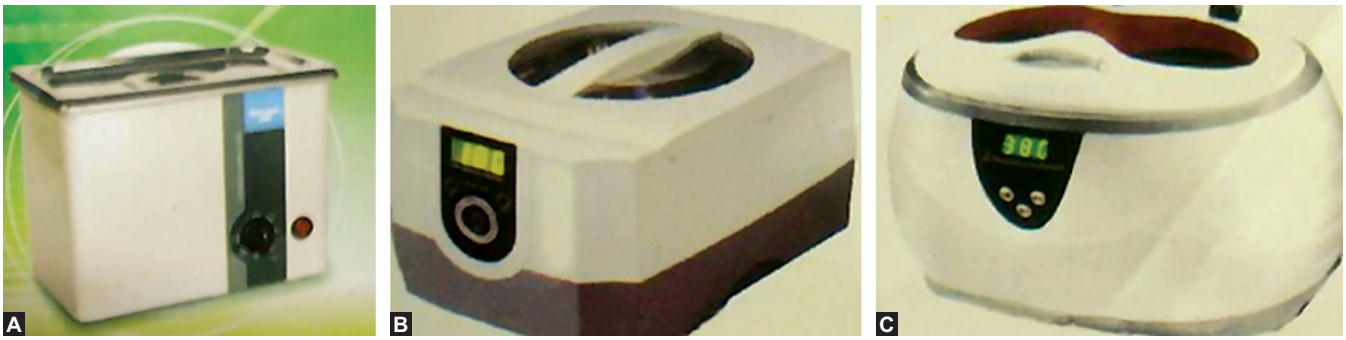
They are used to disinfect the skin of a patient prior to surgery and to disinfect the hands of the operator. No available chemical solution will sterilize instruments immersed in it. Secondly, there is a risk of producing tissue damage, if residual solution is carried over into the wound while it is being used. The chemicals used are: aldehydes, diguanides, phenolics and halogen derivatives **(Figs 6.9 and 6.10).**

Aldehydes

- **Formaldehyde:** This is a broad-spectrum antimicrobial agent, which is used for disinfection. It is a hazardous substance, flammable and irritant to the eye, skin and respiratory tract. This is used up to 50°C and has limited sporicidal activity. It is used for large heat



Figs 6.9A and B: Chemical sterilization box



Figs 6.10A to C: Ultrasonic cleaners

sensitive equipment such as ventilators and suction pumps excluding rubber and some plastics.

- **Glutaraldehyde:** It is toxic, irritant and allergenic. It is a high-level disinfectant. It is applicable where heat cannot be used. It is active against most vegetative bacteria (including Mycobacterium tuberculosis), and some viruses (including HIV and HBV), fungi and bacterial spores. It is frequently used for heat sensitive material. A solution of 2% glutaraldehyde (Cidex) requires immersion of 20 minutes for disinfection and 6–10 hours of immersion for sterilization.

Diguanides

Chlorhexidine is active against number of bacteria including Staphylococcus aureus and some gram-negative bacteria but not spores, fungi and viruses. It can be prepared in alcohol or with cetrimide. It gets inactivated in the presence of soap, pus, plastics, etc. It is mainly used for cleaning skin and mucous membrane; 0.5% chlorhexidine in 70% alcohol or chlorhexidine with cetrimide (Cetavlon or Savlon), or a 4% solution with detergent (Hibiscrub) as a preoperative scrub. As a 0.2% aqueous solution or 1% gel, it can be used for suppression of plaque and postoperative infection.

Halogens

Hypochlorites: They are active against bacteria, spores, fungi and viruses, including hepatitis B virus. They are readily inactivated by blood, pus and dilution. Sodium hypochlorite solution (household bleach) 1:10, freshly prepared solution, is an effective surface disinfectant.

DISINFECTANTS

Disinfectants may be classified on the basis of their properties into the following: bactericidal, sporicidal, viricidal and fungicidal. They are usually used for decontamination of inanimate objects. The increase in their efficiency is related to increased toxicity. Certain limitations have to be considered prior to embarking on their use:

- **Inactivation:** The presence of debris, blood or pus, inactivate the agents; hence, the instruments and the surfaces to be disinfected should be thoroughly cleaned.
- **Concentration:** Many agents retain their effectiveness in concentrated forms and some agents at certain temperatures.
- **Stability:** Certain agents are not stable, particularly when used in dilute forms and get deteriorated on storage. These agents are required to be prepared freshly. Such dilute solutions loose their efficacy and become contaminated and grow bacteria and yeasts.
- **Adequate contact:** Disinfection requires an appropriate period of exposure to the agent.
- **Neutralization:** Substances such as soaps and detergents may neutralize the actions of the disinfectants.

Alcohols: Low-level Disinfectant

Ethanol and isopropyl alcohols are frequently used as antiseptics. Alcohols possess some antibacterial activity against some Gram-positive and Gram-negative bacteria, especially against *M. tuberculosis*. Alcohols act by denaturing proteins. They are not effective against spores and viruses. Spaulding (1939) found that to have maximum effectiveness the alcohol must have 10 minutes contact with the organisms. Solutions of 70% alcohol are more effective than higher concentrations, as the presence of water speeds up the process of protein denaturation as reported by Lawrence and Block (1968). The alcohols do not function as disinfectants when instruments, handpieces or other equipment are simply wiped with them since they evaporate quickly. Instruments made of carbon steel should not be soaked in alcoholic solutions, as they are

corrosive to carbon steel. Rubber articles absorb alcohol and prolonged soaking can cause a reaction when the article subsequently comes in contact with living tissue.

Alcohols can dissolve cements holding instruments, and plastics may harden or swell in their presence.

Aqueous Quaternary Ammonium Compounds

Benzalkonium chloride (Zephiran) was commonly used both as an antiseptic and a disinfectant. Neugeboren et al. (1972) reported that the spectrum of their antibiotic activity is similar to alcohols, being limited largely to Gram-positive organisms and some Gram-negative organisms. It is not effective against spores, viruses and *M. tuberculosis*. Hotchkiss (1946) reported that the molecule is a strong surfactant that increases the bacterial permeability of bacterial cell wall and permits escape of phosphorous and nitrogen. It also denatures intracellular proteins.

The effectiveness of these compounds depends on strength, activity and duration of contact. In many circumstances, these goals are not achieved. Certain studies have reportedly implicated quaternary ammonium compounds contaminated with certain pathogens, such as *Pseudomonas, Enterobacter* and other Gram-negative organisms with outbreaks of nosocomial (hospital-acquired) infections.

Phenolic Compounds: Intermediate Level, Broad-Spectrum Disinfectant

Phenol itself is toxic to skin and bone marrow. The phenolic compounds were developed to reduce their side effects but are still toxic to living tissues. These compounds in high concentration are protoplasmic poison, and act by precipitating the proteins and destroy the cell wall.

Lawrence and Block (1968) reported that their spectrum of activity includes lipophilic viruses, fungi and bacteria but not spores. The newer synthetic combinations seem to be active against hydrophilic viruses; hence, these are approved by ADA for use as surface or immersion disinfectant.

These compounds are used for disinfection of inanimate objects such as walls, floors and furniture. They may cause damage to some plastics, and they do not corrode certain metals such as brass, aluminum and carbon steel. It has unique action that it keeps working for longer period after initial application known as "residual activity".

ANTISEPTICS

An antiseptic is a chemical disinfectant (usually bacteriostatic in the concentration it is used) that can be diluted sufficiently to be safe for application to living tissues (intact skin, mucous membranes and wounds) while still retaining its antimicrobial property. They are less toxic than the disinfectants or the agents used for sterilization. Notable antiseptic agents include—alcohols, aqueous quaternary ammonium compounds, hexachlorophene and iodophor compounds.

Alcohols

Two types of alcohols are available: (i) ethyl alcohol, (ii) isopropyl alcohol. They are frequently used for skin antisepsis as surface disinfectant prior to needle puncture. They are good organic solvents. Their benefit is derived primarily in their cleansing action. The alcohols must have a prolonged contact with the organisms to have an antibacterial effect. This contact is prevented due to its rapid evaporation.

Alcohol is sometimes used as a rinse following a surgical scrub. Its effectiveness lies in the solvent action and not in its antibacterial properties. Ethanol (ethyl alcohol) is employed in the concentration of 70% as a skin antiseptic. It has poor activity against bacterial spores, fungi and viruses. Isopropyl alcohol is an inflammable secondary alcohol with an unpleasant burning taste. It is about twice as toxic as ethyl alcohol. It is slightly more potent a germicide than ethyl alcohol and has a marked degreasing action. It is used in the concentration of 60–70% v/v for disinfection of skin. The alcohols do not have reliable sporicidal, viricidal or fungicidal action; hence, they are not useful for sterilizing surgical instruments.

Aqueous Quaternary Ammonium Compounds

Benzalkonium chloride (Zephiran) is the most commonly used antiseptic. Its spectrum of activity is primarily Gram-positive bacteria. It is well tolerated by living tissues. It is not widely used because of its narrow spectrum of activity.

Hexachlorophene Compounds

These compounds are used for many years for surgical scrubs and preoperative preparation of the surgical site. They are effective against Gram-positive organisms, less

effective against Gram-negative organisms and fungi and are not effective against viruses, spores and *M. tuberculosis*. Skin cleansing with an agent causes reduction in surface bacteria. The bacteria in crevices and follicles begin multiplying immediately. The studies by Best et al. (1950), and Lowbury and Lilly (1960) have shown that repeated scrubs allow hexachlorophene buildup on the skin. This caused a reduction in skin bacterial count. Harber et al. (1967) reported that hexachlorophene solutions are susceptible to bacterial contamination. Smylie et al. (1959) have shown that hexachlorophene to be fully effective must be applied to dry skin because the combination of water and protein will precipitate it. Despite the disadvantages, these compounds are valuable solution for surgical preparation in patients sensitive to iodine.

Iodophor Compounds: Intermediate Level, Broad-Spectrum

It is used for surgical scrub, soaps and surface antisepsis. It can discolor surfaces and clothes. Usually effective within 5–10 minutes. Many studies have shown that iodophor compounds are the most effective antiseptics. Iodine is complexed with organic surface active agents such as polyvinylpyrrolidone (Betadine, Isodine). Their activity is dependent on the release of iodine from the complex. The surface agent is film forming; this prevents the solution from staining clothes or skin. Boswick et al. (1961) have shown that skin sensitivity to the iodine is not a major problem because of its complexing action.

These compounds are effective against most bacteria, spores, viruses and fungi. These are the most commonly used surface disinfectants along with hypochlorite. Concentrated solutions have less free iodine. Iodine is released as the solution is diluted. An appropriate dilution is 1:2:3 parts of iodophor (Iodine-Povidone-Iodine) and distilled water respectively.

The advantages are: (i) low toxicity, (ii) prolonged residual effect, (iii) inexpensive and (iv) odorless. Geraci (1963) reported that these compounds build up on the skin after successive scrubs and that this provides long lasting antibacterial activity.

Chloride Compounds

Available as two types: (i) sodium hypochlorite (household bleach) (ii) chlorine dioxide.

- Sodium hypochlorite—rapid action (3 minutes) surface disinfectant, highly corrosive and has strong odor. A solution of one part of 5% sodium hypochlorite with nine parts of water is used.
- Chlorous acid and chlorine dioxide is high-level disinfectant in 3 minutes.

OPERATING ROOM PROCEDURES

The ceiling, walls and floors are regularly disinfected, especially following a contaminated case. The operating rooms should have two sets of doors. The operating theater should provide a safe, efficient and user-friendly environment, being at the same time, free from bacterial contamination as far as possible. The access to operation theater and the recovery area is restricted to operation theater personnel, who are required to don (wear) special scrub dress before entering the operating room area. The scrub suit comprises of a pair of pants/skirt/pyjama and a shirt/blouse. A surgical cap is used to cover the hair completely. A mask is then placed and tied over the nose and mouth. Theater shoes or shoe covers may be used. Conductive shoes are helpful, as these prevent build-up of static electricity which can cause spark and subsequent explosion involving the volatile inflammable anesthetic gaseous agents. The shoes also lessen the chance of patient electrocution. The various electrical devices surrounding and attached to the patient in the operating theater are potential sources of electrical shock. Arbeit et al. (1972) reported that one-tenth of a milliampere of a 60 cycles per second current can produce ventricular fibrillation. The surgeon, with the conductive shoes, becomes an alternative pathway for aberrant currents. Sterile clothing, masks, gloves and special shoes or shoe covers are worn during the operation **(Figs 6.11 and 6.12).**

Once the patient is prepared and draped, only those personnel who have scrubbed, gowned and gloved may work at the surgical site. The backs of those, who are gowned, are considered nonsterile and also the areas below the waist unless the gowns are long and back gowns are worn. Hence, one must be careful to keep the arms above the waist when not operating. The mask and surgical cap are not sterile, hence should not be touched. Some of the hospitals have the operating light's handles, which are detachable and sterilizable that can be adjusted by the surgeon. Other lights must be adjusted by other members of the nonscrubbed staff.

The operation theaters are disinfected by fumigation. Fumigation can be achieved by the use of fumigators as well as potassium permanganate reaction technique.





Fig. 6.11A and B: Cleaning and disinfection of operation theatre prior to surgery: (A) Thorough cleaning of the floor; (B) Cart containing all necessary disinfectant and mops etc.should be ready to be used between surgeries



Fig. 6.12: Operation theater dressing code

Table 6.2: Parameters and the optimum levels for effective fumigation

Sl. No.	*Parameters*	*Optimum levels for effective fumigation*
1.	Relative humidity	Over 70%
2.	Temperature	30–40°C
3.	Formaldehyde levels	5 ppm or more

Fumigation is initiated after setting up of the instrument (STERI-TRAX) in place. The chemical used is 40% formalin. Fumigator is set for 30 minutes **(Table 6.2).**

Relative Humidity

Relative humidity (RH) plays a major role in fumigation. A minimum 70% of humidity is essential. Higher the humidity the better is the disinfection. Water used in the fumigator along with the fumigant (formalin) helps to achieve and maintain the desired RH.

Temperature

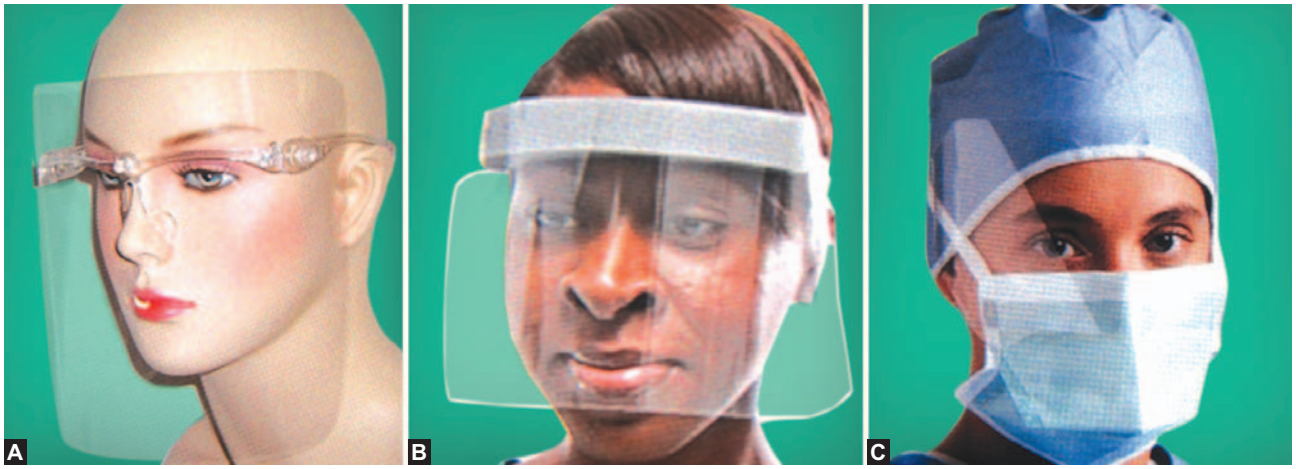
Evaporation of gaseous fumigant is more at the higher temperature. The use of fumigator makes the temperature factor less important since it allows the formation of mist in the operation theater.

Formaldehyde Levels in the Operation Theater

The dose of formalin is usually decided by the size of the room. As a general rule, about 180 mL is used for a room of the size 1,000 cubic feet (= 10 × 10 × 10 feet).

Masks

Disposable masks made of synthetic fibers are better and contain filters made of polyester (e.g. Bard Vigilon) or polypropylene (e.g. Filtron).



Figs 6.13A to C: Full cover transparent shield for face



Figs 6.14A to C: Eye protection during surgery

Surgical antifog masks with flexible nosebands are available which follow facial contours and retain a high efficiency of filtration. Masks provide protective function for the wearer against blood-borne viruses, as part of a policy of universal precautions. Full-face visors offer better protection **(Figs 6.13A to C)**.

Eye Protection

It is advisable to wear eye protection during any procedure, which is likely to generate droplets of blood or other body fluids. It also protects mucous membrane of the eyes of the wearer from blood-borne viruses. A variety of lightweight antifog goggles, glasses and visors are available which do not obstruct vision **(Figs 6.14A to C).**

Hair or Beard Cover

Long hair must be tied up and all hair must be completely covered by close fitting cap made of synthetic material. Beards should also be completely covered.

Footwear

There is little evidence that floor plays a significant role in spread of infection in hospital. Staff members should wear clean, comfortable, anti-slip and antistatic shoes. Footwear should fit well and avoid producing "bellows effect." Construction should be significantly robust to protect the feet from sharp injury.

Antiseptic Environment

The principle is to minimize bacterial contamination, especially in the vicinity of operating table; the concept of zones is useful and must be employed.

- Outer or general access zone, e.g. patient reception area and general office
- Clean or limited access zone, e.g. the area between reception and general office, dispersal area, corridors and staff room.
- Restricted access zone, e.g. for those properly clothed personnel engaged in operating theater activities, anesthetic room, etc.
- Aseptic or operating zone, e.g. the operating theater
- **Airflow:** The air may be filtered or allowed to flow past an ultraviolet radiation device to reduce bacterial counts. Operating theaters have two types of airflow: (i) conventional and (ii) unidirectional. The normal turbulent airflow through theater is necessary to maintain humidity, temperature and air circulation. Besides, an increased rate of air change is necessary to reduce the number of contaminated particles over the patient. Air is pumped into the room through filter and passed out of vents in the periphery of operating room and does not return to operating room.

Hand Scrub Techniques

Hand scrub is the first step toward aseptic surgical technique. Several studies have shown that it is the single most important and successful method of controlling the spread of infection in the hospital environment.

Wise et al. (1959) have shown that 20–30% of surgeon's gloves get punctured by the end of operation. Cole and Bernard (1964) have documented the outpouring of bacteria from the surgeon's hands through the punctured gloves into the wound. The gloves are likely to get punctured or ripped while working with wires or instruments. It is therefore imperative to have clean hands inside the gloves.

The purpose of hand scrub is twofold: The first is to remove the superficial contaminants and loose epithelium. This is achieved by the mechanical action of the brush. The second purpose is to reduce bacterial count on the skin. Selwyn and Ellis (1972) reported that the use of the iodophor scrubbing solutions results in the effectiveness of the scrub in reducing the surface bacterial count. About 20% of skin bacteria are inaccessible, residing in the follicles, crevices and lipids of the skin. The residual antiseptic scrub solution also helps in keeping the surface bacterial count low. Many techniques of hand scrub have been suggested.

All jewellery be removed before washing. The nails should be checked for cleanliness. All gross subnail contamination should be removed. The scrubs can be prepacked impregnated with soap solutions or can be reusable with a soap dispenser. Nails should be scrubbed first thoroughly with a brush. The arms are wetted to a few inches above the elbows.

The scrubbing begins at the tip of one finger of one hand. The scrubbing is continued along the skin surfaces of fingers and the inter finger webbing. The scrubbing is continued until all the surfaces of the hand are completed. Then the hands are cleaned along the forearms and the scrubbing is progressed toward the elbow extending 2" above the elbow. In the similar manner, the other hand is scrubbed beginning at the fingertips and scrubbing toward the elbow.

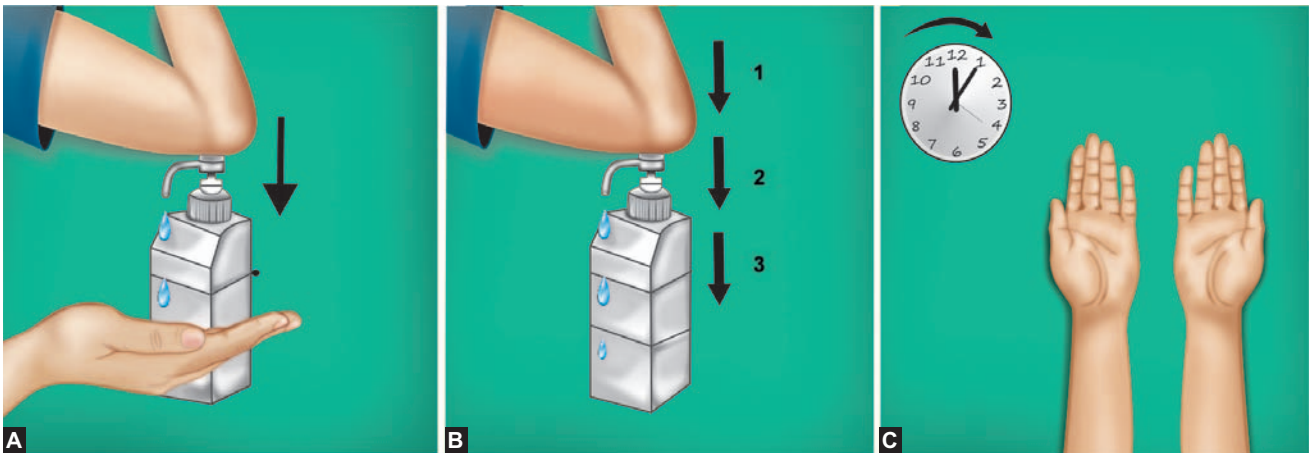
A scrubbed area should not be touched again because of the possibility of contamination from an unscrubbed area. Dunphey and Way (1973) recommend that scrubbing procedure may be done for approximately 10 minutes. After the scrubbing of both the arms, the brush is discarded and the arms are rinsed of excess soap. The rinse should be done with arms elevated above the elbow height to enable the water to drain from the fingertips progressing down the arms and the elbows. The arms are not rubbed during the rinse. Only the superficial excess soap is removed. Dobson and Shulls (1967) have shown that the residual soap provides about 3 hours of antibacterial action.

The surgeon approaches the scrub nurse for the sterile drying towel. The technique of drying begins at the fingertips of one hand and progresses down the arm. Then, with the opposite side of the towel, the other arm is dried in a similar manner.

Hand Disinfection

There are some proprietary preparations available for preoperative washing of hands of surgeons and assistants which have a bactericidal effect and which do not cause excessive drying of skin **(Fig. 6.15).** The preparations available are:

- Hibiscrub and Phisomed—contains 4% chlorhexidine gluconate
- Betadine contains 7.5% Povidone-Iodine
- Three percent para-chloro-meta-xylenol (PCMX)
- Soap containing disinfectants like hexachlorophene
- Seventy percent hibisol (2.5% chlorhexidine in 70% alcohol) lotion may be applied as an extra precaution.



Figs 6.15A to C: Surgical hand disinfection: (A) Disinfectant soap solution is dispensed on the palm, 3 ml per push, (B) Three such pushes give adequate quantity for hand scrub, Rub into hands, grooves and up to elbows for 5 minutes and scrub with the brush, (C) You are ready to put on gloves

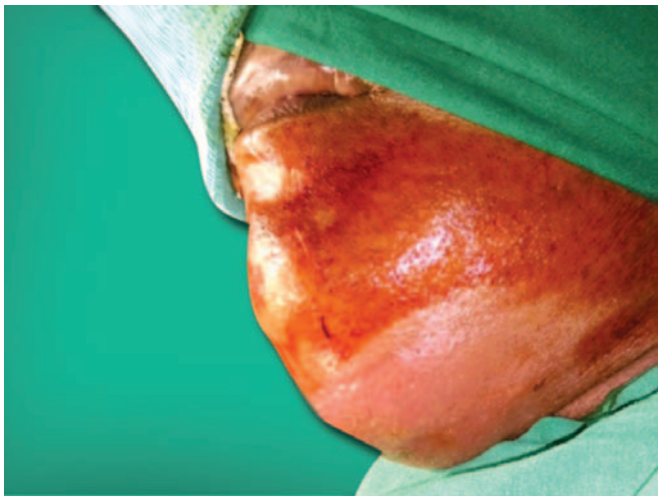


Fig. 6.16: Preparation of surgical site and draping the patient

Washing must be continued for 5 minutes in running water. This is followed by drying of hands and forearms.

Gloving

All protective barrier techniques should be employed. Hand gloves—they help to protect the operator from infection by bacteria and viruses from patient's blood. They may be washed and sterilized, and worn again for more than one operation provided they have not been punctured or damaged. Gloving is essential to protect both the surgeon and the patient from blood borne viruses and to prevent wound becoming contaminated with the surgeon's skin flora.

There are two types of gloves:

1. **Latex gloves:** It is a clear and the most common type of glove.
2. **Brown milled rubber gloves:** These are thinner than latex gloves and provide a better tactile sensation. However, they are more fragile and require more frequent changes during the operation. The "hand to glove" and "glove to glove" technique of donning the gloves should be employed. Double gloving affords extra protection but at the expense of reduced sensitivity and dexterity, and possible discomfort.

Preparation of the Surgical Site

Hair in the area of surgery is removed, preferably just prior to scrubbing the skin. Shaving the area at night before produces small abrasions on the skin and resident bacteria multiply as a result of injury. This problem can be overcome by decreasing the time interval between the shave and the skin preparation. A lubricating ointment should be applied to patient's eyes and they are covered. The external auditory meatus is plugged and blocked, if bleeding in the vicinity is anticipated.

The scrubbing should begin in the center of the site to be prepared and move outward concentrically, away from the site of operation. This avoids contamination of already scrubbed site of surgery **(Fig. 6.16).**.

Studies by Zinner et al. (1961), Scopp and Orvieto (1971) and Cutcher et al. (1971) have shown remarkable reduction in bacteremia during tooth extraction following

preparation with iodophor or phenol-alcohol mouth rinses. These transient bacteremias are not of importance in normal patients; however, this preparation is very important in the following categories of patients:

- History of Rheumatic Heart Diseases: Prosthetic heart valves, prosthetic hip replacement
- Shunts for dialysis
- Patients on immunosuppressive therapy
- Other debilitating diseases.

It is important to reduce contamination by the patient's own normal flora and the resistant bacteria acquired from hospital environment. This significantly reduces the incidence of postoperative infections.

Much depends upon the type of surgery to be performed. For all extraoral procedures, a presurgical scrub is recommended. The skin in and around the site is prepared. The solutions used are cetavlon and betadine (povidone-iodine). For intraoral surgery, a circumoral preparation should precede to prevent transfer of resident skin flora to intraoral site. The same solutions may be used. Mouth can also be disinfected by the use of 0.2% chlorhexidine just prior to surgery.

The iodophor compounds are by far the most effective solutions for skin preparation. Prigot and Roc (1962) have shown that they do not interfere with wound healing.

Draping the Patient

The purpose of draping a patient is to isolate the field of surgery from other parts of body that have not been prepared for surgery and also from nonsterile equipment. Patient should be draped with sterile towels. Patient's hair should be covered with sterile head cover. Another towel should cover chest and shoulders. The suction tubing is clipped to this towel, so as to prevent it from falling down and from touching nonsterile and nondisinfected surfaces. The site of needle puncture in oral mucosa preferably dried and an antiseptic, such as chlorhexidine 0.5% or povidone-iodine solution, may be applied.

Disposable Items

Many disposable items are supplied in sterile packs by their respective manufacturing companies. These are sterilized by methods such as gamma radiation. The sterility of such products can be relied upon, if the supplier is from a reputable manufacturer and the wrapper seal is not broken. The single use surgical blades and suture needles are recommended **(Figs 6.17A to D).**

Other Precautions

Preoperative Gingival or Periodontal Care

It is necessary that the interdental embrasures are rendered free of plaque, food debris, and if calculus is present, it is desirable that the patient should undergo preoperative scaling and the patient is given oral hygiene instructions. This helps in keeping the bacterial population to a minimum.

Use of Antimicrobial Mouth Rinse

The use of an antimicrobial mouth rinse preoperatively reduces the number of bacteria considerably. The action is a combination of mechanical removal and antisepsis. The recommended rinses contain diguanides like chlorhexidine.

Use of Antibiotic Prophylaxis

The clinician relies on the use of antibiotics prophylactically to reduce the incidence of postoperative infection. It is prudent that clinician should employ adequate aseptic procedures and perform meticulous surgical procedure obviating the need of using antibiotic prophylactically. Antibiotics should be avoided when there is no real and specific indication as it causes bacterial resistance and super infection.

Handpieces

Ham et al. (1970) evaluated sterilization of handpieces. The sterilization of handpieces is frought with many



Figs 6.17A to D: Disposable items—presterile packs: (A) Collagen membrane; (B) Gelfoam; (C) Vicryl suture; and (D) Synthetic bone graft



Figs 6.18A to D: (A) Handpieces, tube, motor is placed in the cassette for sterilization; (B) After use handpieces are cleaned with spray rotor for removing the deposits with pressurized air; (C and D) A Universal machine to clean, lubricate disinfect and sterilize handpieces

difficulties. The saliva, bone debris, bacteria and other contaminants get sucked inside the handpiece during their usage. Amongst the handpieces that are available in market, only a few are autoclavable. Autoclaving of handpieces leads to increase in corrosion, rendering subsequent cleaning more difficult. The handpieces after their sterilization require lubrication prior to their usage. This lubrication may further lead to contamination. Immersion in boiling oil has been advocated; however, the oil that collects on the inner side of handpieces is difficult to be removed which ultimately lands up into the surgical sites. Disinfection of handpieces is not adequate **(Figs 6.18A to D)**.

Formalin Disinfection

Equipment, which is seriously contaminated such as anesthesia apparatus is cleaned by this method.

Common Disinfectants

- **Chlorhexidine (Hibitane):** There are several commercial preparations. It is used for skin and body tissue disinfection. It is used with isopropyl alcohol to enhance its efficiency for skin. It can also be used with cetrimide to have detergent activity.
- **Phenolics:** These are not used for skin or tissues. It is used for areas with significant soiling. It should not be used in food preparing areas.
- **Glutaraldehyde:** Used for disinfection of heat sensitive instruments, e.g. endoscopes. It should not be used for environmental cleaning.
- **Isopropyl alcohol preparation:** They are used for disinfecting skin, e.g. venipuncture.
- **Povidone-iodine:** Solutions containing a detergent are employed for preoperative skin preparations.
- **Hypochlorites (Chloros, Domestos):** These act by release of chlorine. It is readily inactivated by organic matter, pus, etc. It is useful for food preparation, feeding bottles and rubber teats. It is useful in areas where there are hazards of viral hepatitis.

Points to Remember

- Definitions of various terminologies
- Transport of used items
- Cleansing of instruments
- Packaging or wrapping instruments for autoclaving
- Methods of sterilization
- Storage of sterile goods.

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CHAPTER 7 Infection Control

INTRODUCTION

The control of cross infection and cross contamination in dental surgery is the focus of much debate and as a result, recommendations and guidelines are regularly reviewed in the light of available latest information.

The implementation of an infection control policy and standard operating procedures requires a thorough knowledge of the risks and the practical measures to be taken using the best practice guidelines and recommendations from Government health department. Clinicians have a duty to take appropriate precautions to protect their patients, their staff and themselves from the risk of cross infection. This chapter contains detailed guidelines on control of cross infection.

OBJECTIVE

Elimination or reduction in spread of infection from all types of microorganisms is the main objective of infection control. It is the duty of every dental practitioner to care for all patients, including those with infectious diseases. The clinician also has a professional responsibility for implementing effective infection control to protect other patients, and a responsibility for safe practice for all members of the dental team. Sir William Osler once remarked that "Soap and water and common sense are the best disinfectants". Despite the advent of numerous disinfectants, thereafter, the basis of infection control still remains the same as the above-mentioned basic procedure.

INFECTION

Infection is the deposition of organisms in the tissues and their growth resulting in a host reaction. In case the response of a host is minimal or nil, it is usually termed as "colonization". The acquisition of a strain of *Staphylococcus aureus*, which grows in anterior nares, without causing any tissue reaction, and the person is not aware that he is a carrier, is an example. On the other hand, the same strain may cause an infection at the angle of lips (angular cheilitis) in the same person.

The number of organisms required to cause an infection is termed "the infective dose". The infective dose is dependent on:

- Virulence of the organism
- Susceptibility of the host
- Other important and relevant factors are age, pre-existing disease and drug therapy, etc.

Infection Control

Infection control involves two basic factors:

1. Prevention of spread of microorganisms from their hosts (patients and clinicians)
2. Killing or removal of microorganisms from objects and surfaces.

Cross Infection

Cross infection is defined as the transmission of infectious agents among patients and staffs, within a clinical environment. In dentistry, the source of infection may constitute:

- Patients suffering from infectious diseases
- Patients who are in the prodromal stage of certain infections
- Healthy carriers of pathogens.

Pathways of Cross Infection

There are six common pathways:

1. Patient to practitioner
2. Practitioner to patient
3. Patient to patient
4. Clinic to community

5. Clinic to practitioner's family
6. Community to patients.

Patients suffering from acute illnesses usually do not seek dental treatment. The likely source of infection is usually a person who is in the prodromal phase of an infection and attends the clinic. The patient at this stage may appear healthy, but the saliva and blood may be infectious. The diseases which can spread easily in this manner are viral infections, such as measles, mumps and chickenpox.

Healthy carriers who are important factors in the transmission of disease can be classified as follows:

- **Convalescent carriers:** In this stage, the patient suffers an acute illness and apparently recovers. However, the blood and secretions serve as persistent reservoirs of the infective organisms. Such individuals can be identified on the basis of past history of infection.
- **Asymptomatic carriers:** These persons may have a subclinical infection; and are unaware of it. They give no history of past infection, hence cannot be diagnosed easily. These individuals may carry infective organisms in saliva and blood.

The classic example is that of hepatitis B virus (HBV) infection. It may manifest with or without symptoms, and the clinician may be faced with either convalescent or asymptomatic carriers of HBV infection.

Routes of Transmission

Transmission of infection within a dental surgery may occur via several routes:

- Direct contact of tissues with infective biological fluids, such as blood and oral secretions
- Indirect contact with contaminated instruments, equipment, or environmental surfaces
- Inhalation of aerosolized infective droplets/particles
- Direct inoculation into cuts and abrasions of unprotected skin or mucosa via contaminated sharps or instruments.

Infection through any of these routes requires that all three of the following conditions be present, "the chain of infection":

1. **Pathogen:** Sufficient infectivity and sufficient dose
2. Exposure portal through which the pathogen may enter the host.
3. Susceptible host.

Dental patients and Dental Health Care Workers (DHCWs) may be exposed to a variety of microorganisms via blood or oral or respiratory secretions. These microorganisms may include the following:

- **Bacteria:** Staphylococci, streptococci, *Mycobacterium tuberculosis (MTB)*
- **Viruses:** Herpes simplex virus (HSV) types 1 (HSV-1) and 2 (HSV-2), cytomegalovirus (CMV), HBV, hepatitis C virus (HCV), human immunodeficiency virus (HIV)
- Other bacteria and viruses, specifically those associated with upper respiratory tract infections. Some of the infectious agents of concern in dentistry and their possible routes of transmission are summarized in **Table 7.1.**

INFECTIOUS DISEASES OF CONCERN IN DENTISTRY

Bacterial Infections

Tuberculosis (TB)

This disease is caused by *MTB*. It is transmitted by inhalation, ingestion and inoculation. The two main

Table 7.1: Some infectious agents of concern in dentistry and their routes of transmission

Microorganisms	*Major transmission route*
Bacteria	
• Neisseria gonorrhoeae	Inoculation
• *Treponema pallidum*	Inoculation
• *Mycobacterium tuberculosis* (MTB)	Inoculation/inhalation Ingestion
• *Streptococcus pyogenes*	Inhalation
Viruses	
• Cytomegalovirus (CMV)	Inhalation
• *Hepatitis viruses:*	
▪ Hepatitis B virus (HBV)	Inoculation
▪ Hepatitis C virus (HCV)	Inoculation
▪ Hepatitis D	Inoculation
• Herpes simplex virus (HSV) types 1 (HSV-1) and 2 (HSV-2)	Inoculation
• Human immunodeficiency virus (HIV)	Inoculation
• Measles virus	Inhalation
• Mumps virus	Inhalation
• Respiratory viruses:	
▪ Influenza virus	Inhalation
▪ Rhinovirus	Inhalation
▪ Adenovirus	Inhalation
• Rubella virus	Inhalation

infections seen are in the form of tuberculous cervical lymphadenitis and pulmonary infection. Immunization with Bacillus Calmette-Guérin (BCG) vaccine adequately covers dental staff. In addition, gloves and masks should be worn. The inhalation, sedation and anesthesia equipment must always be treated with high-level disinfectants. It is worth remembering that *MTB* is highly resistant to heat and chemical disinfectants, as it has a thick lipid coat.

Syphilis

This is caused by *Treponema pallidum.* Transmission in a dental set up is not reported, probably, because the organism is highly labile. However, regular wearing of gloves offers adequate protection.

Gonorrhea

It is caused by *Neisseria gonorrhoeae.* It is more common sexually transmitted disease. There is no report of such a transmission episode in dental care set up. However, gloves offer adequate protection.

Legionellosis

It is caused by Gram-negative bacteria, which usually reside in warm and stagnant water reservoirs. They cause life-threatening pneumonias in elderly. The majority of infections are subclinical, while a minority causes pneumonia (Legionnaire's disease) and a flu-like illness (Pontiac fever). The organism is waterborne and is transmitted via aerosols. These factors indicate that there is a possibility that legionellosis may spread via water in the dental unit water systems, which are frequently aerosolized. There is evidence to indicate that *Legionella* species multiply in dental unit water systems, which sometimes remain unused for days.

The dental unit water systems should be flushed with fresh water before and after use and particularly prior to the treatment of the first patient in the morning to eradicate any contaminants. The dental staff should be informed of the long-term risk of legionellosis.

Viral Infections

Herpes Virus Infection

There are at least six herpes viruses: HSV-1 and HSV-2, varicella-zoster virus (VZV), Epstein-Barr virus (EBV), Cyto-megalo virus (CMV) and human herpes virus 6 (HHV6). A single exposure is sufficient for infection with these DNA viruses, which often results in the development of a lifelong latent infection.

Herpes Simplex Virus

This is the most common herpes virus transmitted to dental clinical staff. The major signs of primary herpes infection are acute illness with fever and malaise, cervical lymphadenopathy and ulcerative gingivostomatitis. Sometimes a recurrent infection, in the form of herpes labialis, occurs. This begins with discomfort at the site of infection and the appearance of clusters of small vesicles that soon rupture, followed by coalescence into a large ulcer. 90% of orolabial herpes simplex lesions are caused by HSV-1 and 10% by HSV-2; HSV infections of the fingers (herpetic whitlow) can be caused by direct contact with either a herpetic lesion or infected saliva. Patients who are immunocompromised, e.g. HIV positive, or those who are immunosuppressed, and those with cancer therapy, may have more frequent and prolonged episodes of herpes infections, and are a relatively common source of cross infection.

Transmission occurs by direct contact of abraded skin or intact mucosa with infected lesions or secretions. Transmission of infection to dental staff can result in primary herpetic stomatitis or herpetic whitlow. The latter is a painful infection on a finger characterized by vesicles, which precede skin breakdown and subsequent crusting. Treatment with acyclovir, taken when the premonitory signs are present, decreases the symptoms and duration of viral shedding and, possibly the number of recurrences in some patients. Wearing of gloves provides adequate protection against the virus.

Varicella-zoster Virus

This virus is the causative agent of both chickenpox and shingles; the former is the primary disease and the latter is the secondary disease, caused by the reactivation of the latent virus residing in sensory ganglia. Chickenpox is the mild form, and is mainly seen in children. Shingles can be painful and debilitating, especially if trigeminal ganglion is involved.

Chickenpox

It is highly contagious and spreads via airborne route. The nonimmune dental staff may contact the disease via inhalation of aerosols from a patient, who is incubating the disease, attends the clinic. Masks and gloves offer some protection.

Cytomegalovirus (CMV)

This virus has the characteristic ability to cause latent infections. The fetus, preterm neonates and

immunocompromised patients are at risk of serious disease. Congenital CMV syndrome is the most important, affecting the live births leading to encephalitis, microcephaly and mental retardation.

A possible link between risk for congenital defects in neonates of Health Care Workers (HCWs) and CMV infection has been suggested, as CMV infection occurs in medical personnel to a great extent than nonmedical personnel. There is no documentary evidence of transmission of CMV to dental staff. However, female staff of child-bearing age should note that CMV is transmitted in body fluids, particularly saliva; and most of the individuals shedding CMV are healthy and unidentified. Routine use of gloves and masks is a good protective measure.

Epstein-Barr Virus (EBV)

The virus causes glandular fever (infectious mononucleosis), particularly in young adults. The virus may remain latent in oropharyngeal or salivary epithelium. The major mode of its spread is by kissing; it may also be transmitted by blood. The virus is present in saliva, and the dental staff is at no risk of EBV infection. Masks and gloves offer adequate protection.

Human Herpes Virus 6 (HHV-6)

This is the new addition to the herpes family. It causes a generalized rash (exanthema subitum) in the affected individual. It is present in saliva of some population; however, occupational hazards to medical or dental staff have not been reported.

Influenza, Rhino and Adenoviruses

These viruses commonly cause respiratory tract infections. The route of transmission of these viruses is by droplets. The members of dental staff are at risk from these infections. However, there is little documentary evidence to substantiate this relation. Masks and gloves offer good protection.

Rubella (German Measles)

This virus belongs to the family of Toga viruses and has worldwide distribution. It affects developing fetus by causing cataract, deafness and hepatosplenomegaly, etc. At risk is nonimmune female staff of child-bearing age. The virus is transmitted by droplets. Female staff should be warned of the possible dangers of the virus to the fetus. Rubella vaccine, a constituent of combined MMR (measles, mumps, rubella) vaccine, should be given to such members of staff.

Coxsackie Virus Infections

The diseases caused by this virus are hand, foot and mouth disease and Herpangina. These diseases are of importance in dentistry, because: (1) they cause oral ulcerations; and (2) they possibly can spread in the dental clinic. These infections may remain subclinical and may occasionally lead to myocarditis or encephalitis. The virus is found in saliva. It can spread via direct contact or aerosols. Gloves and masks offer protection.

Human T-cell Lymphotropic Virus 1 (HTLV-1)

This is a RNA retrovirus (same family as HIV). It has been reported in intravenous (IV) drug users. This virus plays a role in adult T-cell leukemia and tropical spastic paraparesis. The route of its spread is via blood, while sexual transmission and IV drug abuse have been implicated. In dental practice, it can spread due to contaminated sharps and needle-prick injuries.

Hepatitis B Virus

This is a DNA virus, which causes acute hepatitis. It has a long incubation period (45–180 days, mean 75 days). During the acute infection, and in carriers of HBV, viral particles released from the liver are present in circulation. Hepatitis B surface antigen (HBsAg) is identified by serological tests as the main indicator of active infection. A second antigen, HBeAg (hepatitis Be antigen), which is derived from core particles of the virus present in the liver. It indicates continuing activity of the virus in the liver and the presence of HBeAg in the blood correlates with high levels of infectivity.

Patients with history of multiple blood transfusions, IV drug abuse, chronic hepatic disease, chronic renal failure, etc. should be subjected to routine hepatitis profile. The mode of transmission is by sexual intercourse, blood transfusion, contaminated needles and sharp instruments; and from mother to child. There are no important dental or oral manifestations in HBV infection. All members of the dental team should be vaccinated against HBV and maintain this vaccination schedule.

Hepatitis C Virus

It is a RNA virus, now recognized as the major cause of non-A, non-B hepatitis. The mode of transmission is similar to HBV infection; being predominantly blood-borne and infection is common in injecting drugs users and recipients of unscreened blood and/or blood products. The acute phase of HCV infection is usually

asymptomatic and only approximately 10% of individuals have overt hepatitis. Following primary infection, however, the majority (about 80%) proceeds to become persistent carriers of the virus and, as with HBV infection, there is a long-term risk of chronic liver disease with cirrhosis and hepatocellular carcinoma.

Human Immunodeficiency Virus

HIV is a RNA retrovirus. The virus infects the major cellular component of immune system and the central nervous system (CNS); especially the T-helper cells. The majority of the manifestations seen in HIV infection are due to affection of this immune system.

The mode of transmission of HIV is quite similar to that of HBV; through sexual contact, blood or blood products, and from mother to child.

Infection with HIV has oral manifestations. Hence with HIV exposure, testing may be useful to ascertain the possible future occurrence of oral manifestations of HIV infection. This requires more frequent oral examinations. It is imperative that HIV testing be done in conjunction with a physician and with patient's informed consent.

Human Immunodeficiency Viruses (HIV-1, HIV-2)

The two viruses are very similar and their modes of spread and clinical effects are identical. Although there is some evidence that disease progression is slower in HIV-2 infection. Recent work has shown that an HIV-infected individual produces very high levels of virus, 10-10 virus particles per day, and is consequently potentially infectious to others for life. At ambient temperatures, the virus is protected from desiccation and may persist in dried blood or secretions for several days. The major cellular component for HIV is the CD4 antigen which is present on helper.

Signs and Symptoms of HIV Disease

The World Health Organization (WHO) report on acquired immunodeficiency syndrome (AIDS) (1990), describes the various signs and symptoms of HIV disease/AIDS, as follows:

Earlier Signs

- Unexplained weight loss of more than 10% of body weight
- Unexplained fever lasting more than 1 month
- Unexplained chronic diarrhea
- Shingles (caused by HZV)
- Oral thrush (infection by a fungus, *Candida albicans*)
- Oral hairy leukoplakia
- Persistent generalized lymphadenopathy (PGL): Persistent increase (>3 months) in the size of the lymph nodes in several sites of the body, such as neck, axilla and groins.

Classification of Oral Manifestations (HIV)

Group I: Lesions strongly associated with HIV infection

- **Candidiasis:** Erythematous, hyperplastic and pseudomembranous
- Hairy leukoplakia
- HIV gingivitis
- Necrotizing ulcerative gingivitis
- HIV periodontitis
- Kaposi's sarcoma
- Non-Hodgkin's lymphoma.

Group II: Lesions less commonly associated with HIV

- Atypical ulceration (oropharyngeal)
- Idiopathic thrombocytopenic purpura
- Salivary gland diseases:
  - Dry mouth due to decreased salivary flow rate
  - Unilateral or bilateral swelling of major salivary glands
- Viral infections (other than EBV):
  - CMV
  - HSV
  - Human papilloma virus (warty-like lesions):
    - Condyloma acuminatum
    - Focal epithelial hyperplasia
    - Verruca vulgaris
    - VZV: Varicella zoster virus
      - Herpes zoster virus
      - Varicella.

Group III: Lesions possibly associated with HIV infection lesions

- Bacterial infections excluding gingivitis/periodontitis:
  - *Actinomycosis*
  - *Enterobacter cloacae*
  - *Escherichia coli*
  - *Klebsiella pneumoniae*
  - *Mycobacterium avium-intracellulare*
  - TB.
- Cat-scratch disease
- Exacerbation of apical periodontitis
- Fungal infection other than candidiasis: Cryptococcosis, geotrichosis, histoplasmosis and mucormycosis.
- Melanotic hyperpigmentation
- Neurologic disturbances: Facial palsy and trigeminal neuralgia
- Osteomyelitis
- Sinusitis
- Submandibular cellulitis
- Squamous cell carcinoma
- Toxic cell epidermolysis.

Late Signs

Approximately 30–40% of seropositive patients will develop AIDS within 7 years after infection. The manifestations appear when the immune system is severely damaged. AIDS is responsible for two main categories of disease:

1. Opportunistic infections
2. certain tumors.

- **Opportunistic infections:** The clinical signs vary according to the organism responsible and the organs affected. The principal organs affected are the lungs, gastrointestinal tract, brain and skin. The following is a list of the main signs of opportunistic infections more specifically diagnostic of AIDS:
- **Lungs:** Cough, shortness of breath and chest pain
- **Gastrointestinal tract:** Difficulty in swallowing, nausea, vomiting, abdominal pain, severe weight loss (malabsorption) and chronic severe diarrhea
- **Brain:**
  - Headache, impaired mental function, fits, peripheral and central paralysis, incoordination and coma
  - Visual defects
- **Skin/mucocutaneous:**
  - Perioral and oral ulceration
  - Genital and perianal ulceration.
- **Kaposi's sarcoma:** Generalized Kaposi's sarcoma is frequently associated with AIDS. It affects about 15% of patients with AIDS in Africa. It presents in the form of purple or red/brown cutaneous plaques or nodules. These lesions are found not only in the skin, but also in the mucosal lining, such as in the mouth, lungs and gut. A characteristic clinical appearance is of one or more erythematous or violaceous macules or swellings with or without ulceration. It is predominantly seen in the palate or gingiva.
- **Lymphomas:** The risk of lymphoma (tumors of the lymph nodes, skin, gut and brain) is about 100 times greater in patients with AIDS than in normal subjects. The commonly seen tumor is non-Hodgkin's lymphoma. It presents in the form of a firm, elastic, reddish or purplish swelling, with or without ulceration. The most common sites are gingiva and palate. If universal precautions are undertaken, the infection control procedures will not change, due to patient's positive history of HBV or HIV. Referral to patient's physician for serological confirmation may be considered, if the results of such tests will help the dental practitioner in the management of the patient's overall dental needs.

GENERAL PRINCIPLES

Universal Precautions

Infection control strategies reduce the risk of transmission of infectious diseases caused by blood-borne pathogens, such as HBV and HIV. All infected patients cannot be identified on the basis of medical history, physical examinations and laboratory investigations; hence, the philosophy is that to consider all patients to be infected with pathogenic organisms. Hence, it is recommended that certain basic infection control procedures must be followed routinely for all patients, referred to as "**universal precautions**".

Universal precautions, for dental team, entail:

- Employment of various personal protective barrier techniques, such as gowns, facemasks, protective eyewear, gloves, etc. which reduce the risk of exposure to potentially infectious material. In addition, precautions should be taken against injury from sharp instruments
- **Immunization:** The Centers for Disease Control and Prevention (CDC) recommends that all members of the dental team who are exposed to blood or blood contaminated articles should be vaccinated against hepatitis B, with a booster dose after 3 years.
- Routine handwashing.

Handwashing

It is an important and effective way of preventing spread of infectious organisms from one person to another. In a clinical set up, hands must always be washed:

- At the beginning of each session
- Between patient contacts
- Before putting on sterile gloves
- Immediately after skin contact with blood or other body fluids
- After touching inanimate objects
- Before touching eyes, nose, face or mouth
- Before leaving the clinic
- Before eating, drinking, smoking, or inserting contact lens

- After any break in the routine or chain of asepsis, such as answering the telephone or retrieving an instrument. Soap dispensers and taps should be operated by the elbows or wrists, and not with gloved hands or bare hands.

Hand wash Technique

- Remove all jewelry (watch, ring, bracelet)
- Clean fingernails with a plastic or wooden stick
- Scrub hands, nails and forearm with a liquid germicidal agent
- Rinse hands thoroughly with running water
- Dry hands with towel.

The hands should be thoroughly washed with an antimicrobial handwash, using a recommended procedure prior to wearing gloves. A combination of liquid soap and an antimicrobial agent is more effective than bar soap alone. Gloves should be removed as soon as patient contact is over.

- **Hand care:** Gloving is an important aspect of hand care. Some of the "skin reactions" to gloving are caused by bacterial irritation rather than a true allergic response. The bacteria on the skin beneath the gloves thrive in a moist and warm environment and may produce enough waste products to irritate the skin. It is recommended to dry hands thoroughly after washing before gloving. Torn, cut or punctured gloves must be removed immediately. Any obvious sores, abrasions and cuts must be covered with protective adhesive waterproof dressings (elastoplast) prior to donning gloves. Personnel with exudative or suppurative lesions or dermatitis should refrain from direct patient care and equipment, until the lesions are healed completely. Hand cream must be used at the end of the session, to prevent drying and cracking of skin. Finger-nails should be short, trimmed and clean.

Personal Protection

Barrier Technique

The use of barrier technique is very important, which includes clinic attire, facemask, protective eyewear and gloves **(Figs 7.1 and 7.2).**

Clinic Attire

All personnel involved in direct patient care must wear freshly laundered uniform or high necked, long cuffed, sleeved cover gowns while performing surgery. The American Dental Association (ADA) guidelines recommend changing garments at least daily and more frequently and when visibly soiled or contaminated. All protective clothing should not be worn outside of the clinic areas, such as corridors, canteens and elevators. All disposable protective barriers should be discarded prior to leaving surgery or the operative area.

Facemasks

These must be worn by all the members of the staff during patient care. Masks should be changed when sneezing occurs, when damp, and in between patients. The maximum time for wearing masks should be not more than 1 hour, since it becomes dampened from respiration, causing degradation in its filterability. A chin length plastic



Fig. 7.1: Use of protective clinic attire



Fig. 7.2: Use of sterile gloves

face shields must be worn, in addition to facesmasks, for greater protection against splatter.

Head Caps

Hair should be properly tied. Long hair (which extends below collar level) must be either covered or restrained away from face. In case, hair contamination is expected, hair cover/caps must be used.

Protective eyewear

Eyewear with solid side shields or chin length face shields must be used, when splashing and splattering of blood, saliva or pus is expected. This occurs from sprayed debris, particularly when rotary cutting instruments are used.

Gloving

It is an effective barrier to reduce risk of transmission of disease. Gloving is mandatory for all types of patient care. All staff must wear gloves during patient contact (blood, saliva, mucous membrane). It has been shown that working with bare hands results in the retention of microorganisms, saliva and blood under the fingernails for several days. There is an evidence to indicate that dental staff who do not wear gloves contract HSV, HBV and possibly HIV infections. Recent studies also show that gloves will minimize needle-stick injuries.

The disposable gloves are made of latex or polyvinyl. Sterile gloves are required during surgical procedures **(Fig. 7.2).** For other procedures, non-sterile gloves should be worn. Over gloves or paper towels must be used for opening drawers, cabinets, etc. The contamination caused by pushing up glasses, touching the face and hair, rubbing the nose, adjusting the mask, etc. should be avoided. If contact must be made, a barrier (such as paper towel) should be used, or gloves removed, and a new pair used before proceeding. The efficacy of gloves as a barrier/protection is greatly diminished, if they are perforated. It is important that the dental practitioner ascertains the quality of the gloves prior to their purchase and uses those with good quality assurance. The frequency of changing of gloves is a topic of debate. It has been shown that approximately 80% of gloves may get perforated during surgery and one-half of them become permeable to bacteria after several hours of use; therefore, it is advisable to change gloves at least hourly for long procedures, even on the same patient.

The standard recommendation is that a new pair of gloves is used for each new patient. New gloves should be worn for surgical cases or any other treatment, which results in blood or saliva contamination. The ADA has condemned the reuse of gloves, because this practice results in defect in the glove material, which will diminish its value as an effective barrier, and adequate removal of previous patient pathogen cannot be uniformly guaranteed.

Rarely, allergic reactions to gloves may develop in some members of staff or patients. This may be due to latex (polyisoprene) or antioxidants, such as mercaptobenzothiazole, and these individuals can safely use polyurethane or vinyl gloves. In addition, skin creams; a spray on microfilm on the skin or a cotton glove liner may be of some value. The dental practitioner should be aware of some drawbacks related to the usage of gloves, namely: (1) Difficulties in handling small instruments, such as endodontic instruments (lessens with practice); (2) Loss of fine sense of touch (minimized by gloves with a good fit); (3) Inflammability, and hence the danger of working close to open flames; and (4) Possible effect on setting time of some impression materials (eliminated by correct purchasing or glove removal).

Refreshments

Eating, drinking, or application of cosmetics in clinical areas including clinical laboratories, is not recommended.

Prevention of Contamination

Uncovered jewelry should not be worn during dental procedures. A wristwatch worn under the cuff of the cover gown, and thus is protected by it, is acceptable. Pens/pencils should be cleaned and disinfected if contamination has occurred. Food and beverages must not be kept in patient care, laboratory and sterilization areas. All procedures and manipulations of potentially infective materials should be performed carefully to minimize droplets, splatters and aerosols, whenever possible. Use of rubber dam and high-volume evacuation (HVE) is recommended.

Spills of Blood and Body Fluids

Gross inorganic material should be removed with an absorbent material, using a glove, followed by disinfection. In case, there is a blood contamination on the floor, a disposable impervious shoe covering should be used. Spraying solution directly on to a spill should be avoided in order to decrease the risk of splatter exposure.

Environmental Cleaning and Disinfection

At the end of treatment session of each patient and at the completion of each session of daily work, dental



Fig. 7.3: Environmental cleaning and disinfection

unit surfaces and countertops should be cleaned. These surfaces should be disinfected with a suitable chemical *germicide*. The chemical germicides are of two types **(Fig. 7.3)**.

The chemical germicides are of two types: (1) Intermediate level disinfectants:and (2) Low level disinfectants.

Intermediate Level Disinfectants

A "hospital disinfectant", which is labeled as "tuberculocidal" (mycobactericidal) is recommended for disinfecting surfaces that have been soiled by patient material. These disinfectants include phenolics, iodophors and chlorine containing compounds. Because mycobacteria are among the most resistant groups of microorganisms, germicides effective against mycobacteria should be effective against many other bacterial and viral pathogens. A fresh solution of sodium hypochlorite (household bleach) prepared daily is an inexpensive and effective germicide. Concentrations ranging from 500 ppm to 800 ppm of chlorine are effective on environmental surfaces that have been cleaned of visible contamination. Caution should be exercised, since chlorine solutions are corrosive to metals, especially aluminum.

Low Level Disinfectants

A "hospital disinfectant" which is not labeled as for tuberculocidal activity (e.g. quaternary ammonium compounds) are appropriate for general cleaning purposes, such as floors, walls and other surfaces. Intermediate- and low-level disinfectants are not recommended for reprocessing critical and semicritical dental instruments.

All environmental surfaces should be disinfected between patients and at the beginning and end of the day. Use of 70% alcohol and quaternary ammonium compounds or antiseptic agents for surface disinfection within the clinical and surgical areas are considered to be inadequate.

Disposable blood/saliva impermeable barriers, such as plastic wrap or aluminium foil must be used to cover the surfaces from direct or indirect contact, whenever possible. Areas difficult to clean and disinfect include: light handles, light controls, chair switches, evacuation controls, 3-way syringe, saliva ejector, etc. Floor should be cleaned daily.

Protective barriers must be worn during cleaning. Heavy duty puncture-resistant rubber gloves, facemask and protective eyewear must be worn during surface cleaning and disinfection.

The "spray-wipe-spray" technique, for cleaning, should be employed to clean and disinfect all "high-touch areas", is as follows:

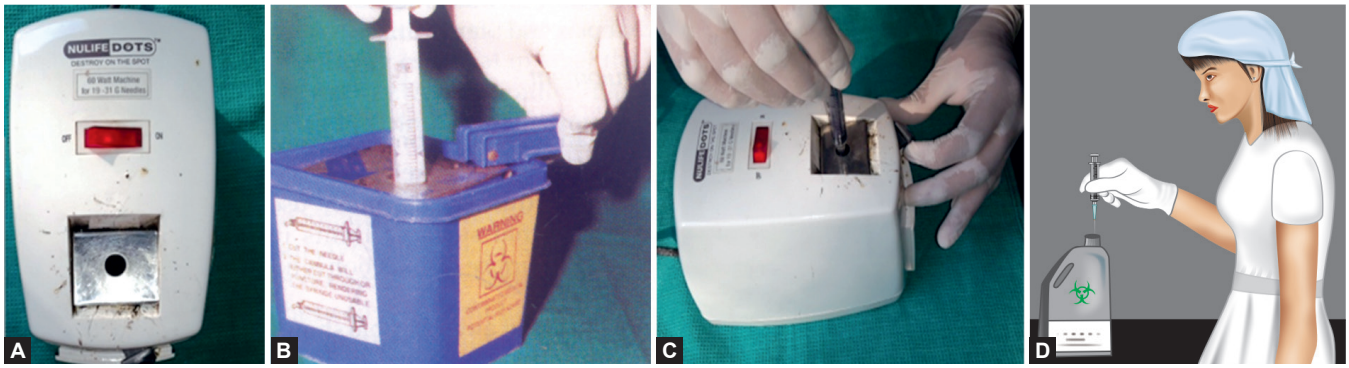
- Spray the surface and/or equipment with cleaner/disinfectant
- Dry the surface with paper towel and discard
- Spray the surface and/or equipment with cleaner/disinfectant and leave in contact for 10 minutes
- Set up for next clinical procedure
- Clean the chair with soap and water.

This technique is performed in three stages. The first "spray" stage is a cleaning stage. In the second stage the surfaces are "wiped" cleaned. The third stage is to "spray" the areas again and leave them in contact for 10 minutes. This is the disinfecting stage.

Bulletin boards used for displaying posters, schedules and other information, etc. should allow for easy cleaning of wall surfaces and should be located outside of splatter zone. Patient's charts and radiographs should not be handled in the operating areas to avoid contamination. Chart entries can be made after gloves are removed and hand's washed to prevent contamination with blood/saliva.

Handling Sharp Instruments and Needles

Sharp items, such as needles, blades and wires; contaminated with patient's blood or saliva should be considered potentially infective; and handled with care to prevent injuries. All sharp items should be disposed off in designated puncture-resistant containers. Orthodontic wires and bands are also considered sharps, and disposed off accordingly. Unsheathed needles should not remain on the instrument tray or in the operating field. An uncapped needle and syringe should not be passed from assistant to surgeon and vice versa **(Figs 7.4A to D)**.



Figs 7.4A to D: (A) Needle; (B) Syringe hub cutter; (C) Needle destroyer; and (D) Storage of sharps for disposal

Patient Management

It is safer to accept that all patients should be handled as if they were an infection risk, or as carriers of blood-borne pathogens (universal precautions).

Use of Antimicrobial Mouth Rinse

0.2 % chlorhexidine is required before and after treatments. Rubber dam and High Volume Evacuation (HVE) must be used during dental procedures whenever possible.

Identification of Risk (Patient Screening)

The medical history of each patient should be obtained and updated at each visit. While taking history, the clinician should identify the infectious diseases of concern, and appropriate questions, such as medications, recurrent illnesses, hepatitis status, unintentional weight loss, lymphadenopathy, oral soft-tissue lesions or other infections should be included. All patients should be asked routinely about a history of TB and symptoms suggestive of TB. Persons with known active pulmonary TB, or those who warrant a high index of suspicion of TB, should not be provided elective dental care. Dental treatment should be postponed until the medical chart shows that the patient is undergoing treatment and compliance with TB medication is documented. A high index of *suspicion* of pulmonary TB should be maintained in a patient with any of the following: recent history of productive cough lasting in excess of 3 weeks, bloody cough, fever, complaints of fatigue, chills and night sweats.

The following procedures should be performed in the patient's presence:

- Sterile trays and the handpiece opened
- Suction tips and saliva ejector placed on the hoses
- Paper cup placed on its stand. The patient should be discouraged from bringing family members into the operatory area.

Sterilization and Disinfection of Instruments

Refer to Chapter 6 on "Asepsis and Sterilization".

Disinfection of Dental Equipment

Handpieces (Sterilization of Handpieces)

The internal surfaces of handpieces become contaminated with blood and debris, etc. This retained material is expelled intraorally during subsequent use. Restricted access to internal surfaces limits its cleaning and disinfection. Surface disinfection is not adequate.

The handpieces, which are not autoclavable, should be subjected to a disinfection regimen. The handpiece is wrapped in gauze soaked with a recommended disinfectant and kept in a sealed plastic bag for a recommended time. Prior to use, the residual chemical residue may be removed by rinsing with sterile water or wiped with gauze soaked in alcohol.

Other Methods

Disinfectant sleeves: These are readily available disposable disinfectant sleeves. It contains a combination of alcohol and two synthetic phenols, which is sealed for 10 minutes.

Handpiece condom: It is a thin disposable sheath made of latex. It covers the entire handpiece.

Dental Unit Water Systems (DUWSs)

The DUWSs (the tubes that connect the high-speed handpiece, air/water syringe and ultrasonic scaler to the water supply) have been shown to harbor a wide range of microorganisms including bacteria, fungi and protozoas. These organisms gain an entry along with water. When the system is switched off, a negative pressure is created, resulting in retraction of water. These microorganisms colonize and replicate on the inner surfaces of the

waterline tubings, resulting in microbial accumulations termed "biofilms". These biofilms, once formed serve as a reservoir for amplifying free floating microorganisms in the water exiting the waterlines. Heating dental unit water to increase patient comfort may further augment biofilm formation. If dental unit waterlines, systems not maintained properly, these microbial accumulations can contribute to occasional odors and visible particles of biofilm material exiting the system.

Water Quality Improvement

The ADA Council on Scientific Affairs recommends to improve the design of dental equipment so that water delivered to patients during nonsurgical dental procedures contains no more than 200 colony-forming units/mL (CFU/mL) of bacteria at any point of time in the unfiltered output of dental unit. Marais and Brözel (1999) reported that distilled water was ineffective in controlling bacterial counts and biofilm. Electrochemically activated water was effective for this purpose. This problem can be taken care of by employing the following:

Antiretraction valves: These valves are fitted to the DUWSs. Retraction valves may cause aspiration of potential infected material back into the handpiece and waterlines. Antiretraction valves (1-way flow check valves), should be installed to prevent aspiration and to prevent transfer of potentially infected material.

Bacterial filter: Filters are fitted in waterlines of handpieces and 2-way syringe hoses.

Chemical disinfection regimens: The DUWSs are flushed with a disinfectant, e.g. sodium hypochlorite solution. This reduces bacterial population. Presently, some units have integrated disinfecting system.

Aspirators: They should be cleaned and flushed after every patient, and flushed with a disinfectant at the end of the day. The liquid waste is drained directly into the drains.

Surgery design and zones: The working area of the clinic is divided into various zones. These zones are high and low contamination zones. The surgery arranged accordingly. The aim is to restrict contaminated items to as small an area as possible.

High contamination zone (zone A): This area is of a high contamination potential. This zone is an area around the patient which includes the dental unit, waste disposal bag, instruments and materials, etc. The staff or the dental surgery assistant should remain within this area.

Low contamination zone (zone B): This comprises of the remainder of the clinic.

Handling Biopsy Specimens

Specimens incorrectly collected and transported substitute a danger to members of staff and laboratory personnel. Hence, it should be put in sturdy containers with a secure lid to prevent leaking during transportation. It is absolutely essential to label the specimens clearly and accurately. Avoid contaminating the exterior of the container. In case, contamination occurs, use another container. Use appropriate transport media and refrigeration, if necessary. Avoid delay in dispatching to laboratory. *Hemolytic streptococci* on a dry swab may survive only for as short time as 30 minutes; while *Gonococci* survive only for seconds. In case of doubt about the need for urgent transport, the microbiologist should be consulted. High-risk specimens, as in hepatitis are subject to special precautions.

Swabs: While taking the specimen, rotate the swab to ensure even distribution of microorganisms on the collecting material. Swabs selected from infected sites should be transferred slowly and carefully to the swab container, so as to avoid contamination of the rim.

Other Precautions

Rubber Dam Isolation

The advantages are:

- It reduces aerosols and droplets that may be contaminated with infectious microorganisms
- It eliminates splatter.

Dental Aerosols and Splatter

Aerosols and splatter is generated by high speed handpieces, air water syringes and ultrasonic scalers. The magnitude of aerosol and splatter can be reduced by the use of rubber dam and high speed evacuation.

Needlestick Injury

Measures for Prevention

This can be prevented by:

- Ensuring that the needles and surgical blades are sheathed/covered, when not in use
- Keeping full control of sharp instruments; and retaining full concentration while handling such instruments
- Keeping gloved fingers behind the cutting edges of surgical blades and elevators or the points of probes or needles
- Adequate retraction of tissues with appropriate instruments

- Placing needles in sharp safe box
- Taking care when clearing away the surgical sharps, wires, etc.
- Over gloving or using double gloves, whenever indicated.

Post-accidental Management: Chemoprophylaxis

The measures to be undertaken are as follows:

- Remove the gloves and wash the site of injury under running water with soap and water
- Avoid scrubbing and encourage bleeding and then protect
- It is controversial, whether or not, to apply antiseptic preparations like spirit or povidone iodine. Some workers do not advise to use antiseptic preparation, as their effects on local defenses are not known
- Inform the patient about the incident
- Usually, it is necessary to take blood specimens of both the patient and the injured person; and tested for HBV and HIV. In case, the patient is seropositive, has AIDS, or refuses the test, the HCWs should be:
- Counseled about the risks of infection and evaluated clinically and serologically as soon as possible after exposure. A baseline HIV test should be carried out immediately, since seroconversion will not have occurred immediately after injury
- Advised to report and seek medical evaluation for any febrile illness that may occur within 12 weeks of exposure
- The HIV test should then be repeated approximately 6–12 weeks after contamination, and on a periodic basis, if seronegative
- Advised to follow recommendations for preventing transmission of HIV infection
- During this period, advise from HIV counselors is of utmost importance; regarding domestic relations and procedures at workplace
- The practitioner should be immediately evaluated by a physician.

If the patient is known or suspected HBV carrier, the prophylactic requirement will depend upon the immune status of the clinician. Those clinicians: (1) who never had vaccination should receive hepatitis B immunoglobulins (HBIg) within 48 hours of exposure and a course of HB vaccination should begin as soon as possible, and (2) those who have been vaccinated, the management, would much depend upon, the antibody response. If the antibody titer is more than 100 mU/mL within the previous year, no further action is necessary. If blood testing was not done within the year, or, if there is low-antibody titer, a booster dose of vaccine, followed by retesting of antibody titer may be necessary. Those who fail to respond to the vaccine should be given protection with HBIg.

Presently, there is no prophylaxis for HCV infection. The management would consist of monitoring liver functions and testing for anti-HCV antibodies. There is little evidence to suggest that such cases may respond favorably, if treated at the earliest sign of infection with interferon-α.

HIV Infection Control

It can be described under two headings:

1. Measures at the time of surgery
2. Measures for HCWs.

Measures at the Time of Surgery

The protocol to be followed in the operation theater, is as follows:

Special Precautions

When dealing with HIV positive or "high-risk patients", special precautions are to be taken, which are as follows:

Operation Theater

The following factors may be considered:

- The patient should be posted at the end of operation list to allow for sufficient time for adequate cleaning of the theater following surgery
- It is advisable to cover the operating table with waterproof sheet
- The patient should be allowed to recover fully in operating room, so as to restrict contamination to operating room, and to avoid contaminating recovery room.

Personnel

- Members of staff with laceration or abrasions on their hands are excluded from the theater
- Nonessential personnel should not be allowed inside the theater; or their number is kept to a minimum
- A member of staff, nurse/technician, may be stationed outside operation theater as an additional circulating member to fetch anything, viz., drugs, equipment, required by the operating team. This prevents infections spreading to the rest of the area of theater complex
- All members of staff not actually involved in the surgery should have following attire, wherever possible:

  - Disposable foot covers
  - Disposable cap and facemask
  - Disposable plastic gowns and gloves
  - Protective eyewear
- All members of staff, included in actual surgery; in addition to the attire mentioned above should have following: usual hand scrubbed and autoclaved gown and two pairs of disposable (single use) sterilized latex gloves. The contamination of skin from glove perforation can be reduced approximately fivefold by wearing double gloves. It is usually comfortable, if the larger sized glove is worn first (inside; in proximity with the skin) and smaller glove is worn outside (as an over glove)
- In case, the mask or cap of any of the member of operating team is splattered with blood it should be immediately changed.

Surgery Technique

- A "no touch" technique is employed, wherever possible, to minimize risk of sharp injury
- Scissors or cutting diathermy must be used in preference to blade/scalpel
- Sharp instruments should not be handed over to the surgeon and vice versa; instead they are placed in a receiver or kidney tray and then transferred across. This reduces the risk of sharp injury
- Emphasis is laid on meticulous surgery and adequate attention to achieve good hemostasis. This reduces the risk of inadvertent injury to the operators, in case there is unexpected bleeding.

Post-surgery

- Patient should be allowed to recover from anesthesia in operation theater and not taken to recovery room. Patient is transferred directly to the ward
- In case of spillage of blood or body fluids, the area should be mopped up by a person experienced in the job, using gloves and old linen/paper towels or newspapers and sent for incineration in plastic bags. The area should then be covered with 1% "sodium hypochlorite" for 30 minutes. The solution is cleaned up with absorbent material (thick quality blotting paper) and placed in the contaminated waste container. The floor should then be wiped with soap and water followed by 1% sodium hypochlorite solution
- The members of operating team should remove their shoe covers and gowns before removing gloves. The gloves should be discarded and sent along with the infected waste for proper disposal.

Operation Theater Waste Disposal

- All disposable sharps should be put in a rigid puncture-proof plastic container, properly labeled and sent for incineration. Needles to be capped after shredding
- All nonsharp waste (like gauze pieces, IV bottles, tubings, etc.) should be put in a large plastic bag, labeled and sent for incineration.

Reusable Instruments

- The instruments, which can be autoclaved, should be autoclaved before washing. The instruments are allowed to cool. They are washed with soap and water with brushes. They are rinsed thoroughly with running water and re-autoclaved
- The non-autoclavable instruments are immersed in 2% glutaraldehyde solution for 1 hour. The solution is discarded. The instruments are cleaned with warm water and detergent. They are rinsed and left to soak in 2% glutaraldehyde for 3 hours
- The suction bottles should contain 30 mL of 2% glutaraldehyde or 60 mL of 1% sodium hypochlorite solution. At the end of surgery, they should be carefully emptied out, rinsed and autoclaved
- The ventilator tubes should be rinsed with running tap water for 5 minutes. Subsequently, immersed in 2% glutaraldehyde solution for 2 hours.

Laboratory Specimens

They should be put in 10% formalin filled jars with a tight leak-proof cork, and then put in a plastic bag which is tightly closed and sealed, properly labeled (biohazardous) and transported to the laboratory.

Operation Theater

The operating room need not be closed down or fumigated after performing surgery in a seropositive patient. The operation table, floor and walls should be thoroughly cleaned with 1% sodium hypochlorite solution.

Equipment and Surfaces

The equipment and surfaces, which are difficult to disinfect and may get contaminated, should be covered/wrapped in/by aluminium foils, or by disposable plastic covers.

Universal Precautions

These are the usual aseptic precautions which should be observed for all the patients during any surgical procedure. These comprise of:

- Proper handwashing

- Surgical attire used for operation theater
- Covering the operation table with waterproof or disposable sheet

All the steps mentioned above should be undertaken in all cases, regardless of the HIV status of the patients.

Measures for Health Care Workers

The transmission of HIV infection from patient to HCWs has been reported. The published data abroad showed that the risk of acquiring HIV through needlestick injury is approximately 0.4% and through exposure of mucous membrane is 0.04%. Needlestick injury, is the most common cause of contracting HIV infection in HCWs. The risk of acquiring HIV infection can be negligible, if the HCWs observe adequate safety measures.

The infectivity of HIV virus is less than that of HBV. Seroconversion after needlestick injury with HBV infected blood is 6–30% as against HIV, which is 0.4%. The precautions required for attending patients which HIV/AIDS infection and HBV infection are identical.

The transmission of HIV infection can also take place in healthcare setting from patient to patient. However, the blood-borne spread from infected patient to other patient is of minimal concern, whenever sufficient medical and surgical equipment are available and careful attention is paid to the sterilization of instruments and other procedures to minimize the risk of blood contamination, i.e. observing universal safety precautions.

As a general principle, if certain strict precautions are followed, the chances of transmission of HIV infection and other infections through blood-borne agents in healthcare setting can be avoided. In this unit, we would deal with these precautionary measures to be followed by HCWs in healthcare settings.

Need for HIV Infection Control

The majority of people infected with HIV, look and feel healthy for a number of years. The disease has a long-latent period (5–10 years) in the development of full-blown disease or with clear-cut clinical manifestations; hence these patients are asymptomatic. Secondly, during the early phase, known as "window period", antibodies are not demonstrated; despite presence of high degree of viremia (infective virus in blood). This period may last from 4 weeks to 12 weeks after exposure to virus. During this period, the patient is highly infectious; however, he will be taken as a normal individual, as antibodies are not demonstrated. In view of these facts, it is advisable for the HCWs, to consider all patients as potentially infected with HIV and take "universal precautions" regardless of the HIV infection status. These precautions include: handwashing, careful handling of sharp objects, proper sterilization, disinfection or disposal of instruments after use, appropriate use of gloves, masks and gowns, etc.

Inform the patient about the incident. Usually, it is necessary to take blood specimens of both the patient and the injured person; and tested for HBV and HIV. The operator should be given hepatitis prophylaxis since the risk of developing hepatitis after contamination with blood from a high-risk patient is greater than the risk of HIV infection.

HIV Postexposure Prophylaxis (PEP)

The guidelines for use of postexposure chemoprophylaxis to prevent HIV infection; adopted in UK Health Departments and USA.

Postexposure prophylaxis is recommended when there has been significant exposure to material known or strongly suspected, to be infected with HIV. The significant routes of exposure are percutaneous inoculation, exposure of broken skin or contact with mucous membranes including the eye.

For convenience of description, it can be described in the following way:

- Exposure has occurred, with the mucous membrane or skin with evidence of chapping, dermatitis, abrasion, or open wound; and the volume of blood is small (e.g. few drops, short duration). There is negligible risk; risk or drug toxicity may outweigh benefit of PEP regimen, if source HIV titer is high or unknown
- Exposure has occurred, with similar conditions; however, to a larger volume of blood (e.g. several drops, major blood splash, and/or duration of several minutes or more); then the basic PEP regimen is recommended, if the source has high HIV titer, then expanded regimen is recommended
- The exposure is percutaneous, however, is less severe (e.g. solid needle, superficial scratch), then the basic PEP regimen is recommended, or if the source has high HIV titer then expanded regimen is required
- The exposure is percutaneous, however, is more severe (e.g. large bore hollow needle, deep puncture, visible blood on device or needle used in source patient's artery or vein), then expanded regimen is recommended **(Table 7.2).**

Table 7.2: HIV-postexposure chemoprophylaxis for health workers

Type	*Drugs*	*Regimen*
Basic (28 days)	Zidovudine + lamivudine	600 mg/day (300 mg BID, 200 mg TID or 100 mg 4 hourly) + 150 mg
Expanded (28 days)	As above + indinavir/ nelfinavir/nevirapine	800 mg 8 hourly, 750 mg TID, or 200 mg BID

WASTE DISPOSAL

Aims of Waste Treatment

- Disinfection
- Reduction in the bulk volume
- Making surgical waste unrecognizable
- Rendition of the dangerous recyclable items unusable.

WHO Classification of Waste

- General nonhazardous
- Sharps
- Chemical and pharmaceutical
- Infectious
- Other hazardous medical wastes.

Types

Waste materials can be of two types biohazardous and nonbiohazardous.

Biohazardous Material

- Waste items soaked with blood or other body secretions
- Waste capable of causing infectious disease
- Waste that is capable of having a poisonous effect
- Human tissue removed during surgery
- Teeth and incidental tissue
- Blood soaked material (cotton roll, gauze, pellets, etc.)
- Bloody gloves **(Fig. 7.5)**.

Non-biohazardous Material

- Matrix band (it should be disposed in sharp container)
- Masks, caps, gloves, patient's napkins
- Impression materials, X-ray packets, surface covers.

Segregation

Segregation is the key to management of hospital waste. It allows sorting out of different categories of waste and placing them in different containers or bags **(Fig. 7.6).** The advantages are:



Fig. 7.5: Biohazardous waste disposal



Fig. 7.6: Segregation of waste materials

- Reduction in total treatment cost
- General waste does not become infectious
- Reduction in the chances of infecting HCWs
- Segregation of different wastes on the basis of classification, and as per the guidelines.

The bags should be labeled; bearing the international biohazard symbol. All the waste, after segregation, must be stored in color coded containers. The following is the color coding prescribed by Bio medical Waste (Management and Handling) Rules, 1998; **(Table 7.3).**

Hospital Waste Disposal

Household Noninfective Waste

It is to be collected in thick polythene bags or plastic cans and discarded-like household waste **(Table 7.4)**.

Table 7.3: The color coding to be employed in waste disposal

Color coding	*Type of container*	*Waste category*	*Treatment options as per schedule 1*
Yellow	Plastic bag	Categories: 1, 2, 3 and 8	Incineration/deep burial
Red	Disinfected container/plastic bag	Categories: 3, 6 and 7	Autoclaving/microwaving/chemical treatment
Blue/white translucent	Plastic bag/puncture-proof container	Categories: 4 and 7	Autoclaving/microwaving/chemical treatment and destruction/shredding
Black	Plastic bag	Categories: 5, 9 and 10 (solid)	Disposal in secured landfill

Table 7.4: Types of waste and the methods of disposal

Waste	*Method of disposal*
Liquid waste, bloody body fluids, suction fluids, excretions and secretions	Buried in deep pit, and covered with bleaching powder and lime
Solid wastes and dressings	Incineration
Laboratory and pathology wastes	Deep burial



Fig. 7.7: Collection of biohazardous wastes from institutions and sending it to common community incinerator

Sharp infected Hospital Waste

It is to be collected separately in puncture-resistant or plastic containers containing 1% sodium hypochlorite, which can be closed or sealed. Needles and syringes should be disinfected and destroyed mechanically before disposal.

Infected Hospital Waste

The infected waste from the wards, operation theater, outpatient department (OPD) and laboratories should be collected in metallic containers decontaminated by autoclaving and then disposed off at garbage disposal sites in the hospital, which is subsequently transferred to the municipal disposal sites on daily basis. The metal containers should be thoroughly cleaned and disinfected after emptying the waste.

The staff engaged in disposal of hospital waste should be made aware of the risks involved, adequately trained in safe handling and experienced in this regard.

Disposal Procedure of Medial Waste

The following procedure is adopted for disposal of medical waste:

The bags used for collection and disposal of different waste are color-coded for ease of identification. In a clinical set up, the medical waste is collected in a small bag. After completion of procedure the bag is closed and sealed. The waste bag is disposed in yellow plastic trash bags. All other waste, such as gloves, masks, paper towels and paper barriers, should be placed in blue plastic bags. Sharp objects are collected in separate puncture-proof containers, and taken for incineration. Liquid waste is poured into a drain and flushed with water.

In a hospital set up, the contaminated or infected waste includes instruments, dressings, syringes, blood-stained beddings, and clothing which has been in direct contact with infectious patients. It also includes the gloves, masks and caps worn in contact with the infected patients or those under isolation. These articles are collected in orange plastic bags, and two bags should be used for safety. It should be transported directly to a special chilled infection store for final removal to the incinerator. All handling of infected waste must be done by staff who are trained, experienced and well aware of hazards of the job and take appropriate precautions **(Fig. 7.7)**.

Disposal of Infected Waste

It is done by the following methods:

- Incineration—It is a sophisticated method of burning the waste
- Deep burial with bleaching powder or lime.

Points to Remember

- Objective of infection control
- Infection and its control
- Cross infection
- Infectious diseases in dentistry
- General principles to be followed-universal precautions
- Waste disposal.

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CHAPTER 8 Antimicrobial Therapy

INTRODUCTION

- Antimicrobial agents include antibacterial, antiviral and antifungal agents. Antimicrobial therapy is an integral part of dental practice. This chapter deals with the antimicrobial agents commonly used in orofacial infections. There is a plethora of antimicrobials available now.
- The clinician should be conversant with these drugs and basic principles of using them effectively. In order to have a clear understanding, we must know the different terminologies used.
- **An antibiotic** is a chemical substance produced by a microorganism, which has the capacity, in dilute solutions, to inhibit the growth of or kill other organisms.
- **A chemotherapeutic agent** is a drug, which is manufactured entirely by chemical synthesis, e.g. sulfonamide, trimethoprim and many of antitubercular drugs. The term chemotherapy is also now used for the drug treatment of malignant neoplasms **(Tables 8.1 and 8.2).**

CLASSIFICATIONS

1. **On the basis of preparation:**
   (i) Naturally occurring: For example from fungi, e.g. penicillins, cephalosporins, erythromycin, tetracycline, chloramphenicol and aminoglycosides, etc.
   (ii) **Synthetic:** Sulfonamides
2. **On the basis of family:**
   (i) Penicillins
   (ii) Cephalosporins
   (iii) Sulfonamides
   (iv) Tetracyclines
   (v) Aminoglycosides
   (vi) Macrolide

Table 8.1: Factors determining the efficiency of antimicrobial agents

1.	Host defense
2.	Source of infection
3.	Tissue(s) affected
4.	Margin of safety
5.	Bacterial susceptibility/resistance to the agent being used

3. **On the basis of spectrum of activity:**
   (i) Narrow: Penicillins
   (ii) Broad: Ampicillins, tetracyclines
4. **On the basis of effect:**
   (i) Bacteriostatic: Erythromycin, tetracycline, sulfonamide, etc.
   (ii) Bactericidal: Penicillins, cephalosporins, etc.
5. **On the basis of their effect on Gram-positive or Gram-negative bacteria:**
   (i) Antibiotics acting on gram-positive bacteria: Penicillins, cephalosporins, erythromycin, bactrim, tetracycline, gentamycin, etc.
   (ii) Antibiotics acting on gram-negative bacteria: Penicillin acts on gonococci.
6. **On the basis of systems:**
   (i) Urinary tract:
      (a) Nalidixic acid: Acts on kidney and urinary bladder.
      (b) Furadantin: Acts on bladder.
   (ii) Skin: Neomycin, bacitracin, polymyxin.
   (ii) Locally: Neomycin, streptomycin.

PRINCIPLES OF ANTIBIOTIC THERAPY

There are many antibiotics available now; it is prudent for a clinician to have guiding principles in applying a rational regimen in a patient. For the convenience of description, the principles can be divided into the following groups:

Table 8.2: Mechanisms of action of antimicrobial agents

Sl. No.	*Actions*	*Antimicrobial agents*
1.	Inhibition of cell wall synthesis	Penicillins, cephalosporins, bacitracin, vancomycin
2.	Inhibition of the cytoplasmic membrane	Polymyxin, colistin, polyene, antifungal antibiotics
3.	Inhibition of protein synthesis and impairment of function of ribosomes	Aminoglycosides, tetracyclines, chloramphenicol, macrolide antibiotics and lincomycin
4.	Interference in transcription/translation of genetic information	Quinolones, metronidazole
5.	Antimetabolite actions	Sulfonamides, trimethoprim
6.	Binding to viral enzymes essential for DNA synthesis	Vidarabine and acyclovir

Selection of Antimicrobials

- **Clinical evaluation and diagnosis for antimicrobial etiology:** This is to ascertain that the infection is due to microorganisms susceptible to the available antimicrobials. The use of antibiotics, as nonspecific antipyretics should be disapproved.
- **Study of culture and sensitivity:** In order to identify the causative organism and whenever possible, samples of pus, saliva, blood and urine should be taken. The causative organisms are cultured and tested against a range of antibiotics for maximum sensitivity. Successful therapy depends upon the nature of causative organisms and their sensitivity patterns, e.g. in case of osteomyelitis caused by penicillin-resistant *Staphylococcus aureus*, the following antibiotics may be used—flucloxacillin or cephalosporin.
- **Age of the patient:** Certain drugs like chloramphenicol may cause serious toxic effects in infants; hence, should not be used.
- **Pregnancy and neonatal period:** Many of the antimicrobial agents cross placental barrier. They should be used only when it is really necessary. Penicillins, cephalosporins, erythromycin, (except estolate which is hepatotoxic), lincomycin, clindamycin, azithromycin and probably sulfonamides (for short-term use) can be safely used.
- **Severity of the disease:** In general, antimicrobial therapy should be considered for patients with established orofacial infections. Empirically, a bacteriostatic agent should be used. In cases of severe infections, a combination of antibiotics effective against a wider spectrum may be employed.
- **Nature of the drug:** It is preferable to use bactericidal drug but not essential. However, bactericidal drugs are essentially used in the management of infective endocarditis and immunocompromised patients.
- **Possibility of drug resistance:** In case the infection is caused by staphylococci resistant to penicillin, an alternative should be prescribed.
- **History of previous allergic reactions to a microbial agent:** Two aspects must be reviewed:
  - Previous allergic reactions
  - Previous toxic reactions.
- An alternative drug must be used in case of allergic reactions.
  - **Risk of toxicity of the drug:** The antibiotics, in general, are safe drugs; however, patients should be warned of possible side effects. The risk is much more particularly in the presence of hepatic and renal damage. The mechanisms of clearance of drugs have to be considered. There are two ways the drugs can be cleared: (i) by renal excretion and (ii) by nonrenal mechanisms **(Table 8.3).**
  - **Cost of therapy:** Presently many effective drugs are available. Newer drugs are added from time to time, which are usually more expensive but not necessarily more effective. Proper selection of the suitable drug is imperative.
  - **Use of narrow-spectrum antibiotic:** It minimizes the risk of superinfection with resistant organisms.

Table 8.3: Mechanisms of clearance of antimicrobials

Renal excretion	*Nonrenal excretion*
Penicillins	Erythromycin
Cephalosporins (except cefoperazone)	Doxycycline Chloramphenicol
Fluoroquinolones	
Aminoglycosides	
Amphotericin B	

Antimicrobial Combinations

Use of combinations of 2–3 antimicrobial drugs, routinely, is not recommended. However, the drugs are combined under certain situations for the following reasons:

- To have an additive synergistic effect against an organism.
- In mixed infections when bacteria are sensitive to different drugs.
- To achieve delay in development of resistance.
- To decrease the incidence of adverse reactions to an individual drug, another drug is added so that the doses of individual drug can be reduced and possible toxic effects can be avoided.
- When the infection is severe and body defense is inadequate and where the diagnosis is difficult. The combination therapy widens the spectrum of activity. However, once a diagnosis is made, an appropriate regimen must be instituted.
- **To reduce the chances of superinfections:** Prolonged therapy with broad-spectrum antibiotic, such as tetracycline, is sometimes combined with antifungal agents to prevent superinfections due to fungi such as *Monilia*.
- **To reduce cost of therapy:** In susceptible organisms, co-trimoxazole works out to be cheaper than amoxicillin or cephalosporin.

The bactericidal drugs act on multiplying bacteria and hence, if a bacteriostatic drug is used with a bactericidal agent, inhibition of bacterial multiplications may occur. This reduces the efficacy of bactericidal agent.

Combining penicillin with chlortetracyclines produces antagonistic effect—in general, when a bacteriostatic agent is added to bactericidal agent, one of the following may result:

- **Antagonism:** If the bacteria are highly sensitive to bactericidal drug.
- **Additive effect:** If the bacteria are relatively resistant to bacteriostatic drug.

Combining certain bacteriostatic drugs may have additive effect, sometimes may have synergistic effect as with combination of sulfamethoxazole and trimethoprim. Combining bactericidal drugs may cause synergistic effect, especially with drugs with different mechanism of action, e.g. combination of penicillin with aminoglycoside results in synergism against susceptible *Escherichia coli*, *Klebsiella*, *Proteus*, *Pseudomonas*. This occurs because penicillin helps in entry of aminoglycoside through microbial cell wall, e.g. combination of ampicillin and clavulanic acid acts synergistically, the latter drug inhibiting beta-lactamase production by the organism and thus, protects penicillin.

The risks involved in combination therapy are following:

- Increased risk of superinfection by resistant organisms.
- Emergence of organisms resistant to multiple drugs used.
- Increased risk of adverse reactions.
- Sense of false security, which may lead to incomplete evaluation and inadequate therapy for the patient.
  - Increase in the cost of therapy.

In general, antibiotics should not be combined unless they are documented by sensitivity testing and antagonism has been excluded.

Antimicrobial Prophylaxis

The situations where prophylaxis is indicated are as follows:

- For preventing endocarditis following minor surgical procedures or tooth extraction.
- In patients with compound musculoskeletal injury, penetrating wounds, skull injuries or rhinorrhea and otorrhea.
- Deep punctured wounds that are at high-risk for infection.

Routine prophylaxis in cases of minor surgical procedures is not necessary. Indiscriminate use of antimicrobial agents on the contrary can be hazardous. Such a procedure may cause allergic and adverse reactions, leads to emergence of resistant organisms and causes superinfection due to other nonresistant organisms. However, they are useful when used as specific agents to prevent or to destroy specific organisms. Prophylaxis for short periods is more likely to be successful than given for long periods. Prolonged therapy also leads to emergence to resistant organisms.

Bacterial Resistance

It can be (1) Natural or (2) Acquired.

REMOVAL OF SOURCE OF INFECTION

Antimicrobial therapy is not a substitute for surgery. All sources of infections must be adequately dealt with. The offending tooth must be either extracted or endodontically treated, collection of pus must be drained, foreign bodies and infected nonvital tissues such as sequestra must be removed.

On an outpatient basis and in clinical emergency situations, such as septicemia or Ludwig's angina, antimicrobial agents are prescribed empirically. As soon as the results of culture and sensitivity are available, the treatment should be reviewed.

Principles of Antibiotic Administrations

The principles comprise of the following:
- Dosage and duration of drug
- Route and frequency of administration.

Dosage

Dose must be adequate to produce a concentration of antibiotic at the site of infection greater than that required for inhibiting the causative organism.
- In renal failure, the dosage of drugs excreted by renal route may require change of drug or reduction in its dosage (e.g. aminoglycosides, vancomycin), whereas those drugs eliminated by hepatic route (e.g. erythromycin) can usually be given in normal dosage.
- In severe infections, a loading dose or a large initial dose is useful.

Duration

- Antibiotics once prescribed should be taken at least for a period of 4–5 days. In severe infections, prolonged use may be necessary.
- The antibiotic once prescribed should not be changed until an adequate time lapse, i.e. 48–72 hours, for evidence of effectiveness or otherwise.
- After the infection is successfully resolved, treatment should be continued for a period of 48–72 hours.

Route and Frequency of Administration

The antibiotics used by oral route should be acid stable (e.g. penicillin V, amoxicillin) and should be absorbed from gastrointestinal tract.

Use of Narrow-spectrum Antibiotic

It minimizes the risk of superinfection with resistant organisms.

Antibiotic Prophylaxis

Successful prophylaxis is possible when the pathogens are sensitive to drug(s) prescribed **(Table 8.4).**

Collaboration between Clinician and Bacteriologist

It is an important aspect of antimicrobial therapy, especially in severe infections. Frequent discussions are to be encouraged.

BETA-LACTAM ANTIBIOTICS

Antibiotics of this group are: (1) Penicillins, (2) Semi-synthetic derivatives of penicillin, and (3) Cephalosporins.
- **Structure:** These substances and their derivatives have a molecular structure based on a nucleus of two fused rings, one of which is the beta-lactam ring. This structure is common to all antibiotics in this group.
- **Antibacterial activity:** Beta-lactam antibiotics act by inhibiting cell wall synthesis of susceptible bacteria. They are effective mainly during the growth phase when cell walls are being synthesized.
- **Bacterial resistance:** The bacteria can develop enzymes known formerly as penicillinase. These enzymes can destroy the beta-lactam ring in the nucleus of

Table 8.4: Microorganisms commonly found and implicated in orofacial infections

Dental caries	*Periodontal disease*	*Apical abscess*	*Other diseases*
Strep. mutans group	*Porphyromonas gingivalis*	*Streptococci species*	*A. israelii*
Crown caries	Adult periodontitis	*Strep. intermedius*	Actinomycosis
Strep. salivarius	Rapidly progressing periodontitis	*Strep. angiosus*	*C. albicans*
Root caries	*Prevotella intermedia*	*Strep. constellatus*	Candidiasis
Actinomyces species	Severe gingivitis	*Bacteroides* species	
Root caries	*Fusobacterium*		
Lactobacilli	Acute necrotizing ulcerative gingivitis		
	Actinobacillus actinomycetemcomitans		
	Juvenile periodontitis		
	Borrelia vincenti		

penicillins and its derivatives thereby rendering them ineffective. Cephalosporins are generally more resistant to the effect of beta-lactamases.

- **Toxic effects:** The principal adverse effect of penicillin is allergy. Allergy established to one type of penicillin is likely to cause similar reaction to other penicillins and its derivatives.
- **Excretion:** These antibiotics are excreted unchanged through kidneys.

Penicillins

Penicillin was discovered in 1929; however, the clinical trials were performed in 1940. It is derived from a mold, *Penicillium notatum*. It was the first antibiotic drug to be used and is still the best.

Classification

- **Naturally occurring penicillins:** Crystalline penicillin (penicillin G), phenoxymethyl penicillin (penicillin V).
- **Semisynthetic penicillins:**
  - Short-acting, e.g. ampicillin, amoxicillin, amoxicillin with clavulanic acid, piperacillin and methicillin. They have special properties and uses. They are stable to gastric acids, make oral administration reliable and are resistant to beta-lactamase.
  - Long-acting, e.g. procaine penicillin, procaine penicillin fortified and benzathine penicillin.

Penicillin is linked with procaine to provide a sustained release preparation which gives an effective level of penicillin over a period of 24 hours.

Administrations

- **Route of administrations:** The oral route is the safest and the most frequently employed. In cases, where the intramuscular (IM) injections are given in surgeries, which should be adequately equipped to deal with emergencies which may arise following such injections. In situations, where IV administration is indicated the patient should be hospitalized.
- Subsequent to parenteral administration or doses in excess of one gram taken orally, the patients should be kept under observation for at least 30 minutes, until it is established that no immediate side effects are likely to occur.
- **Broad-spectrum with IV administration:** Administration of penicillins through IV route achieves much higher serum levels. The spectrum of bactericidal activity is much greater following IV use of penicillins because of higher serum levels achieved.

Oral Administration

Since the levels of penicillin G achieved following oral administration are not reliable, it is no longer administered by this route.

The semisynthetic penicillin that is phenoxymethyl penicillin and ampicillin are well absorbed following oral administration. However, should be administered at least 1 hour before meals or 3 hours after meals to obtain maximum effect. Amoxicillin is well absorbed orally and can compete with food for absorption. It can be administered independently of food taken. The absorption of orally administered drugs is not reliable following administrations of atropine or atropine like substances used in dentistry as premedications for either sedation or general anesthesia. Under such circumstances parenteral route should be employed.

Length of Course

- Antibiotics once instituted should be continued for at least 4–5 days to prevent reinfection or recurrence of disease and to completely eradicate the disease.
- **Broad-spectrum effect with clavulanic acid:** Clavulanic acid is derived from *Streptomyces clavuligerus*. It acts by inhibiting beta-lactamase enzymes. The result of combining with amoxicillin is to broaden antibacterial spectrum of amoxicillin to include organisms that are resistant to amoxicillin because of their beta-lactamase production, e.g. species of staphylococci, nonhemolytic streptococci (including *Streptococcus faecalis*) and some Gram-negative bacteria like *Hemophilus*, *E. coli, Klebsiella* and *Proteus* species.

Measurements of Penicillin (Units and Micrograms)

- A standard method of expressing the potency of penicillin was adopted in 1944, using crystalline sodium penicillin G as the standard. It is expressed in "international units (IU)".
- 250 mg penicillin equals approximately 400,000 IU.

Toxic Effects

- Penicillin is remarkably free of toxic effects even in large doses administered over long periods. However, hypersensitivity reactions in the form of allergy and anaphylaxis are reported. In case of allergy to one

type of penicillin, there is likelihood that the person is allergic to other penicillins and in some cases to cephalosporins.
- There is an inherent risk with all antibiotics of superinfection by a resistant organism. Allergy is the most common side effect of penicillin therapy. It may manifest in the form of skin rashes, dermatitis and serum sickness. These effects can be controlled by withdrawal of penicillin and use of antihistaminics.

Anaphylaxis

Anaphylaxis can occur and is a life-threatening situation. It is sudden in onset, characterized by coughing, tonic spasms, gasping, cyanosis, weak pulse and rapid drop in blood pressure.

Other Effects

- **Pregnancy:** The absolute safety of any of the penicillins or their semisynthetic derivatives taken during pregnancy is not established. Penicillin should be employed only if there is an infection caused by a susceptible organism. The first choice is amoxicillin.
- **Lactation:** Penicillin appears in breast milk, as similar levels to serum levels. Phenoxymethyl penicillin is preferable because of lower concentration in breast milk than serum.
- **Oral contraceptives:** Penicillin may render oral contraceptives ineffective. However, it has been reported that ampicillin did not reduce efficiency of oral contraceptives in the limited number of cases studied.

Cephalosporins

Cephalosporins have similar structure to penicillin, but have a different source **(Table 8.5).**
- **Mode of action:** They are bactericidal. They act by inhibiting the cell wall synthesis in growing bacteria. They should not be used with other bacteriostatic agents, which inhibit protein synthesis such as tetracycline, erythromycin and lincomycin, etc.
- **Spectrum of activity:** They are effective against most species of staphylococci and streptococci except some species of *S. faecalis*.
- **Indications:** Cephalosporins are bactericidal antibiotics and effective against most Gram-positive cocci, including most division III streptococci (enterococci) and most staphylococci. Cephalosporins provide an alternative drug in cases where penicillins are contraindicated.
- Cephalosporins because they are bactericidal may be used as an alternative drug to penicillin for prophylaxis against infective endocarditis.
- **Classification:** Cephalosporins are arbitrarily classified by generations, which are based on general features of spectrum of activity.
  - **First generation:** Cephalosporins of this generation are effective against Gram-positive microorganisms, most Gram-positive cocci except enterococci. Methicillin-resistant *S. aureus* (MRSA) and *Staphylococcus epidermidis*. They are also active against *E. coli, Klebsiella*, pneumoniae and *Proteus mirabilis*: This generation of cephalosporins includes cephalothin and cephalexin.
  - **Second generation:** This generation of cephalosporins has greater activity against Gram-positive microorganisms than first generation cephalosporins. This generation of cephalosporin includes cefotaxime.
  - **Third generation:** These cephalosporins have less activity against Gram-positive organisms than first generation and more activity against Enterobacteriaceae, including beta-lactamase producing strains.

Tetracyclines

The tetracyclines are a large family of antibiotics that were discovered as natural products by Benjamin Minge Duggar and first described in 1948. Benjamin Duggar made his discovery of the world's first tetracycline antibiotic, aureomycin, in 1945.

The first of these compounds was chlortetracycline, which was introduced in 1948, under the name of aureomycin (because of the golden yellow color of *Streptomyces aureofaciens* colonies producing it) followed by oxytetracycline and tetracycline. Tetracyclines had marked contrast from penicillin and streptomycin, in being active orally and were effective against a wide range of microorganisms, hence are called "broad-spectrum antibiotic". All tetracyclines are slightly bitter solids, which are weakly water soluble, but their hydrochloride salts are more soluble. The aqueous solutions are unstable. The tetracyclines developed later on have high lipid solubility and greater potency.

Table 8.5: Summary table of cephalosporins

Cephalosporins	*1st generation*	*2nd generation*	*3rd generation*	*4th generation*
Cefacetrile	♦			
Cefaclor		♦		
Cefadroxil	♦			
Cefalexin (Cephalexin)	♦			
Cefaloridine (Cephaloridine)	♦			
Cefalotin (Cephalothin)	♦			
Cefamandole (Cephamandole)		♦		
Cefapirin (Cephapirin)	♦			
Cefatrizine	♦			
Cefazedone	♦			
Cefazolin	♦			
Cefdinir			♦	
Cefditoren*			♦	♦
Cefepime				♦
Cefetamet pivoxil			♦	
Cefixime			♦	
Cefmenoxime			♦	
Cefmetazole**		♦		
Cefminox**		♦		
Cefodizime			♦	
Cefonicid		♦		
Cefoperazone			♦	
Ceforanide		♦		
Cefotaxime			♦	
Cefotetan**		♦		
Cefotiam		♦		
Cefoxitin**		♦		
Cetpimizole			♦	
Cefpiramide			♦	
Cefpirome				♦
Cefpodoxime			♦	
Cefprozil		♦		
Cefradine (Cephradine)	♦			
Cefroxadine	♦			
Cefsulodin			♦	
Ceftazidime			♦	
Ceftezole	♦			
Ceftibuten			♦	
Ceftizoxime			♦	
Ceftriaxone			♦	
Cefuroxime		♦		
Latamoxef			♦	
Loracarbef		♦		

Keys: * Cefditoren has many characteristics of the 3rd and 4th generation cephalosporins.

** Belongs to cephamycins group, which has increased resistance to beta-lactamases of Gram-negative organisms relative to the "true" 2nd generation cephalosporins.

Classifications

Tetracyclines are classified as broad-spectrum antibiotics.

- **On the basis of chronology of development**, as well as for convenience of description, they may be divided into 3 groups:
  - **Group I:** (1) tetracycline, (2) chlortetracycline, and (3) oxytetracycline
  - **Group II:** (1) demeclocycline, (2) methacycline, and (3) lymecycline
  - **Group III:** (1) doxycycline and (2) minocycline
- **On the basis of occurrence:** Tetracyclines can also be divided on the basis of occurrence in the following way:
  - **Naturally occurring:** (1) tetracycline, (2) chlortetracycline, (3) oxytetracyclines, and (4) demeclocycline
  - **Semisynthetic:** (1) doxycycline, (2) minocycline, (3) meclocycline, (4) lymecycline, (5) methacycline, and (6) rolitetracycline.

Mechanism of Action

Tetracyclines are primarily bacteriostatic; the drugs inhibit protein synthesis by binding to the 30S subunit of microbial ribosomes in susceptible organism. Subsequent to this binding, attachment of charged aminoacyl tRNA to the mRNA-ribosome complex is interfered with. This results in failure of growth of peptide chain.

They prevent introduction of new amino acids to the nascent peptide chain. The action is usually inhibitory and reversible upon withdrawal of the drug. Resistance to the tetracyclines results from changes in permeability of the microbial cell envelope. In susceptible cells, the drug is concentrated from the environment and does not readily leave the cell. In resistant cells, the drug is not actively transported into the cell or leaves it so rapidly that inhibitory concentrations are not maintained. This is often plasmid controlled. Mammalian cells do not actively concentrate tetracyclines.

Mechanism of Resistance

There are three types of tetracycline resistance:

1. Tetracycline efflux
2. Ribosomal protection
3. Tetracycline modification.

Antibacterial Spectrum

The tetracyclines inhibited practically all types of pathogenic microorganisms except fungi and viruses; hence, the tetracyclines are "broad-spectrum antibiotics". They are active against the following microorganisms:

- Gram-positive and Gram-negative bacteria
- Spirochetes including *Treponema pallidum*
- Mycoplasmas
- Rickettsiae
- *C. albicans*
- *Mycoplasma pneumoniae*
- *Chlamydia trachomatis*
- *Borrelia recurrentis*
- *Yersinia pestis*
- *Vibrio cholerae*
- *Campylobacter fetus*
- *Brucella species*
- *Streptococcus pneumoniae* and
- *Neisseria gonorrhoeae.*

Pharmacokinetics

The earlier tetracyclines are incompletely absorbed from gastrointestinal tract; absorption is better if taken on empty stomach. Doxycycline and minocycline are completely absorbed irrespective of food.

Formation of Metal Chelates

Stable chelate complexes are formed by the tetracyclines with many metals, including calcium, magnesium and iron. Such chelates are usually very insoluble in water.
The affinity of tetracyclines for calcium causes tetracyclines to get incorporated into newly forming bones and teeth as tetracycline-calcium orthophosphate complexes. Deposits of these antibiotics in teeth cause a yellow discoloration.

Tetracyclines are widely distributed in the body tissues. They are concentrated in liver and spleen and binds to connective tissue in bone and teeth. They bind to mitochondria. The cerebrospinal fluid (CSF) concentration of tetracyclines is one fourth that of plasma. Most tetracyclines are excreted in urine. The dose has to be reduced in renal failure, except doxycycline.

The tetracyclines cross the placental barrier into the fetus. They are also secreted in the milk of lactating mothers in sufficient amounts to affect the infant. The possible effects of these agents on bones and teeth of the child should be considered before their use during pregnancy or in children under 8 years of age.

Indications

It is first-line therapy for Rocky Mountain spotted fever (*Rickettsia*), Q-fever (*Coxiella*), psittacosis and lymphogranuloma venereum (*Chlamydia*), and to eradicate nasal carriage of meningococci. Tetracycline tablets were used in the plague outbreak in India in 1992. Doxycycline is also one of many recommended drugs for

chemo prophylactic treatment of malaria for travellers to areas of the world where malaria is endemic.

Cautions, Contraindications, Side Effects

The tetracycline antibiotics group:

- Can stain developing teeth, even when taken by the mother during pregnancy.
- Can cause permanent teeth discoloration (yellow-gray-brown) when taken during infancy and childhood to 8 years of age.
- Gets inactivated by Ca^{2+} ion and hence not to be taken with milk, yogurt and other dairy products.
- Gets inactivated by aluminium, iron and zinc and hence not to be taken at the same time as indigestion remedies.
- Gets inactivated by common antacids and over-the-counter heartburn medicines.
- Causes skin photosensitivity and hence exposure to the sun or intense light is not recommended.
- Causes drug-induced lupus and hepatitis.
- Can induce microvesicular fatty liver.
- Can cause tinnitus.
- May interfere with methotrexate by displacing it from the various protein binding sites.
- Can cause breathing complications as well as anaphylactic shock in some individuals.
- Should be avoided during pregnancy as it may affect bone growth of the fetus.
- Passes into breast milk and is harmful to breastfed infants, and should therefore be avoided during breastfeeding if possible.

In 2010, the Food and Drug Administration (FDA) added tetracycline to its Adverse Event Reporting System (AERS). The AERS contains a list of medications under investigation by the FDA for potential safety issues. The AERS cites a potential link between the use of tetracycline products and Stevens-Johnson syndrome, toxic epidermal necrolysis and erythema multiforme.

Other Uses

Since tetracycline is absorbed into bone, it is used as a marker of bone growth for biopsies in humans. Tetracycline labeling is used to determine the amount of bone growth within a certain period of time, usually a period of approximately 21 days. Tetracycline is incorporated into mineralizing bone and can be detected by its fluorescence. In double tetracycline labeling, a second dose is given 11–14 days after the first dose, and the amount of bone formed during that interval can be calculated by measuring the distance between the two fluorescent labels.

Tetracycline is also used as a biomarker in wildlife to detect consumption of medicine or vaccine containing baits.

In genetic engineering, tetracycline is used in transcriptional activation. Tetracycline is also one of the antibiotics used to treat ulcers caused by bacterial infections. In cancer research at Harvard Medical School, tetracycline has been used to reliably cause regression of advanced stages of leukemia in mice by placing it in their drinking water.

Administration

The most commonly used dosage form is oral capsule. The capsule should be taken half an hour before or 2 hours after food. Oral suspension and dry syrup are banned in India to avoid their usage by children. It is not recommended for IM route as it is very painful and has poor absorption from the site. It can be used by IV route, slowly, only in severe cases.

Preparations

- **Oxytetracycline:** Terramycin 250, 500 mg capsules
- **Tetracycline:** Achromycin, hostacycline, resteclin, 250, 500 mg capsules
- **Demeclocycline:** Ledermycin, 150, 300 mg capsules
- **Doxycycline:** Tetradox, biodoxi, doxt, novadox, 100 mg capsules
- **Minocycline:** Cynomycin 50, 100 mg capsules.

Precautions

- Avoid administering to pregnant and lactating women, and infants and children up to 12 years of age.
- Avoid administering along with common antacids, as they get inactivated.
- Avoid administering along with milk and milk products, as it gets inactivated by Ca^{2+} ion
- Avoid administering along with indigestion remedies as it gets inactivated by aluminium, iron and zinc.

Adverse Reactions

- **Allergy:** Tetracyclines can cause skin rashes, urticaria and pruritus. They can cause skin photosensitivity and hence exposure to the sun or intense light is not recommended. Very rarely, they can cause breathing complications as well as anaphylactic shock.
- **Gastrointestinal tract:** They can cause epigastric pain, nausea, vomiting and diarrhea.
- **Superinfection:** Tetracyclines are the most common antibiotics responsible for causing superinfection

because they cause marked suppression of the normal intestinal flora.

- **Antianabolic effect:** When administered in large doses and for prolonged periods, tetracyclines can produce an anabolic effect resulting in increased excretion of urinary nitrogen and certain amino acids, leading to weight loss.
- **Liver:** Tetracyclines can induce microvesicular fatty liver (hepatitis), if taken in large doses over a short period of time.
- **Pregnancy:** Tetracyclines should be avoided in pregnancy in the interest of both mother and fetus, as it may affect bone growth of the fetus.
- **Kidney:** In patients with renal impairment, tetracyclines may cause an aggravation of azotemia.
- **Teeth and bones:** Tetracyclines chelate calcium, resulting in the formation of a tetracycline orthophosphate complex and therefore are deposited in areas of calcification in bones and teeth. Administration of tetracyclines to pregnant women may lead to yellow staining of teeth of infants. It may lead to defective enamel formation and hypoplasia of teeth. Pigmentation of teeth may occur and there is increased risk of caries. These drugs should be avoided in infants and in children up to the age of 12 years.
- **Benign intracranial hypertension:** Some infants may develop increased intracranial pressure, which manifests in the form of bulging of the anterior fontanelle, headache, photophobia and papilledema in adults.
- **Miscellaneous:** Intravenous (IV) administration of tetracyclines may cause local thrombosis or thrombophlebitis of the injected vein. These drugs may interfere with blood coagulation, especially in those having a bleeding tendency; this effect probably is secondary to chelation of calcium.

Erythromycin

- Erythromycin is the principal member of macrolide group of antibiotics. Other macrolides currently available are azithromycin and roxithromycin, both are available for oral administration.
- Erythromycin is a broad-spectrum antibiotic. It is effective against most Gram-positive cocci, including many penicillinase resistant strains of staphylococci and *S. aureus*, and many Gram-negative bacteria encountered in dental infections.

Preparation

It is available in forms of oral, IM or IV administrations.

Mode of Action

Erythromycin is generally considered to be a bacteriostatic agent, though in some circumstances, it has bactericidal effect. It acts by inhibition of protein synthesis.

Pharmacology

Oral preparation salts: Erythromycin is available as stearate or estolate salt. The stearate salt is acid-labile but less readily absorbed than the estolate form. The estolate form is well absorbed, but in adults is associated with cholestatic hepatitis.

- **Intramuscular preparations:** Erythromycin (base or plain) is utilized for IM injections.
- **Intravenous preparations:** Erythromycin lactobionate is used for IV administration slowly, in conjunction with IV infusion.

Absorption

Erythromycin is absorbed from upper part of small intestine. Food may delay absorption and it is recommended that erythromycin be given 1 hour before meals.

Excretion

Erythromycin is excreted unchanged in bile via liver. Approximately, a quarter of the total dose is excreted through kidneys. Impaired liver, or to a lesser extent, impaired kidney function could increase toxic effects of erythromycin. Hence, patients with hepatic or renal dysfunction who are taking erythromycin should be observed for adverse effects.

Toxic Effects

- **Allergy to erythromycin is rare:** Allergic reactions reported are skin rash and other skin symptoms. Anaphylaxis is reported.
- **Gastrointestinal effects:** These include nausea, vomiting and diarrhea, etc.
- **Cholestatic hepatitis:** Erythromycin has been associated with cholestatic hepatitis in adults only. It is almost always related to the use of estolate forms.

Interactions

With antihistaminics and sympathomimetics: Erythromycin in conjunction with astemizole causes increased

levels of astemizole, leading to serious arrhythmias. Erythromycin, concurrently used with terfenadine may produce serious prolongation of QT interval [electrocardiogram (ECG)]. There is a potential for arrhythmia with sympathomimetic drugs. Hence, such combinations are contraindicated.

- **With theophylline:** Erythromycin when given with high doses of theophylline may produce theophylline toxicity including arrhythmias. Further, theophylline may reduce the serum concentration of erythromycin to subtherapeutic levels.
- **With carbamazepine:** Erythromycin when administered along with carbamazepine may increase the risk of carbamazepine toxicity.
- **With warfarin:** Patients taking erythromycin and warfarin concurrently, there is increase in prothrombin time leading to an increased risk of bleeding.
- **With benzodiazepines:** There is an increase in half-life of some benzodiazepines including midazolam and triazolam.
- **With oral contraceptives:** Erythromycin may affect the action of oral contraceptives.

Use During Pregnancy and Lactation

There are no teratogenic effects reported with the use of erythromycin. Erythromycin appears in breast milk. No adverse effects have been reported on infants fed by mothers taking erythromycin.

Concomitant Use of Other Antibiotics

- As the mechanism of action of erythromycin is different from that of penicillin and cephalosporins, these antibiotics may be less effective when used together.
- Lincomycin and clindamycin appear to compete with erythromycin; hence, these antibiotics should not be used along with erythromycin.

Sulfonamides and Trimethoprim

Sulfonamides were first introduced in 1935. These agents are bacteriostatic and get inactivated by presence of pus. Sulfonamides act by inhibition of bacterial synthesis of folic acid from para-aminobenzoic acid (PABA).

Absorption, Distribution and Excretion

- Sulfonamides are well absorbed after oral administration and widely distributed through all body fluids.
- They cross placental barrier and also appear in breast milk.
- They are excreted through kidneys by glomerular filtration with preferential water reabsorption. The concentration of sulfonamides in urine is greater than that in blood. This leads to formation of crystals of sulfonamides termed as crystalluria and leads to renal damage. This can be avoided by excessive fluid intake and by administering substances which increase urine alkalinity.

Toxic Effects

- **Allergic reactions:** They include skin rashes, exfoliative dermatitis, S-J syndrome, polyarteritis nodosa and peripheral neuritis and photosensitivity.
- **Hematopoietic system:** Prolonged therapy can lead to macrocytic anemia due to inhibition of conversion of folic acid to folinic acid, rarely depression of bone marrow or selective blood dyscrasias like acute hemolytic anemia, agranulocytosis and aplastic anemia.
- **Renal damage:** Crystallization of sulfonamides may lead to renal damage. The signs include blood stained urine, renal pain and reduced urinary flow.

Prolonged therapy should be accompanied by regular blood investigations including a differential white cell count.

Pregnancy and Lactation

Sulfonamides, including the combination with trimethoprim may cause kernicterus by displacing bilirubin from plasma albumin in babies during their initial month of intrauterine life. Sulfonamides may cause increase in incidence of fetal malformations.

The drugs also are present in breast milk and may lead to diarrhea, rash, jaundice or kernicterus. Sulfonamides or trimethoprim, or their combinations are not recommended for use in pregnancy or lactation.

Oral Contraceptives

Sulfonamides and trimethoprim may render oral contraceptives ineffective.

Sulfadiazine

It penetrates blood-brain barrier and achieves high levels in CSF. It is commonly used for prophylaxis to post-traumatic meningitis. A loading dose of 3 g is followed by 1 g, 6 hourly for 7–10 days. The drug can be administered by IV route, 1 g, 6 hourly. Caution should be exercised by taking a fluid intake of at least 2 L/day to avoid crystalluria and renal damage.

Co-trimoxazole (Combination of Sulfamethoxazole and Trimethoprim)

This agent inhibits the conversion of folic to folinic acid, which is important for bacterial synthesis of DNA and RNA. In this way, two bacteriostatic agents join to form a bactericidal combination, co-trimoxazole (bactrim or septran).

- **Spectrum of activity:** It is active against *Streptococcus pyogenes* and most staphylococci.
- **Indication:** Useful in acute exacerbation in postirradiation osteomyelitis secondary to osteoradionecrosis. It is also used in mixed actinomycotic infections along with penicillin.
- **Preparations:** It is available for oral administration.
- **Adult:** 80 mg of trimethoprim and 400 mg of sulfamethoxazole tablets are available. Two tablets are taken 12 hourly.
- **Child:** 20 mg and 100 mg respectively. The tablets can be dissolved in water and therefore useful in patients with intermaxillary fixation.

Quinolones

Mechanism of Action

Inhibit synthesis of bacterial DNA.

Nalidixic Acid

- **Spectrum of activity:** It is effective against Gram-negative bacteria, especially *E. coli*; *Shigella* and many strains of *Proteus* and less effective against *Aerobacter* and *Klebsiella* species.
- **Absorption, distribution and excretion:** It is easily absorbed from gastrointestinal tract. It remains bound to plasma proteins and excreted through kidney.
- **Adverse reactions:** Include nausea, vomiting and diarrhea. Allergic reactions include pruritus, rash, urticaria, fever, eosinophilia and photosensitivity. Central nervous system (CNS) manifestations include headache, malaise, drowsiness and myalgia. Overdosage may lead to convulsions in children.
- **Dosage:** It is available as 250 and 500 mg tablets and syrup. The dose is 4 g daily in four divided doses. It should not be prescribed in cases of cerebral arteriosclerosis, Parkinsonism, impairment of hepatic and renal functions. It should be avoided during pregnancy and young children.

Fluoroquinolones

They are chemically related to nalidixic acid and have fluorine in their chemical structure and hence the name. The commonly used fluoroquinolones are—acrosoxacin, enoxacin, cinaxon, norfloxacin, ciprofloxacin, ofloxacin, pefloxacin, lomefloxacin and sparfloxacin.

- **Antibacterial spectrum:** They have broad-spectrum of activity and are bactericidal against most Gram-positive and Gram-negative organisms. It is effective against staphylococci including MRSA and against streptococci including *S. pneumoniae*. They have good activity against Enterobacteriaceae (*E. coli, Klebsiella* and *P. mirabilis*), including many organisms which are resistant to penicillins, cephalosporins and aminoglycosides.
- **Absorption, distribution and excretion:** They are adequately absorbed from gastrointestinal tract and distributed in body fluids. Most of them, except pefloxacin, are excreted by kidney.
- **Therapeutic uses:** These drugs, except norfloxacin, are useful in treating systemic and serious infections. Norfloxacin because of its low serum levels is not useful in systemic infections, is effective in infections of urinary and gastrointestinal tracts.
- **Adverse reactions:** Generally, these drugs are well-tolerated.
  - Gastrointestinal tract toxicity includes nausea, vomiting, diarrhea, anorexia and abdominal discomfort.
  - CNS toxicity includes confusion, nervousness, agitation and hallucinations.
  - Allergic reactions are rare.

ANTIVIRAL ANTIBIOTICS

- Viruses are of two types:
  1. Deoxyribonucleic acid (DNA) viruses, e.g. herpes simplex, varicella zoster, smallpox, hepatitis B, human cytomegalovirus.
  2. Ribonucleic acid (RNA) viruses, e.g. rubella, measles, dengue, human immunodeficiency virus (HIV).
- Antiviral compounds can be classified as follows:
  - Compounds interfering with nucleic acid synthesis, e.g. idoxuridine, acyclovir
  - Thiosemicarbazones, e.g. methisazone

- Natural substances, e.g. interferon
- Miscellaneous agents, e.g. amantadine, antiviral antibiotics, gamma globulin.

Acyclovir (Cyclovir, Zovirax)

Acyclovir is a guanosine analogue and a potent antiviral drug with low toxicity. It is useful in treating infections with:

- Herpes simplex virus types (I and II)
- Varicella zoster virus.

Action: It inhibits viral DNA synthesis in patients with herpes zoster. Acyclovir does not reduce intensity of postherpetic neuralgia.

Dosage: Oral 200 mg five times a day for 7 days or by IV infusion.

Both herpes simplex and varicella zoster viruses produce their effects by replicating in them. To be effective, treatment must be started soon after onset of lesions or during the prodromal phase of illness. Most of herpes lesions are mild and heal without any problem.

The treatment of the cases of herpes virus can be described in the two following ways:

1. **In immunocompetent individuals:** The treatment is used for those who have early lesions and for those in whom the lesions are widespread.
2. **In immunocompromised individuals:** In these cases it may lead to dissemination of infection, hence, treatment should begin at any stage of infection.

Oral acyclovir is partially absorbed with bioavailability of 15–30 %.

- **Adverse reaction:** The drug is generally well tolerated and is less toxic. With IV administration, it may cause thrombophlebitis, elevation of blood urea and creatinine, CNS toxicity includes delirium, tremors, abnormal electroencephalogram (EEG) and psychiatric disturbances. The drug should be avoided in pregnancy.
- **Preparations:** Acyclovir is available as cream, 3% eye ointment, tablets and powder for preparing infusion.

Valacyclovir and Famciclovir

These are prodrugs for cyclovir and pencyclovir, respectively and are used for similar purposes.

Ganciclovir

Ganciclovir is an analog of guanine and is a virustatic. It is available in the form of IV infusion. Its use is limited to immunocompromised cases with cytomegalovirus (CMV) infections because of its toxicity. Its adverse reactions include neutropenia, thrombocytopenia, gastrointestinal and gonadal toxicity.

Aminoglycosides

Aminoglycosides group of antibiotics includes gentamycin, vancomycin, streptomycin, kanamycin, neomycin, and tobramycin. These are bactericidal and similar in structure and are effective against many Gram-negative bacteria, especially those resistant to penicillins. These are potentially toxic and are administered parenterally. These drugs are used in the treatment and prevention of severe infections.

Aminoglycosides are known to have toxic effect on vestibular and cochlear (auditory) branches of VIII cranial nerve and on kidneys. This toxicity is due to accumulation of the drug secondary to impaired renal function. These are bactericidal and act by inhibition of protein synthesis.

Gentamycin

- **Administration:** It is preferably administered by IM injection, as there is a better control on absorption and avoids high serum concentrations.
- **Spectrum of activity:** Gentamycin is effective against a wide range of Gram-positive and Gram-negative bacteria, including penicillinase resistant staphylococci.

  The combined effects of ampicillin and gentamycin are effective against a wide spectrum of Gram-positive bacteria, including streptococci and staphylococci and Gram-negative bacteria. Gentamycin and ampicillin should be administered separately. In solutions containing both ampicillin and gentamycin, the gentamycin is destroyed.
- **Indications:** In orofacial region, gentamycin is indicated in severe anaerobic infections. In the past, the main indication used to be for prophylaxis to infective endocarditis.
- **Dose and route of administration:** Gentamycin is administered either by IV infusion or by IM injection. When administered intravenously, it should be infused to avoid high serum concentration and possible toxic effects from rapid administration. Intramuscular route is preferable as it gives more reliable serum concentration.
  - Adult dose is 3–7 mg/kg/day in 2–3 divided doses.
  - Child dose is 1–3 mg/kg/day in 2–3 divided doses.

- **Toxic effects:**
  - It causes ototoxicity (vestibular and cochlear), if the serum concentrations exceed 10 mg/mL, transient tinnitus has been reported.
  - When used for a period exceeding a week, nephrotoxicity may occur.
  - Allergic reactions are reported. In such cases its use is contraindicated and an alternate drug may be used.
- **Pregnancy and lactation:** There is no established evidence that its use in pregnancy is safe. There are no reports of whether or not gentamycin appears in breast milk. Hence, it is not recommended to use gentamycin in lactating mothers.

Vancomycin

Vancomycin has similar properties to gentamycin. It is bactericidal and effective against most Gram-positive bacteria including many strains of streptococci as well as a number of gram-negative bacteria.

Indications

- Severe orofacial infections
- Patients who are allergic to penicillin
- Patients with risk for endocarditis.

Dose and Route of Administration

- It is administered by slow, intermittent IV infusion.
  - Adult dose is 500 mg (IV infusion) every 6 hourly or 1 g every 12 hourly
  - Child dose is up to 44 mg/kg/day in divided doses by IV infusion.
- **Adverse reaction:** It includes allergic reactions including anaphylaxis, deafness, tinnitus, hypotension and irritation at the site of injection. Rapid administration may lead to pruritus, generalized flushing and erythematous macular rash.
- **Pregnancy and lactation:** Safe use is not yet established. It is not recommended to be used in pregnant women unless expected benefit outweighs the potential risks. Vancomycin is excreted in breast milk and its use in nursing mothers is not recommended.

ANTIMYCOTIC AGENTS

A relatively few antimycotic agents with minimal toxicity and side effects are available as compared to a plethora of antibiotics. The principal antimycotic agents used in oral mycoses fall into two main groups. These agents are used for treatment of different forms of oral candidiasis.

1. **Polyenes:** Nystatin and amphotericin B
2. **Azoles:** Imidazoles and triazoles.

Polyenes

They are commonly used for treatment of oral candidiasis.

Amphotericin B

- **Mode of action:** It acts by inhibiting fungal growth through an interaction with ergosterol. It exerts either a fungicidal or fungistatic effect depending on the concentration used.
  Polyenes bind more effectively to ergort than to other mammalian sterols.
- **Spectrum of activity:** It includes most fungi that cause disease in humans including *Candida* species.
- **Absorption:** Amphotericin B is poorly absorbed from gastrointestinal tract.
- **Administration:** It is usually administered intravenously or used topically.
- **Adverse effects:** The most common adverse effect of systemic use is nephrotoxicity. Hypokalemia and mild anemia are also common. Other rare effects include acute hypersensitive reactions including anaphylaxis.
- **Drug interactions:** Amphotericin B may potentiate nephrotoxicity of other agents such as aminoglycosides and cyclosporins. Its use with glucocorticoids may lead to electrolyte disturbances, particularly hypokalemia.
- **Preparations and dosage:** The available preparations for oral delivery are ointment, suspension, cream and lozenges.
  - Oral systemic dose for adults is 100–200 mg 6 hourly. Lozenges can be given 8 hourly to a maximum of 80 mg/day.
  - **Oral suspension:** 1 mL 8 hourly, retained in the mouth (after food), in contact with the lesions.
  - **IV infusions:** Administered at 0.25 mg/kg/day for both adults and children.

Nystatin

Mode of action: It is the most popular agent for treating superficial infections of *C. albicans.* It should be used topically, however, it may be used orally for the treatment of mucocutaneous infection caused by *C. albicans.*

Nystatin is similar to that of amphotericin B. It has both fungicidal and fungistatic activity depending upon its concentration.

Adverse effects: It causes systemic toxicity.

Preparations: Nystatin is available in the form of creams, tablets, suspensions, oral rinses, gels and pastilles. Ointment is used for the treatment of angular cheilitis. Tablets (500,000 IU) used for the treatment of oral candidiasis. Suspension is used for young children and noncompliant patients. Oral rinse is relatively ineffective because of short contact time with oral lesions. The oral rinse contains sugar and increases the risk of dental caries. Pastilles and lozenges can be sucked slowly and therefore have a longer duration of action. These forms of administration, by the virtue of sweetened formulations, result in better patient compliance and prolonged retention. This results in a better fungicidal action than suspension. Pastilles are ideal for treatment of *Candida* associated denture stomatitis. However, because of their sucrose content, there is increased risk of developing dental caries. A slow released form offers rapid clinical improvement in cases of oral candidiasis. This form is to be kept in mouth and not swallowed, is sugar free and offers prolonged contact time. It is more effective than pastilles; the effect lasting for up to a week after treatment.

The various topical preparations of nystatin in the treatment of oral candidiasis can be summarized as follows:

- Dissolved vaginal pessaries (100,000 IU) one pastille four times a day
- Ointment or cream to be applied to commissures three times daily
- Oral suspension (100,000 units/mL) four times daily, continued for several days after healing.

Azole Antifungal Agents

These agents are classified into two groups:

1. **Imidazoles:** Clotrimazole, econazole, fenticonazole, isoconazole, ketoconazole, miconazole, sulconazole and tioconazole.
2. **Triazoles:** Fluconazole and itraconazole.

Azoles are becoming popular in the management of oral candidiasis. The agent, fluconazole, is the drug of choice in treatment of oropharyngeal candidiasis in HIV infection.

Mode of action: Azoles act by inhibiting the cytochrome P450 enzymes that are involved in synthesis of fungal cell membranes. Clotrimazole, econazole, fenticonazole, isoconazole, miconazole, sulconazole and tioconazole are all used for local treatment. Miconazole can also be given by mouth for oral and intestinal infections. Ketoconazole, fluconazole and itraconazole are used for both local and systemic candidiasis.

Clotrimazole

Clotrimazole is primarily a fungistatic with a broad-spectrum of activity both anticandidal and antistaphylococcal. It is mainly used for superficial infections of oral cavity, skin and vagina caused by *Candida*. As a cream it is useful in the treatment of angular cheilitis due to its dual action.

Adverse reactions: Mild and rare, in the form of local skin irritation, nausea and vomiting.

Preparations: It is available in the form of cream and lozenges. One percent cream is applied three times daily while lozenges are available in 10 mg units, dissolved in the mouth five times a day.

Miconazole

Like clotrimazole, it has broad-spectrum of activity against fungi including *C. albicans* and also against staphylococci. Hence, it is useful in the treatment of angular cheilitis. It can be given topically, intravenously or intrathecally. It is effective in all types of oral candidiasis. Systemic use of miconazole has been taken over by less toxic drugs such as ketoconazole and fluconazole.

Adverse effects: Rare with topical use. The most common effect after IV use is thrombophlebitis. Drugs of azole group are known to enhance anticoagulant effect of oral anticoagulants such as warfarin.

Preparations: It is available in the form of tablets, oral gel, IV injections, topical and vaginal preparations. Cream is used in the treatment of angular cheilitis.

It has been formulated into a lacquer, which is effective in treatment of *Candida* associated denture stomatitis (Dumicoat 50 mg/g). Application of the contents of one bottle to upper surface of upper denture after thorough cleansing and drying, repeated twice at intervals of one week, is recommended. A single application of miconazole lacquer over fitting surface of denture, as a slow delivery, is capable of reducing the numbers of *Candida* on denture surfaces for a substantial period of time.

Ketoconazole

- **Mode of action:** It is effective against a wide spectrum of fungi including *Candida*.

- **Absorption:** Unlike other imidazoles, it is readily absorbed after oral administration.
- **Indications:** Its main indication is secondary oral candidiasis such as chronic mucocutaneous candidiasis.

The most common adverse reactions are gastrointestinal intolerance with nausea and vomiting. Hepatotoxicity is rare. It causes depression of testosterone biosynthesis, which manifests as painful gynecomastia, loss of libido and sometimes loss of hair. It is also a potential teratogen.

Interactions: It interacts with many drugs. With nonsedative antihistamine, such as terfenadine and astemizole, can lead to arrhythmias and tachycardia. With cyclosporin, there can be profound immunosuppression and life-threatening renal dysfunctions. Concomitant use of rifampicin decreases ketoconazole concentrations.

Preparations: It is available in the form of tablets, suspensions and creams. Two percent cream is applied to commissures three times a day in chronic hyperplastic candidiasis. Systemic dose is 200–400 mg daily.

Fluconazole

Fluconazole is water soluble and does not require a low gastric pH for absorption. It is poorly bound to plasma proteins and is eliminated by kidney.

Mode of action: It has a broad-spectrum of antifungal activity. It differs from other azoles in that it has an excellent absorption from gastrointestinal tract and is weakly protein bound in serum. Unlike other azoles, it is not metabolized in humans and is excreted largely through kidney approximately 80% unchanged. It has a high systemic absorption and is now considered a drug of choice for candidiasis in HIV disease, in 200 mg weekly doses.

Adverse effects: Fluconazole is well tolerated. The adverse effects such as nausea, headache and gastrointestinal discomfort are usually mild. It may cause elevation of liver enzymes and an allergic rash. It should be avoided in pregnancy, as it may cause embryotoxicity.

Interactions: Interactions are lesser than the agents mentioned earlier. Being a structural analog to other azoles, it also shows similar interactions. Nonsedative antihistaminics, such as terfenadine and astemizole, should not be administered along with fluconazole. Fluconazole can lead to high serum concentrations of many drugs by decreasing their metabolism in liver. Hence, decreased clearance of cyclosporin may result in significant immunosuppression, leukopenia and renal dysfunction. Similarly, interactions with other drugs such as phenytoin, warfarin and hypoglycemics, fluconazole can produce toxic concentrations in serum, prolonged prothrombin times.

Preparations: It is available in capsule and IV formulations. The adult dose for treating oropharyngeal candidiasis is 50 mg daily for 7–14 days and 50 mg daily for 14–30 days for esophageal candidiasis.

Itraconazole

Itraconazole is water insoluble and lipophilic drug, and requires a lower pH for ionization than ketoconazole. It is highly protein bound and excreted in bile. It is well absorbed after oral administration and has a wide spectrum of activity, including species. It is effective in various superficial mycoses including oral candidiasis due to *C. albicans*, *Candida krusei* and *Candida glabrata*. As the last two are resistant to fluconazole, itraconazole is the drug of choice in treatment of fluconazole resistant *Candida*.

- **Adverse effects:** Generally, it is well tolerated. Gastrointestinal disturbances are rare.
- **Interactions:** Similar to fluconazole.
- **Preparations:** It is available in capsule and oral solution forms. The adult oral dose is 100 mg daily for 15 days for oropharyngeal candidiasis.

Disadvantages of using Azoles

- **All azoles are fungistatic:** This factor should be considered in treating chronic infections in immunocompromised patients.
- None of azoles is entirely beneficial.
- They are expensive.
- Hepatotoxicity may be common to all of them and the potential for endocrine toxicity exists particularly at higher doses.
- **Resistance:** The emergence of resistance to triazoles, particularly to fluconazole is a serious clinical problem in patients with HIV disease.

Metronidazole

It is effective in anaerobic infections and acute necrotizing ulcerative gingivitis (ANUG). Metronidazole is used with one of the penicillins, usually amoxicillin to treat acute orofacial infections with an anaerobic component of causative microorganisms. Metronidazole can also be used in combination with cephalosporins for treating anaerobic infections where there is penicillin allergy or any other contraindication.

- **Spectrum of activity:** It is very effective against a wide range of Gram-positive and Gram-negative bacteria including bacteroides, clostridia and spirochaetes.
- **Indications:** Acute necrotizing ulcerative gingivitis has been successfully treated with metronidazole. It has also been successfully used in chronic destructive periodontal disease and juvenile periodontitis.
- **Administration, absorption and distribution:** Metronidazole is absorbed from gastrointestinal tract. It competes with food for absorption. It is widely distributed through body fluids after administration. It crosses placental barrier and appears in breast milk.
- **Excretion:** Metronidazole is excreted in urine, which may be colored red-brown. Impaired renal and hepatic function can prolong presence of the drug in serum. It is also excreted in saliva and breast milk in similar concentrations to plasma.

Toxic Effects and Contraindications

- Studies in humans have shown no evidence of carcinogenicity; however, teratogenic effects are possible.
- Blood dyscrasias are reported. Blood investigations are recommended if the therapy exceeds 10 days. Metronidazole should be avoided in patients with blood dyscrasias.
- *CNS pathology*: Metronidazole affects patients with CNS pathology such as depression or psychosis. The reported effects are convulsions, dizziness, vestibular symptoms, hypotension and hallucinations, etc. Metronidazole is contraindicated in patients who are taking phenytoin.
- Metronidazole may enhance the effects of warfarin and prolong coagulation time. In such patients, the assistance from physician is obtained to supervise warfarin therapy.

LINCOMYCIN AND CLINDAMYCIN

Lincomycin was first described in 1963 and later its derivative clindamycin. Clindamycin is more active and has less side effects. The oral preparations of clindamycin have replaced oral lincomycin. Lincomycin is reserved for parenteral administrations.

- **Antibacterial activity:** The spectrum of activity of both the antibiotics is similar; however, clindamycin is more active. These antibiotics are bacteriostatic and act by inhibiting protein synthesis. Both antibiotics are effective against most Gram-positive bacteria and against many Gram-negative bacteria including *Bacteroides*, anaerobic streptococci and clostridia.
- **Distribution:** These antibiotics are well distributed; however, they do not penetrate CSF. They appear in breast milk and cross placental barrier. Their distribution includes bone and because of their presence in bone it has been suggested that these antibiotics are suitable for treating bone infections. These antibiotics form a second-line of treatment in osteomyelitis.
- **Administration:** Clindamycin is well absorbed when given orally and may be administered independently of food. Lincomycin does not compete well with food and hence should be administered 1 hour before or 2 hours after meals for achieving maximum absorption. Intramuscular and IV preparations exist.
- **Excretion:** It is either through the kidneys or following liver metabolism through bile or urine. Renal or hepatic disease may prolong the presence of these antibiotics.

Toxic Effects

- The main toxic effects are related to gastrointestinal tract, which include nausea, vomiting and diarrhea. Candidiasis may occur and neither antibiotic may be used in presence of *Candida* infections.
- Hematological reactions include neutropenia, leucopenia, agranulocytosis and thrombocytopenic purpura. In cases, where treatment is prolonged for more than 6 days, necessary investigations should be carried out for detecting blood dyscrasias.
- Pseudomembranous colitis is characterized by diarrhea, abdominal pain, fever, and blood and mucus feces. The antibiotic should be stopped.
- **Pregnancy and lactation:** These antibiotics are safe during pregnancy and lactation. In lactation, alternative drugs appear in low concentrations in breast milk.

GUIDELINES FOR ANTIBIOTIC PROPHYLAXIS

The American Heart Association (AHA) and the American Dental Association (ADA) recently modified their recommended protocols for antibiotic prophylaxis against bacterial endocarditis. In addition, the ADA and the American Academy of Orthopedic Surgeons (AAOS) also issued a new recommendation against routine use of antibiotic prophylaxis in patients with prosthetic joint replacements.

Table 8.6: Cardiac conditions associated with endocarditis

Prophylaxis recommended		*Prophylaxis not recommended*
High-risk category	Moderate risk category	Negligible risk category
• Prosthetic cardiac valves	• Most other congenital cardiac malformations	• Isolated secundum atrial septal defect ASD
• Previous bacterial endocarditis	• Acquired valvular dysfunction, e.g. rheumatic heart disease RHD	• Surgical repair of atrial septal defect or patent ductus arteriosus PDA
• Complex cyanotic congenital heart disease (CHD)	• Hypertrophic cardiomyopathy	• Previous coronary bypass graft surgery
• Surgically constructed systemic pulmonary shunts or conduits	• Mitral valve prolapse	• Mitral valve prolapse without valvular regurgitation
		• Physiologic, functional or innocent heart murmurs
		• Previous Kawasaki disease
		• Previous rheumatic fever
		• Cardiac pacemakers and implanted defibrillators

Table 8.7: Prophylactic regimens for dental, oral, respiratory tract, esophageal procedures

Situation	*Antibiotic*	*Regimen*
Standard general prophylaxis	Amoxicillin	Adults, 2.0 g; children, 50 mg/kg orally 1 hour before procedure
Cannot use oral medications	Ampicillin Cefazolin/Ceftriaxone	Adults, 2.0 g IM/IV; children, 50 mg/kg IM/IV within 30–60 minutes before procedure Adults, 1.0 g IM/IV; children, 50 mg/kg IM/IV
Allergic to penicillin	Clindamycin or erythromycin	Adults, 600 mg; children, 20 mg/kg orally 1 hour before procedure
	or	
	Cephalexin or cefadroxil	Adults, 2.0 g; children, 50 mg/kg orally 1 hour before procedure
	or	
	Azithromycin or clarithromycin	Adults, 500 mg; children, 15 mg/kg orally 1 hour before procedure
Allergic to penicillin and unable to take oral medications	Clindamycin or ceftriaxone	Adults, 600 mg; children, 15–20 mg/kg IV 1 hour before procedure
	Cefazolin	Adults, 1.0 g; children 50 mg/kg IM/IV within 30 minutes before procedure

These changes reflect improvements in understanding of these disease processes and changing attitudes toward the use of antibiotics **(Box 8.1, Tables 8.6 and 8.7).**

Box. 8.1: Dental procedures and endocarditis prophylaxis

- **Endocarditis prophylaxis recommended for:**
  - Dental extractions
  - Periodontal procedures including surgery, scaling and root planning, probing and recall maintenance•
  - Dental implant placement and reimplantation of avulsed teeth
  - Endodontic (root canal) instrumentation or surgery only beyond the apex
  - Subgingival placement of antibiotic fibers or strips
  - Initial placement of orthodontic bands but not brackets
  - Intraligamentary local anesthetic injections
  - Prophylactic cleaning of teeth or implants where bleeding is anticipated

Contd...

Contd...

  - Restorative dentistry (extensive fillings and crown and bridge) with/without retraction cord
- **Endocarditis prophylaxis not recommended for:**
  - Restorative dentistry (operative and prosthodontics) with or without retraction cord
  - Local anesthetic injections (nonintraligamentary)
  - Intracanal endodontic treatment, postplacement and build-up
  - Placement of rubber dams
  - Postoperative suture removal
  - Placement of removable prosthodontics or orthodontic appliances
  - Taking of oral impressions
  - Fluoride treatments
  - Taking of oral radiographs
  - Orthodontic appliance adjustment
  - Shedding of primary teeth.

Points to Remember

Classifications of antibiotics:

- Principles of antibiotic therapy
- Removal of source of infection
- Beta-lactam antibiotics
- Antiviral antibiotics
- Antimycotic agents
- Lincomycin and clindamycin
- Guidelines for antibiotic prophylaxis.

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Section 2

Local Anesthesia in Oral and Maxillofacial Surgery

9. Local Anesthesia

CHAPTER 9 Local Anesthesia

INTRODUCTION

Pain control is an integral aspect of modern dentistry. From the first inferior alveolar nerve block by Halsted in 1884 to the current pain control techniques, the quest has been to make dentistry as painless as possible.

Definition of Pain

Pain is defined as an unpleasant sensational experience initiated by noxious stimulus and transmitted over a specialized neural network to central nervous system (CNS), where it is interpreted as unpleasant pain sensation.

Propagation of electrical impulses across the nerve:
Physiology of nerve conduction:

- Nerve conduction is the self-propagated passage of an electrical current along nerve fibers.
- The conduction of an impulse by a nerve depends on the electrical potential that exists across the nerve membrane.
- When the nerve is at rest (un-stimulated), it is said to have a resting potential; during which time, the nerve membrane is polarized with the electrically negative inside, relative to its outside.
- The negative membrane potential between the inside and outside of the nerve membrane is approximately –70 mV to –90 mV, which indicates that inside the membrane it becomes 70–90 mV more negative than outside.
- The resting potential is maintained by the relative permeability of the cell membrane to potassium (K^+) ion and its relative impermeability to sodium (Na^+) ions.
- **Polarization:** This active mechanism is known as "sodium pump". The pumping action controls the concentration of sodium ions of both sides of the membrane, and thus maintains it in a polarized state. Polarization of the membrane will continue as long as the nerve remains undisturbed.
- **Depolarization:** When a stimulus of sufficient intensity to create an impulse is applied to the nerve, it gets depolarized.
- Alteration in its permeability leads to more rapid influx of sodium ions through the membrane into the nerve cell by displacement of calcium ions and slower passage of potassium ions out of cell.
- **Reverse polarity:** Outside becomes negative relative to inside the nerve cell.
- The passage of the impulse is the result of continuous stimulation, with each area generating its own potential.
- **Repolarization:** Following depolarization, the permeability of the nerve membrane is again decreased. Influx of sodium is restored to its original resting potential.

Definition of Local Anesthesia

Greek word "*an-*" means without and "*aisthesis*" means sensation. So anesthesia means without sensation.

Local anesthesia is defined as transient reversible loss of sensation in a circumscribed area of the body caused by either a depression of excitation in nerve endings, or an inhibition of conduction process in the peripheral nerves, without loss of consciousness.

The sensory or the efferent nerves are blocked at the periphery or at any point between the operative field and the center in the brain. It may be defined as a transient loss of sensation in a particular area to a painful or potentially painful stimulus, resulting from a reversible interruption of peripheral conduction along a specific neural pathway to its central integration and perception in the brain.

Local anesthetic drug causes reversible local anesthesia and a loss of nociception, when it is used on specific nerve

pathways (nerve block), effects such as analgesia (loss of pain sensation) and paralysis (loss of muscle power) can be achieved.

THEORIES FOR MECHANISM OF ACTION OF LOCAL ANESTHETIC AGENTS

There are various theories proposed for explaining how local anesthetic agent blocks the sensation in the given area. All these theories are constantly being evaluated for evidence **(Box 9.1)**.

Details of Mechanism of Action of Local Anesthetic Agent

- Local anesthetic work to block nerve conduction by reducing the influx of sodium ions into the nerve cytoplasm.
- Sodium ions cannot flow into the neuron; thus potassium ions cannot flow out, thereby inhibiting the depolarization of the nerve.
- If this process can be inhibited for just a few nodes of Ranvier along the way then nerve impulses generated downstream from the blocked nodes cannot propagate to the ganglion.
- Voltage dependent sodium channels block primarily open and inactivate sodium channels at specific sites within the channel.

Box 9.1: Theories for mechanism of action of local anesthetic agents

- **Acetylcholine theory:** Acetylcholine is a neurotransmitter at the nerve synapses, supposed to be involved in nerve conduction.
- **Calcium displacement theory:** Depolarization is prevented by displacement of calcium from certain membrane sites that control the permeability to sodium.
- **Surface charge (repulsion) theory:** Local anesthetic agents bind to nerve membrane and change the electrical potential at the membrane surface. Local anesthetic molecules with net positive charge make the surface potential at the nerve membrane more positive and reduce the excitability of nerve by increasing threshold potential.
- **Membrane expansion theory:** Local anesthetic agents diffuse to hydrophobic regions of excitable membrane and expand the membrane, preventing the sodium permeability.
- **Specific receptor theory:** This is the most accepted theory today. Local anesthetic agents act by binding to specific receptors on sodium channels in the nerve membrane. Once the receptor access is gained either on its external surface or on the internal axoplasmic surface, sodium ion permeability is decreased or eliminated, interrupting the nerve conduction.

- Depression of rate of the electric depolarization.
- Failure to achieve threshold potential.
- Lack of development of propagated action potential.
- Conduction blockade.

CLASSIFICATIONS OF LOCAL ANESTHETIC AGENTS

Local anesthetic agents can be classified in the following ways:

On the Basis of Source of Occurrence

- Naturally occurring, e.g. cocaine. Not derived from cocaine, e.g. saxitoxin and tetrodotoxin are usually neurotoxins.
- Synthetic compounds
  - Nitrogenous compounds
    - Derivatives of para-aminobenzoic acid (PABA), e.g. procaine—freely soluble, and benzocaine—poorly soluble
    - Derivatives of acetanilide, e.g. lignocaine (lidocaine, xylocaine)
    - Derivatives of quinolone, e.g. cinchocaine (nupercaine)
    - Derivatives of acridine, e.g. bucricaine (Centbucridine, Centblock)
  - Non-nitrogenous compounds, e.g. benzyl alcohol and propanediol.
- Drugs with local anesthetic action, e.g. clove oil, phenol, chlorpromazine, certain antihistamines such as diphenhydramine.

On the Basis of Chemical Structure

- **Esters:** These can be further classified as:
  - Esters of benzoic acid, e.g. cocaine, benzocaine, and butacaine, hexylcaine, piperocaine, tetracaine
  - Esters of PABA, e.g. procaine, chloroprocaine and propoxycaine.

  The ester drugs are less stable in solution and cannot be stored as long as amides. The metabolism of most of esters results in the production of PABA, which is associated with allergic reaction.
- **Amides**, e.g. articaine, bupivacaine, dibucaine, etidocaine, lidocaine, mepivacaine, prilocaine and ropivacaine. (Remember ABDE LMPR.)
  Amides are heat stable and very rarely cause allergic phenomena. Therefore, amides are now more commonly used than esters.
- **Quinoline**, e.g. centbucridine.

On the Basis of Duration of Action

- *Short-acting*—articaine, lidocaine, mepivacaine, prilocaine, etc.
- *Long-acting*—bupivacaine, etidocaine, bucricaine, etc.
  - **Ultra-short-acting agents:** Where the duration of action is less than 30 minutes.
    - Procaine without a vasoconstrictor
    - 2-chloroprocaine (1.2% or 3%) without a vasoconstrictor
    - 2% lidocaine without a vasoconstrictor
    - 4% prilocaine without a vasoconstrictor for infiltration
  - **Short-acting agents:** Where the duration of action is 45–75 minutes.
    - 2% lidocaine with 1:100,000 epinephrine
    - 2% mepivacaine with 1:200,000 levonordefrin
    - 4% prilocaine when used for nerve block
    - 2% procaine, 0.4% propoxycaine with a vasoconstrictor
  - **Medium-acting agents:** Where the duration of action is 90–150 minutes.
    - 4% prilocaine with 1:200,000 epinephrine
    - 2% lidocaine and 2% mepivacaine with a vasoconstrictor (pulpal anesthesia)
  - **Long-acting agents:** Where the duration of action is 180 minutes or longer
    - 0.5% bupivacaine with 1:200,000 epinephrine
    - 0.5% or 1.5% etidocaine with 1:200,000 epinephrine.

Newer Local Anesthetic Agents

Four newer local anesthetic agents, now available in the market with improved efficacy and safety are (1) articaine, (2) etidocaine, (3) ropivacaine, (4) centbucridine.

Properties of an ideal local anesthetic drug/agent: Remember "**INSTEAD**"

I Non *irritant* and produce no local reaction to the tissues
N No permanent alteration of *nerve* structure
S No *systemic* toxicity or very low systemic toxicity
T *Time* of onset: short (rapid) onset of action
E *Effective* for topical, as well as when injected
D Sufficient *duration* of action
No allergic reaction

- **Good potency:** It should have enough potency to give complete anesthesia without the use of harmful concentrated solutions.
- Stable in solution and readily undergo biotransformation in the body
- Should not interfere with healing of tissues
- Should be compatible with vasoconstrictor drug
- Not expensive
- Reversible action
- Sterile or capable of being sterilized by heat without deterioration.

Common properties of local anesthetic agents used in dentistry are as follows:

- All are synthetic compounds.
- All the agents contain amino group.
- All the agents form salts with strong acids. The synthetic compounds used as injectable local anesthetic agents are weak bases in nature and poorly soluble in water. When combined with hydrochloric acid, they form salts, which are soluble in water and acid in reaction.
- The alkali increases concentration of unionized free base. The unionized free base is soluble in lipids. The chemical characteristics are so balanced that they have both lipophilic and hydrophilic properties. If hydrophilic group predominates, the ability to diffuse into lipid-rich nerves is diminished. If lipophilic group predominates, it is of less clinical value as an injectable local anesthetic since it is insoluble in water and unable to diffuse through interstitial tissues.
- The salts are acid in reaction and relatively stable.
- The agents either hydrolyzed by plasma cholinesterase or undergo biotransformation in liver. The amides undergo biotransformation in liver. The ester-type of local anesthetic agents undergoes hydrolysis in plasma (plasma cholinesterase).
- Their actions are reversible.
- The agents are compatible with epinephrine or allied drugs.
- The agents are compatible with metal salts of mercury, silver and so forth.
- The agents affect nerve conduction in a similar manner.
- The agents are capable of producing toxic systemic effects when a sufficiently high plasma concentration is reached.
- The agents have little or no irritating effect on tissues in anesthetic concentrations.
- *Potency* depends solely upon its chemical structure.
- **Duration of anesthesia:** Depends upon: (1) molecular configuration and (2) presence of a vasoconstrictor.
- **Toxicity:** The first symptom of toxicity of all synthetic local anesthetic agents usually manifested by signs and

symptoms of CNS stimulation. This may vary from mild restlessness to severe convulsions. The stimulating phase is usually followed by depression, which, if severe enough, may cause death.
- All local anesthetic agents cause inhibition of contractility of myocardium.

LIGNOCAINE (LIDOCAINE, XYLOCAINE, OCTOCAINE, DENTOCAINE)

It is the most commonly used local anesthetic agent in dentistry.

Chemistry

- It is an amide and an acetanilide (xylidine) derivative.
- It was first synthesized by Nils Löfgren in 1943 and was marketed in 1948.
- It is the first non-ester-type of local anesthetic agent to be used in dentistry.
- It is a white crystalline powder with a melting point of 69°C and used as hydrochloride salt.
- The lidocaine base is slightly water-soluble, but hydrochloride salt is readily water-soluble.
- It is stable as it can be stored for a long time at room temperature.
- It withstands boiling and autoclaving.
- It is compatible with all types of vasoconstrictors.
- The pH of plain solution is 5–5.5, while that of the solution containing a vasoconstrictor is 3–3.5.

Pharmacology

Diffusion: It rapidly diffuses through interstitial tissues into lipid-rich nerve, giving a rapid onset of anesthesia.

Dissociation constant (pKa) = 7.85. It favors deprotonation and produces more available unionized free base for action on the nerve membrane and for production of conduction block.

Biotransformation

- Lidocaine undergoes biotransformation in liver.
  - **Metabolism:** It is metabolized in liver by microsomal fixed function oxidases.
    Lidocaine and other amide-type local anesthetic agents are not affected by enzyme plasma cholinesterase. Hence, these are the agents of choice in patients with abnormal or insufficient amounts of this enzyme. Use of ester-type of local anesthetic agents should be avoided in these patients. Since mechanism for their degradation is deficient, excessive amounts could accumulate in blood stream leading to toxic manifestations.
  - **Excretion:** Lidocaine and its breakdown products are excreted to some extent in urine by kidney; less than 10% unchanged, more than 80% by various other mechanisms.
- **Potency:** Two times as potent as procaine. Today, it is taken as the standard for comparison of various other local anesthetic agents.
- **Toxicity:** Two times as toxic as procaine.
- **Action on blood vessels:** The action on blood vessels is less than that of procaine but more than those of mepivacaine and prilocaine.
- **Time of onset of action:** Rapid (2–3 minutes).
- **Duration of action:** It depends upon:
  - **Type of injection:** Nerve block has longer duration than infiltration.
  - Amount of vasoconstrictor used in the solution.
- **Effective dental concentration:** 2%
- **Anesthetic half-life:** 1.6 hours
- **Topical anesthetic action:** It has topical anesthetic effect. It forms an excellent surface anesthetic. It is used in the following forms topically:
  - 2% in the form of jelly
  - 5% in the form of ointment
  - 10% and 15% in the form of spray (aerosol).

Maximum Recommended Dose

Lidocaine is the most commonly used local anesthetic agent; hence, it is necessary to consider the instructions of the manufacturers and the recommendations of the American Dental Association are worth following.

To understand the concept of maximum recommended doses, we need to understand the concentration of local anesthetic agents. Consider the example of lignocaine which is the most commonly used local anesthetic agent. It is used in the concentration of 2%. It simply means 2 g of solute is contained in 100 mL of solution, which means 2,000 mg of the solute are present in 100 mL of solution. Hence, it means 20 mg of the solute is contained in 1 mL of solution. In other words, 1 mL of 2% lignocaine solution contains 20 mg of the local anesthetic agent (lignocaine).

The instructions for the local anesthetic agents with or without a vasoconstrictor are as follows:

- **Local anesthetic agents with a vasoconstrictor:**
  As per the manufacturer, the recommended dose of lidocaine with a vasoconstrictor, such as epinephrine, is 7.0 mg/kg body weight but not to exceed 500 mg.

A 2% lidocaine solution contains 2 g/100 mL or 2,000 mg/100 mL or 20 mg/mL of local anesthetic solution. In India, a standard cartridge contains 2 mL of local anesthetic solution. Hence, the recommended maximum dose (500 mg) of the agent will be contained in (500 × 1/20 =) 25 mL *or 12½ cartridges* of the local anesthetic solution.

- **Local anesthetic agents without a vasoconstrictor:** Similarly, as per the manufacturer, the recommended dose of lidocaine without a vasoconstrictor is 4.4 mg/kg body weight but should not exceed 300 mg. A lesser dose is recommended because of faster absorption of the local anesthetic agent. This dose will be contained in *15 mL or maximum 7½ cartridges* of the local anesthetic solution.

Recommendations of the American Dental Association

However, the dosage regimen as suggested by the Council on Dental Therapeutics of the American Dental Association and the United States Pharmacopeial Convention, the maximum recommended dose for lidocaine with or without a vasoconstrictor is 4.4 mg/kg body weight.

The maximum recommended doses are mentioned here as shown in **Table 9.1** for individuals with their body weights ranging from 10 kg to 70 kg.

The dental cartridges usually contain 2 mL of local anesthetic solution in India, 1.8 mL in the USA and France, and 2.2 mL in the UK and Australia.

Other local anesthetic agents used in dentistry are in various concentrations. The various concentrations and the contents of the solution and duration of action are shown in **Tables 9.2** and **9.3**, and **Box 9.2**.

Toxicity of Lignocaine

The deleterious effects of toxic doses of lignocaine on various systems are as follows:

- **Central nervous system:** Toxic doses of local anesthetic agents first produce stimulation followed by depression. The manifestations of stimulation vary from mild restlessness to severe convulsions. The phase lasts for a brief period. The depression is manifested as drowsiness to loss of consciousness. Lidocaine administered intravenously is capable of producing a degree of analgesia and even general anesthesia.
- **Cardiovascular system:** The effects on cardiovascular system vary with the dose used.

Table 9.1: Maximum recommended doses (MDR) for various body weights

Body weight (kg)	*Dose (body weight × 4.4) = mg*	*MRD (mL)*	*MRD (cartridges) (approx)*
10	44	2.2	1.1
20	88	4.4	2.2
30	132	6.6	3.3
40	176	8.8	4.4
50	220	11	5.5
60	264	13.2	6.6
70	300	15.4	7.7

Table 9.2: Various local anesthetic agents along with their concentrations and contents

Percentage	*Example*	*Strength*
0.25%	Bupivacaine	2.5 mg/mL
0.5%	Bupivacaine	5 mg/mL
1%	Lignocaine	10 mg/mL
2%	Lignocaine	20 mg/mL
3%	Mepivacaine	30 mg/mL
4%	Prilocaine	40 mg/mL

Table 9.3: Comparative anesthetic properties of local anesthetic agents

Local anesthetic agents (with vasoconstrictor)	*Onset of anesthesia*		*Duration of anesthesia*	
	Regional	*Infiltration*	*Regional*	*Infiltration*
Lignocaine	5 min	3 min	3 hrs	2 hrs
Prilocaine	3 min	4 min	3 hrs	2 hrs
Bupivacaine	5 min	2-5 min	5-6 hrs	5 hrs
Procaine	7 min	4 min	2.5 hrs	2 hrs

Box 9.2: Lignocaine anesthetic agent availability in India for dentistry

- **Dental cartridges:** 2% lidocaine with epinephrine 1:80,000 in India.
- **Vials:**
  - 2% lidocaine, without epinephrine (Lidocaine Plain)
  - 2% lidocaine with epinephrine 1:80,000, 1:100,000, and 1:200,000.

- **Moderately large doses:** It produces overall inhibition on the contractility of heart muscle in the form of:

  - A decrease in the electrical excitability of myocardium.
  - A decrease in the force of contraction (negative inotropic effect).
  - A decrease in the rate of electrical impulse conduction (negative chronotropic effect).
- **Large doses:** In large doses such as 50–100 mg (1.5 mg/kg body weight), it is given intravenously during general anesthesia and surgery to correct ventricular arrhythmias that occur during surgical procedures. It is one of the most popular antiarrhythmic agents in medicine.

- **Vasculature:** Vasodilatation is produced by direct relaxing effect on smooth muscle of vessel walls. In toxic doses, this action contributes to hypotension and cardiovascular collapse.
- **Respiratory system:**
  - In small doses, it causes mild bronchodilatation.
  - In large doses, it causes respiratory arrest (apnea) (the most common cause of death related to overdose of local anesthetic agent). In majority of cases, respiratory arrest precedes cardiac arrest. However, artificial ventilation and basic life support measures will prevent serious sequelae.

Commercially prepared local anesthetic solution for clinical use in dentistry (Cartridges and vial form) consists of:

- **Local anesthetic agent:** Xylocaine/lignocaine/lidocaine 2%.
- **Vasoconstrictor/vasopressor:** Adrenaline or epinephrine 1:80,000 or 1:100,000 or 1:200,000.
- **Reducing agent/antioxidant for vasoconstrictor:** Sodium metabisulfite.
- **Preservative:** Methylparaben, capryl hydrocuprienotoxin (added in multi dose vials and usually not in single use cartridges).
- **Fungicide:** Thymol.
- **Vehicle:** Distilled water.
- **Salt:** NaCl (sodium chloride) or Ringer's solution **(Table 9.4)**.

LOCAL ANESTHETIC AGENTS

It provides management of pain during dental procedures. Basically, it interrupts impulse propagation to the brain. These agents are available by their percentage concentration. 2% lignocaine will be 20 mg/mL, thus a 2 cc/mL cartridge of 2% local anesthesia contains 40 mg of local anesthetic drug. This solution is stable and can be autoclaved before packing in vial or cartridge without deterioration.

Table 9.4: Components of local anesthetic solution with adrenaline 1:80,000 available in India in vial and cartridge

Component	*Amount*	*In solution with adrenaline 1:200,000*
2% lignocaine hydrochloride	24.64 mg	21.30 mg
Adrenaline bitartrate	0.0125 mg	0.005 mg
Sodium bisulfite		
Sodium metabisulfite		0.5 mg
Methylparaben		1.0 mg
Thymol	0.4 mg	
Chlorbutol	5.0 mg	
Ringer's solution	0.29 mL	
Sodium chloride	6.0 mg	
Water for injection to make	1 mL	1 mL

Vasoconstrictor

Vasoconstrictors are the chemical agents added to local anesthetic solutions (1) to oppose vasodilatation caused by the local anesthetic agents and (2) to achieve hemostasis. (Constrict the blood vessels and control tissue perfusion.)

Actions

The net effects caused by addition of vasoconstrictor to local anesthetic agents are:

- It decreases the rate of absorption of local anesthetic agent into cardiovascular system.
- It lowers the plasma level of local anesthetic agent, and hence, decreases the risk of its systemic toxicity.
- It increases the duration and depth of action, as higher volumes of local anesthetic agent remain in and around the nerve for longer time.
- It decreases bleeding at the site of injection.

The pH of local anesthetic solution with vasoconstrictor is lower or more acidic (3.3–4.0 pH) than without vasoconstrictor (5.5–6.0). Because of less acidic property, the plain solutions will have less burning during injection and have more rapid clinical action.

Reducing Agents or Antioxidant for Vasoconstrictor

Vasoconstrictors are relatively unstable in solutions, and undergo oxidation, when exposed to sunlight. The solution appears pink to brown in color after oxidation. One should discard the solution if color is changed. To ensure a reasonable shelf life, it is necessary to include a reducing

agent or antioxidant in the local anesthetic solutions. The most commonly used agent in the dental cartridges containing a vasoconstrictor is sodium metabisulfite. It competes with vasoconstrictor itself for available O_2 in the cartridge. In the presence of O_2, sodium metabisulfite gets oxidized to sodium bisulfate, utilizing the available O_2, thus prevents the oxidation or deterioration of the vasoconstrictors. But, the solution becomes more acidic after oxidation to sodium bisulfate, lowering the pH. The average shelf life of local anesthetic solution without vasoconstrictor is about 2 years.

The shelf life of local anesthetic solution containing a vasoconstrictor is slightly shorter, i.e. 12–18 months than that of a solution without a vasoconstrictor.

Preservative

Methylparaben: It is bacteriostatic and fungistatic agent added to maintain sterility of solution; however, there are several reports of allergic reactions due to it. The USA stopped using its use in cartridges. Chlorbutol and capryl hydrocuprienotoxin are added as preservative.

Fungicide: Thymol is antiseptic, fungistatic and antihelmintic. Due to fungus growth, the solution will appear cloudy or whitish growth will be seen floating.

Vehicle: Distilled water is used to dissolve the components of local anesthetic solution drugs and also helps reducing the concentration of main drug and maintains the desired percentage or concentration.

Sodium chloride or Ringer's solution makes the solution isotonic, which does not cause burning sensation during injection.

Vasoconstrictors: Classifications

These drugs can be classified on the basis of mode of action into the following three categories.

1. **Direct acting drugs (catecholamines):** These drugs stimulate or exert their action directly on the adrenergic receptors, e.g. epinephrine—natural, norepinephrine—natural, dopamine—natural, levonordefrin and isoproterenol—both synthetic.
2. **Indirect acting drugs (non-catecholamines):** These drugs act by releasing norepinephrine from the adrenergic nerve terminals (e.g. tyramine, amphetamine, methamphetamine, hydroxyamphetamine).
3. **Mixed acting drugs:** These drugs have both direct and indirect actions, e.g. metaraminol and ephedrine.
   Felypressin, a synthetic analog of vasopressin.

Pharmacology of Specific Vasoconstrictor Agents

Epinephrine:

Chemical properties:

- Vasoconstrictors are highly soluble in water and stable in the form of an acid (hydrochloride) salt.
- Slightly acidic solutions are relatively stable if they are protected from air.
- It acts directly on both α- and β-adrenergic receptors; β effects predominate.

It must be borne in mind that the endogenous release of adrenaline, caused by the stress of going to a dental surgeon, sight of dental instruments, and the apprehension of pain caused by the needle sticks produces effects similar to those produced by excessive exogenous administration of adrenaline.

This drug can produce undesirable results (1) if used in large volumes, or (2) if inadvertently injected intravascularly. Hence, these drugs should be used with due consideration to their benefits and risks. It is recommended that the least concentrated solution that produces effective pain control should be used. Lidocaine is available with two dilutions of epinephrine (1:80,000 and 1:200,000) in India and many other countries. It is available in dilutions of 1:50,000 and 1:100,000 in the USA and Canada. In India, the cartridges available contain 2 mL of local anesthetic solution. While in the USA and France, the cartridges contain 1.8 mL of the solution, and in the UK and Australia, the cartridges contain 2.2 mL of the solution. The most commonly used vasoconstrictor is epinephrine (adrenaline).

Dilution of Vasoconstrictors

The dilution of vasoconstrictors is commonly referred to as a ratio and is written as 1:1,000. The maximum doses of vasoconstrictors are presented as milligrams, and hence, the following interpretations will help in conversion **(Table 9.5)**.

Vasoconstrictors used in local anesthetic solutions in dentistry are more diluted than 1:1,000. A solution of 1:1,000 dilution contains 1 g in 1,000 mL. Hence, a solution of a dilution 1:10,000 will contain 0.1 mg/mL of solution and 1:100,000 dilution will contain 0.01 mg/mL of solution **(Table 9.5)**.

Maximum Recommended Doses of Epinephrine

The New York Heart Association in 1954, recommended that the maximum dose of epinephrine should be limited to 0.2 mg per appointment. The American Heart Association has recommended restriction of epinephrine

Table 9.5: It shows the dilution and the amount of vasoconstrictor present

Dilution	mg/mL
1:1,000	1.0
1:10,000	0.1
1:50,000	0.02 used for hemostasis in surgical area
1:80,000	0.0125
1:100,000	0.01
1:200,000	0.005

in local anesthetics when administered to patients with ischemic heart diseases.

Normal healthy adult patients: (0.2 mg per appointment)
- 16 mL of a 1:80,000 dilution (8 cartridges)
- 20 mL of a 1:100,000 dilution (10 cartridges)
- 40 mL of a 1:200,000 dilution (20 cartridges).

Patients with clinically significant cardiovascular disease: (0.04 mg per appointment) (approximately 1/5th of the dose for normal patients)
- 3.2 mL of a 1:80,000 dilution (1.6 cartridges)
- 4 mL of a 1:100,000 dilution (2 cartridges)
- 8 mL of a 1:200,000 dilution (4 cartridges).

Systemic Actions

Myocardium: It stimulates β1 receptors of myocardium. The resultant events are as follows:
- A positive inotropic effect (increases force of contraction), and
- A positive chronotropic effect (increases rate of contraction).

The resultant effects are that the cardiac output and heart rate are increased.

Pacemaker Cells

It stimulates β1 receptors and increases the irritability of pacemaker cells, leading to a greater incidence of dysrhythmias.

Coronary Arteries

It produces dilatation of coronary arteries, resulting in an increased coronary artery blood flow.

Blood Pressure

- Systolic blood pressure is increased, and
- Diastolic blood pressure:
  - It is decreased in small doses because of greater sensitivity to epinephrine of β2 receptors than α receptors present in blood vessels.
  - It is increased in larger doses because of constriction of blood vessels produced by stimulation of α receptors.

Cardiovascular System

The overall actions of epinephrine on the heart and cardiovascular system are the result of direct stimulation. If the stimulation of the heart persists for a long time, there will subsequently be overall decrease in cardiac efficiency. These actions are as follows:
- Increased stroke volume.
- Increased heart rate.
- Increased cardiac output.
- Increased strength of contraction.
- Increased systolic and diastolic pressures.
- Increased myocardial oxygen consumption.

Blood Vessels

The primary effects of epinephrine are on microcirculation (small arterioles and precapillary sphincters). The blood vessels which supply skin, mucous membranes and kidneys contain primarily α receptors. Epinephrine produces constriction of these blood vessels. The blood vessels supplying skeletal muscles contain both α and β2 receptors, with β2 receptors predominating. Epinephrine in small doses produces dilatation of these vessels as a result of β2 effect. β2 receptors are more sensitive to epinephrine than α receptors. Large doses of epinephrine produce vasoconstriction because of stimulation of α receptors.

Rebound Phenomenon

Epinephrine is frequently used as a vasoconstrictor for achieving hemostasis during surgical procedures. The injection of epinephrine directly into the tissues at surgical sites leads to high tissue concentration. Its α effect predominates. The stimulation of α receptor leads to vasoconstriction resulting in hemostasis. However, subsequently, the biotransformation, reuptake and redistribution finally results in low tissue levels of epinephrine, when β receptors are stimulated, and β2 action predominates. The action on blood vessels changes; resulting in vasodilatation. This rebound activity is manifested as some bleeding at the end of, or a few hours after the surgical procedure.

Respiratory System

It has a β2 effect on the smooth muscle of the bronchioles, and hence is a potent dilator. It is a drug of choice in cases of bronchospasm as in bronchial asthma.

Central Nervous System

In therapeutic doses, epinephrine does not stimulate CNS. It stimulates CNS only if excessive doses are used.

Overdose

In small amounts commonly used in dentistry; only the arterioles in the immediate area of injection are affected by vasoconstrictors. The factors that may produce toxic manifestations are: (i) large volumes, (ii) high concentration of vasoconstrictors, and (iii) inadvertent intravascular injection of comparatively small amounts of vasoconstrictors. The manifestations can be in the form of tachycardia, hypertension, palpitation, headache, tremors, pallor, and in rare cases, ventricular fibrillation. The systemic effects of vasoconstrictors usually last as long as the blood levels of the drug remain elevated.

Small doses: The initial clinical features of epinephrine overdose are related to stimulation of CNS, which include fear and anxiety, tension, restlessness, headache, tremor, weakness, dizziness, pallor, respiratory difficulty, and palpitation. This is known as *"epinephrine reaction"*.

Large doses: The manifestations include cardiac dysrhythmias, dramatic increase in both systolic and diastolic blood pressure, which may lead to cerebral hemorrhage, ventricular fibrillation is possible but rare, anginal episodes may be seen in patients with coronary insufficiency.

Felypressin

It is available as a vasoconstrictor, in combination with prilocaine, in dental local anesthetic cartridges, and in many countries as Citanest forte.

Proprietary name: Octapressin.

Availability: It is used in dentistry in a dilution of 0.03 IU (international units)/mL with 3% prilocaine.

Chemical structure: It is a synthetic analog of vasopressin (antidiuretic hormone).

Mode of action: It acts by directly stimulating vascular smooth muscle. It has little direct effect on the heart or on adrenergic nerve transmission. Its actions are more pronounced on venous rather than on arteriolar microcirculation.

Systemic actions:

- **Myocardium:** No direct effects.
- **Uterus:** It has both antidiuretic and oxytocic actions; hence, the latter action contraindicates its use in pregnant patients.
- **Maximum doses:** Patients with clinically significant cardiovascular impairment. Maximum recommended dose: 0.27 IU (international units) (9 mL of 0.03 IU/mL or 4½ cartridges).
- **Clinical applications:** Used as vasoconstrictor with local anesthetic to decrease their absorption and increase their duration of action.
- **Disadvantage:** It acts primarily on venous circulation; hence, felypressin is not as effective as conventional vasoconstrictors in providing hemostasis during surgical procedures.
- **Indications:**
  - It may be safely used in patients with medical problems where there is contraindication for the administration of epinephrine, which include: (i) mild to moderate cardiovascular diseases, including hypertension, and (ii) other non-cardiovascular diseases such as hyperthyroidism.
  - It can be used in patients who are taking antidepressant drugs such as tricyclic or tetracyclic acid antidepressants or monoamine oxidase inhibitors.
- **Contraindications:**
  - It is not recommended for use when hemostasis is required because of their predominant effect on venous rather than arteriolar circulation.
  - **Pregnancy:** It is not recommended for use during pregnancy because of its oxytocic action.

Selection of a Vasoconstrictor

The selection of an appropriate vasoconstrictor is based on following factors:

- Length of the surgical or dental procedure
- Requirement for hemostasis during the surgical procedure
- Requirement for postoperative pain control
- Medical or physical status of the patient and concurrent medications taken **(Box 9.3)**.

Box 9.3: Contraindications for the use of vasoconstrictor in local anesthetic solution

- ❑ Patients with significant cardiovascular disease such as (a) ischemic heart disease, (b) hypertension, and (c) cerebral strokes
- ❑ Patients with certain uncontrolled noncardiovascular diseases such as thyrotoxicosis or hyperthyroid states and diabetes mellitus
- ❑ Patients receiving nonspecific beta-blockers, monoamine oxidase inhibitors, tricyclic antidepressants and phenothiazines
- ❑ Patients with sulfite sensitivity
- ❑ Patients who are undergoing general anesthesia with halogenated agents
- ❑ Pregnancy

ARMAMENTARIUM

The essential components of armamentarium for local anesthesia are as follows: (1) syringe, (2) needle, (3) local anesthetic cartridge or a multidose vial (30 mL or 50 mL vials), and (4) additional armamentarium.

Syringe

It is an instrument whereby the contents of the cartridge or local anesthetic solution drawn from a vial are delivered through the needle to the tissues of the patient.

Types

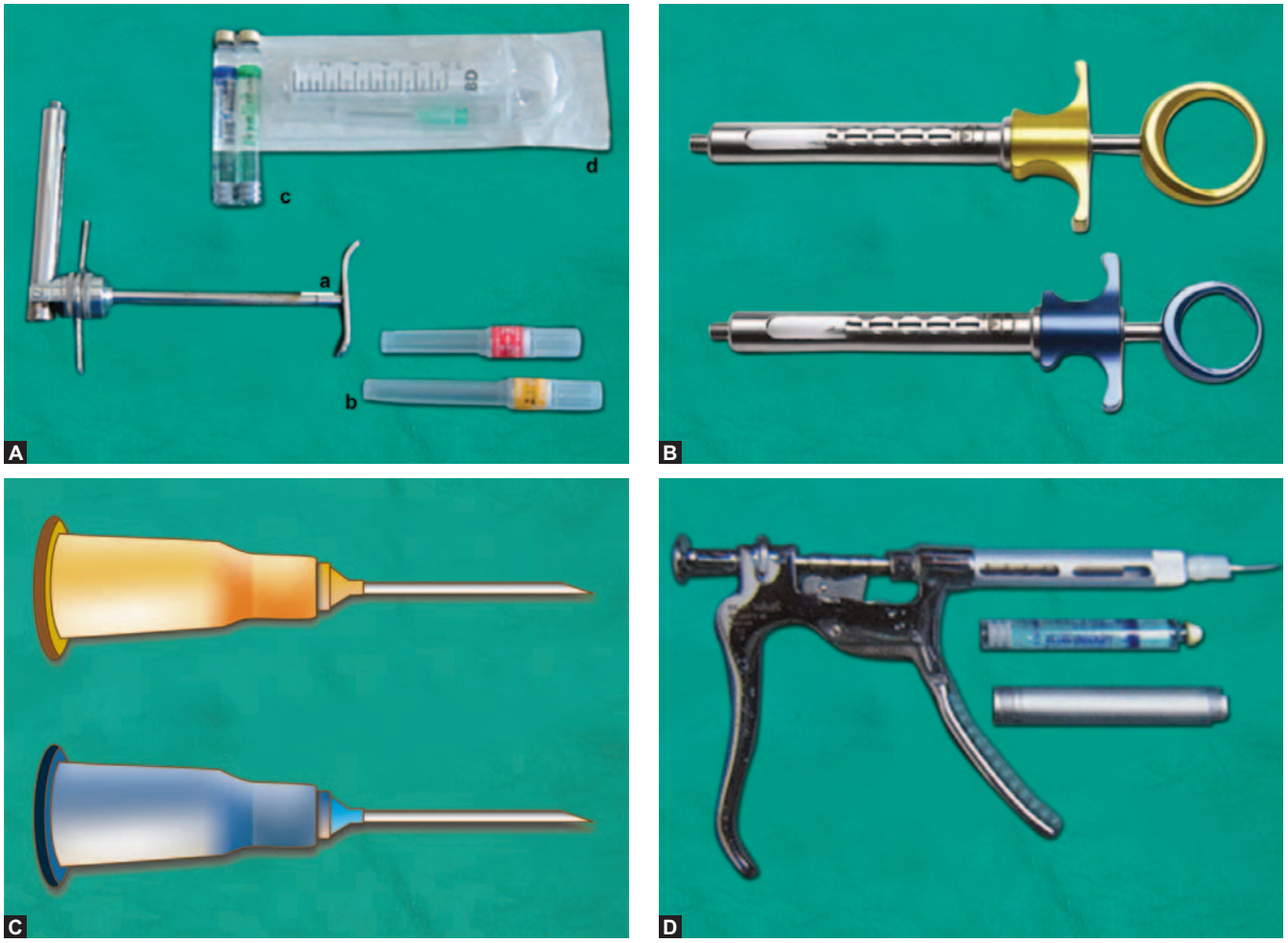
The various types of syringes used for local anesthetic administration in dentistry are as follows **(Figs 9.1 to 9.3, and Boxes 9.4 and 9.5)**:

Box 9.4: Advantages and disadvantages of nondisposable syringes

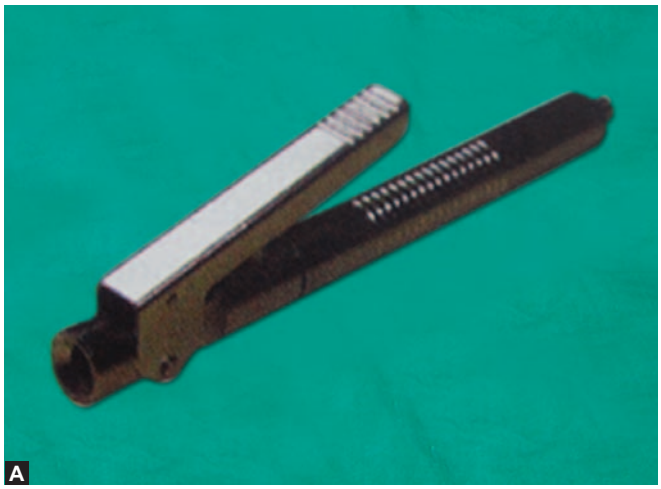
Advantages
- ❑ Aspiration with one hand is possible
- ❑ Autoclavable
- ❑ Long-lasting with proper maintenance
- ❑ Lower cost in the long run

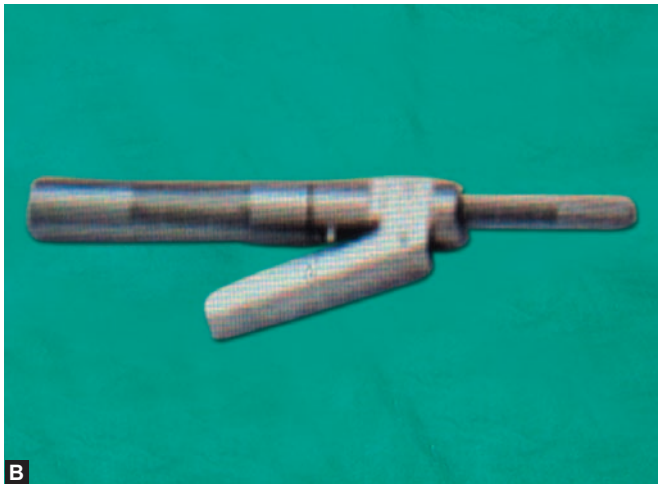
Disadvantages
- ❑ Heavier than plastic disposable syringes
- ❑ Possibility of infection with improper care
- ❑ Deterioration of plastic with repeated autoclaving

- Nondisposable (reusable) syringes:
  - Breech-loading, cartridge type syringe. These syringes are available in the following forms: (i) metallic or plastic, (ii) aspirating or non-aspirating, and (iii) Self-aspirating types



Figs 9.1A to D: (A) *a*, Metallic non-aspirating cartridge syringe with, *b*, disposable short and long needles with caps; *c*, Cartridges; *d*, Disposable plastic syringe; (B) Aspirating metallic cartridge syringes; (C) Disposable needles without cap; (D) Special periodontal ligament injection syringe with ultrafine needle





Figs 9.2A and B: (A) Intraligamentary pressure injection syringe; (B) Jet syringe with needle

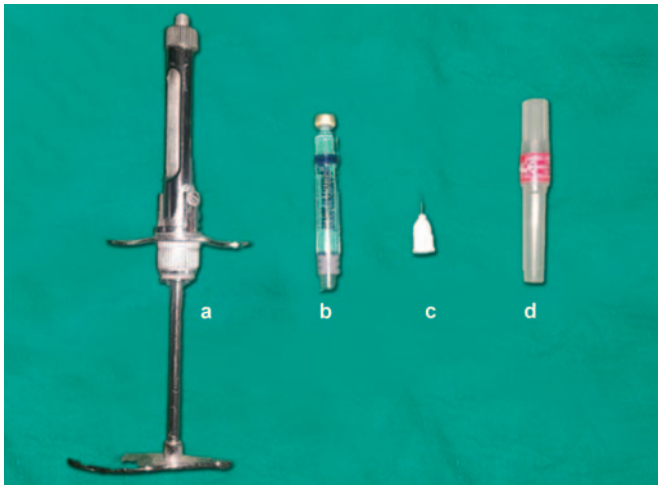


Fig. 9.3: Armamentarium for local anesthesia: (a) Metal syringe, nonaspirating; (b) Local anesthetic cartridge; (c) Needle; and (d) Needle within safety cover

Box 9.5: Advantages and disadvantages of disposable syringes

Advantages
- ❑ Disposable, single use
- ❑ Sterile until opened
- ❑ Light-weight, better tactile sensation
- ❑ Decreased chances of transmitting infections

Disadvantages
- ❑ Does not accept prefilled dental cartridges
- ❑ Difficult aspiration, requiring two hands
- ❑ Increased cost in the long run

  - Side-loading, aspirating and nonaspirating syringes
  - Pressure syringe
  - Jet injector
  - Luer lock glass syringes.
- Disposable or plastic syringes.
- Safety syringes.

Jet Injector

It is a needleless injection. It is primarily used to obtain topical anesthesia prior to insertion of a needle.

Advantages:
- Does not require use of a needle. (Recommended for needle-phobic and especially young children).
- Delivers very small volumes of local anesthetic solution with calculated amount of force.
- Used in topical anesthesia
- Intraligamentary anesthesia can be achieved for individual tooth.

Disadvantages:
- Inadequate for pulpal or regional anesthesia
- Some patients are disturbed by the "jolt" of jet injection
- Expensive.

Needle

The needle permits the local anesthetic solution to travel from the syringe into the soft tissues.

All needles used in dentistry are made of stainless steel and are disposable.

Parts of the Needle

- **Bevel:** It is the point or the tip of the needle. The needles are monobeveled. The recommended bevel is 12° and it influences the degree of deflection.
- **Shank**
- **Hub:** It is a plastic or metal piece through which the needle is attached to the syringe.

Selection of Needles

When needles are selected for various injection techniques, the following two factors are considered.

Gauge: It refers to the diameter of the lumen of the needle. The greater the diameter of the needle, the smaller is the number. Disposable single use needles are of 23–30 gauge. The finer gauge permits easier penetration of the tissues and causes less discomfort to the patients. 25-gauge needles have less deflection and greater accuracy leading to increased success of anesthesia. Also aspiration of blood is easier and more reliable through a larger lumen.

Length: Dental needles are available in two lengths: (i) Short, 25 mm or 1 inch, and (ii) Long, 38–40 mm or 1½ inch or 1-5/8 inch. Long needles are preferred for injection techniques requiring penetration of significant depth of soft tissues, e.g. pterygomandibular block, Akinosi mandibular nerve block, and Gow-Gates mandibular nerve block.

Dental Cartridge

It is a presterilized glass cylinder containing the local anesthetic drug. The cartridges available can contain (a) 1.8 mL of local anesthetic solution (USA and France), or (b) 2.2 mL of local anesthetic solution (UK and Australia). Cartridges are premade in blister packs or canisters. They are available with adrenaline or without adrenaline **(Figs 9.4A and B)**.

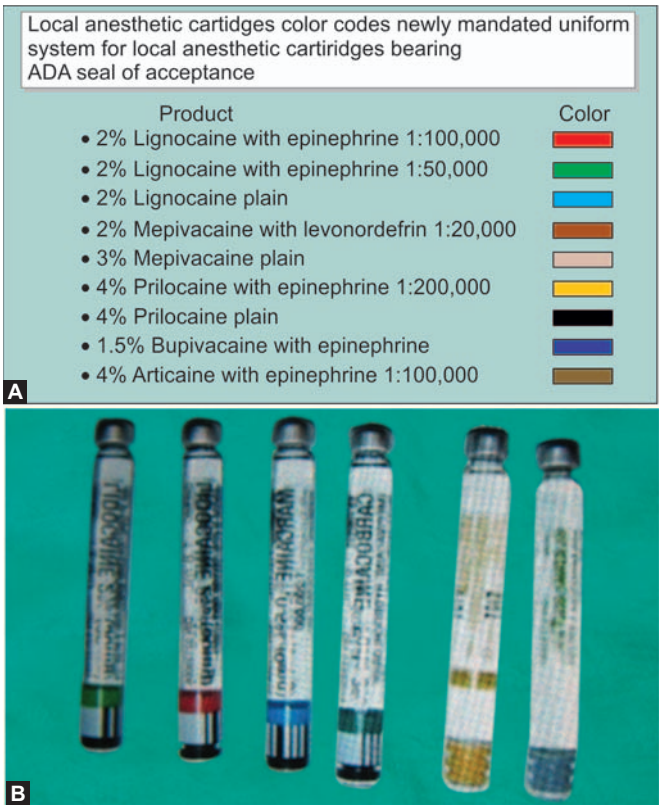
Components

The prefilled dental cartridge consists of four parts:

1. Cylindrical Glass Tube,
2. Rubber Stopper,
3. Aluminium Cap, and
4. Rubber Diaphragm.

A small bubble of approximately 1–2 mm is frequently seen in the cartridge. It is composed of nitrogen gas, which is bubbled into the local anesthetic solution during its manufacture to prevent oxygen from being trapped in the cartridge and potentially destroying the vasopressor

Local anesthetic solution is also available in 30 mL or 50 mL multidose vials **(Fig.9.5)**.



Figs 9.4A and B: (A) Color-coding for cartridges by ADA, (B) Various cartridges available as per color-coding in the market



Fig. 9.5: Local anesthetic solution is also available in 30 mL/50 mL. Multidose vial form, from where it can be drawn in plastic disposable syringe. Amber color bottle for prevention of oxidation of adrenaline from sunlight. Clear bottle for lignocaine plain

Additional Armamentarium

- **Topical antiseptic:** Five percent Betadine (povidone-iodine)
- Topical anesthetic agent
- Applicator sticks
- Cotton/gauze
- Hemostat.

INJECTION TECHNIQUES FOR REGIONAL ANESTHESIA

Prior to the administration of the local anesthesia to the desired target area, the position of the patient, dental chair and operator is adjusted as described in detail the chapter "Exodontia" (*see* **Fig. 18.13A and B) (Figs 9.6 and 9.7**).

There are several general methods of achieving pain control with local anesthetics. Three major types of local anesthetic injection (along with one minor topical type of anesthesia) can be differentiated.

Topical Anesthesia/Surface Anesthesia

Indication for Topical Gels/Ointment/Cream

Prior to the administration of local anesthetic injections, it is desirable to use topical anesthetic agent to mucosa to minimize the discomfort of injection. Topical anesthesia is also used for abscess drainage, suture removal, removal of deciduous teeth and small sharp bony spicules etc. It is also used to suppress gag reflex. Prior to impression taking and intraoral radiographs are also used to relieve discomfort. Topical liquid preparations are used for stomatitis, oral ulcers, denture sores, etc.

Commonly used drugs are cocaine 4%, lidocaine 2% or 4%, 5%, 10%, 15% water-soluble form, Tetracaine 1–2%, Benzocaine-205 w/v—most popular topical agent, poorly soluble in water, added in several medical preparations.

Forms of Topical Anesthetics

Spray:

- 10–15% lignocaine in water base.
- **Ethyl chloride spray:** It causes refrigeration-snow effect.
- **Cetacaine:** Rapid onset 30 seconds, lasts up to 30 minutes.
- Benzocaine 20% spray.

Spray cans are available with disposable extension tubes or autoclavable cannula. Whenever the spray is used, the can is held straight with cannula pointing toward the area of application. Judicious amount of solution is sprayed protecting the eyes. Sprays are flammable. To avoid over delivery, now metered spray cans are also available, which deliver 50 mg/spray.

Ointment for skin and mucosa surface:

- **5% lignocaine:** Onset of action 3–4 minutes, Prilocaine 2.5% cream.



Fig. 9.6: Chair position for extraction of maxillary teeth. The occlusal plane of the teeth is kept at about 45° angle to the floor. The occlusal plane of the teeth should be above the level of operators elbow. Note that the fingers of the nondominant hand are used to support the alveolus and retract cheek/lip



Fig. 9.7: Chair position for extraction of mandibular teeth, the occlusal plane of the teeth is parallel to the floor. The occlusal plane of the teeth should be below the level of operators elbow. Note that the fingers of the nondominant hand are used to support the alveolus and the mandible. It also helps in retracting the cheek and lip

- **Eutectic mixture of local anesthetic (EMLA):** Combination of lidocaine and prilocaine.
- Procaine/lidocaine 8% plus Dibucaine 0.8% in a flavored aqueous base.
- Cinchocaine ointment.
- Emulsion/viscous flavored.

- Viscous of benzydamine hydrochloride 0.15% w/v (Tantum gargles).
- 2% lignocaine hydrochloride used for preventing gagging due to impression procedure, to relieve soreness following minor surgery. It is used for gargles.
- **Gels:** Twenty percent Benzocaine (Hurricaine, Gingicaine) with water-soluble polyethylene glycol base is available in different flavors, such as cherry, banana, strawberry, pineapple, etc., are liked by children. It has quick topical action within 20 seconds. Duration, 12–15 minutes. No systemic absorption and easy to use.
- **Topical patches:** Lidocaine transoral delivery system. Small adhesive matrix containing local anesthetic can be applied to oral mucosa in sore areas.

Direction for use of topical agents: Apply to previously dried oral mucosa with cotton bud for better efficacy. Remove excess saliva during application by suction for minimizing the dilution. Not more than 28 g per patient during a 24-hour period should be used. Keep out of reach of children. Do not swallow **(Fig. 9.8)**.

1. **Local infiltration:** Small terminal nerve endings in the area of dental treatment are flooded with local anesthetic solution. Examples, administration of local anesthetic solution into an interdental papilla prior to root planning.
2. **Field block:** The local anesthetic solution is deposited near the larger terminal nerve branches so that the anesthetized area will be circumscribed. Examples, maxillary injections administered above the apex of the tooth.
3. **Nerve block:** The local anesthetic agent is deposited close to a main nerve trunk, before the nerve trunk divides into terminal branches, usually at a distance from the site of operative intervention. Examples, (i) posterior superior alveolar nerve block, (ii) inferior alveolar nerve block, (iii) infraorbital nerve block, and (iv) nasopalatine nerve block.

Factors affecting selection of the anesthetic technique:

- **Area to be anesthetized** depends on the density of the bone.
- **Extent of surgical procedure:** Multiple extractions should be done with nerve block technique to avoid multiple needle pricks.
- **Duration and profoundness of anesthesia required:** Nerve block will give profound depth of anesthesia for longer duration.
- **Age of the patient:** Older patients have dense bone. In children, blocks should be avoided as far as possible.



Fig. 9.8: Topical anesthesia can be achieved by using local anesthetic spray, ointment, cream

- **Hemostasis**: If required additional infiltration in the area of surgery should be considered.
- **Presence of infection:** Infiltration should be avoided to prevent spread of infection.
- Skill of the operator.

Infiltration and Field Block

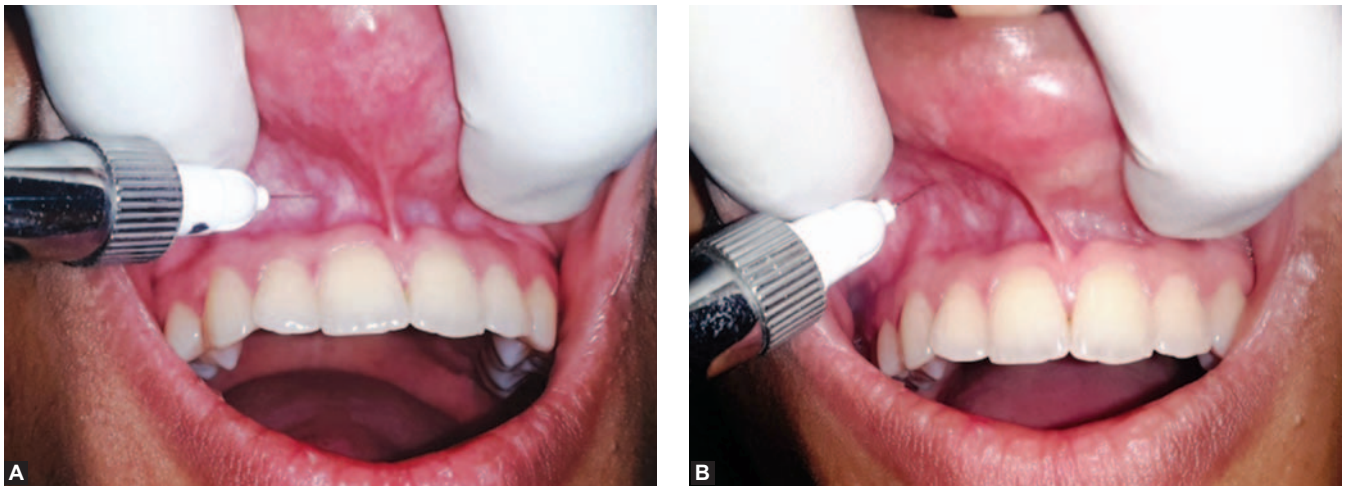
Maxillary anterior region and mandibular anterior region till premolars have thin cortical labial or buccal plate and lingual/palatal plate, where the bone is cancellous/porous in nature. Infiltration or field block in these areas will allow diffusion of local anesthetic solution through the periosteum and the minute foramina in the cortical bone to the nerve filaments inside the cancellous bone.

In the olden days, the terminologies used for infiltration techniques were subdivided into submucosal, supraperiosteal, subperiosteal infiltration. But since this method is a blind technique, it is difficult to differentiate these layers clinically.

Paraperiosteal infiltration method is the acceptable term now in dentistry as the local anesthetic solution is deposited along the periosteum, and it is used for achieving local anesthesia for individual tooth in the maxilla or mandible, except mandibular molar teeth **(Figs 9.9A and B)**.

Paraperiosteal Infiltration Injection

It is commonly called the local infiltration and is the most frequently used local anesthetic technique for obtaining pulpal and investing soft tissue anesthesia in maxillary/mandibular anterior teeth till premolars **(Fig. 9.9A)**.



Figs 9.9A and B: Local infiltration technique: (A) The anesthetic solution is deposited over terminal nerve endings where the procedure is to be carried out. Whereas in field block; (B) Local anesthetic is deposited near the larger terminal nerve branches and the procedure is done away from site of injection

Nerves anesthetized: Large terminal branches of nerves in the apical region of the teeth to be anesthetized buccally/labially and lingually/palatally.

Areas anesthetized: The entire region innervated by large terminal branches such as for the pulp and root area of the teeth, buccal/labial periosteum, lingual/palatal region, connective tissue and mucous membrane.

Indications

- Pulpal anesthesia of the maxillary/mandibular teeth, except mandibular molars, when treatment is limited to one or two teeth
- Soft tissue anesthesia when indicated for surgical procedures in a circumscribed area.

Contraindications

- Infection or acute inflammation or in the area of injection
- Dense bone covering the apices of teeth.

Advantages

- High success rate
- Technically easy injection
- Usually atraumatic.

Disadvantages

Not recommended for large areas because of need for multiple insertions, and the necessity to administer larger total volumes of anesthetic solution.

Technique

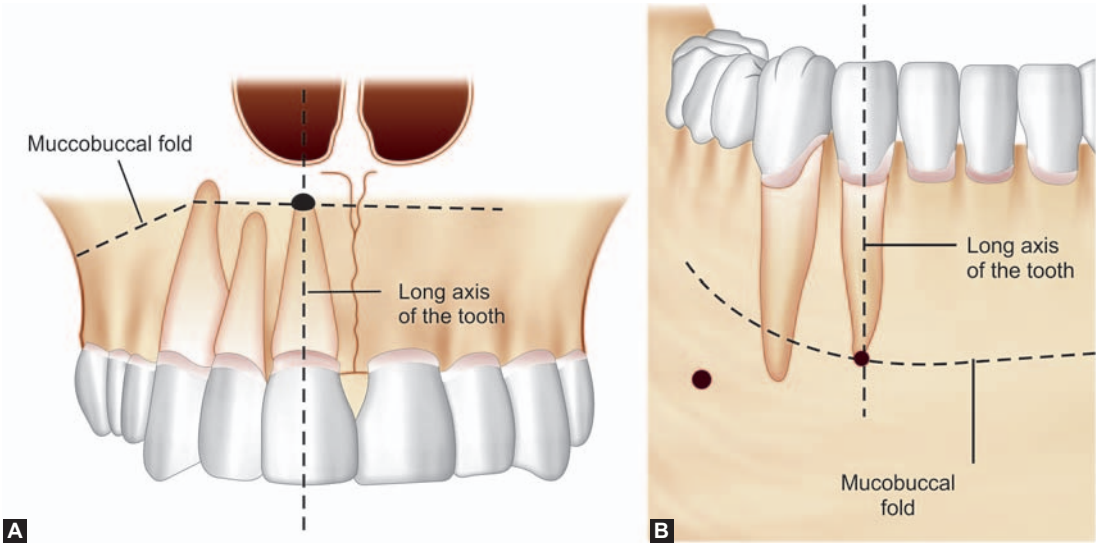
A 25 or 27 gauge short needle is recommended. Non-aspirating syringe can be used. The area of insertion is at the height of mucobuccal fold above the apex of the tooth to be anesthetized. The target area is the apical region of the tooth to be anesthetized. The anatomical landmarks include mucobuccal fold, crown of the tooth, root contour of the tooth. The orientation of the bevel is toward the bone. First imaginary line is vertical line parallel to the long axis of the tooth and second line is a horizontal line along the mucobuccal fold on the buccal/labial side, and for lingual infiltration in mandibular teeth, the second imaginary line should be drawn above the floor of the mouth at mucolingual sulcus **(Figs 9.10 and 9.11)**.

Point of needle insertion:

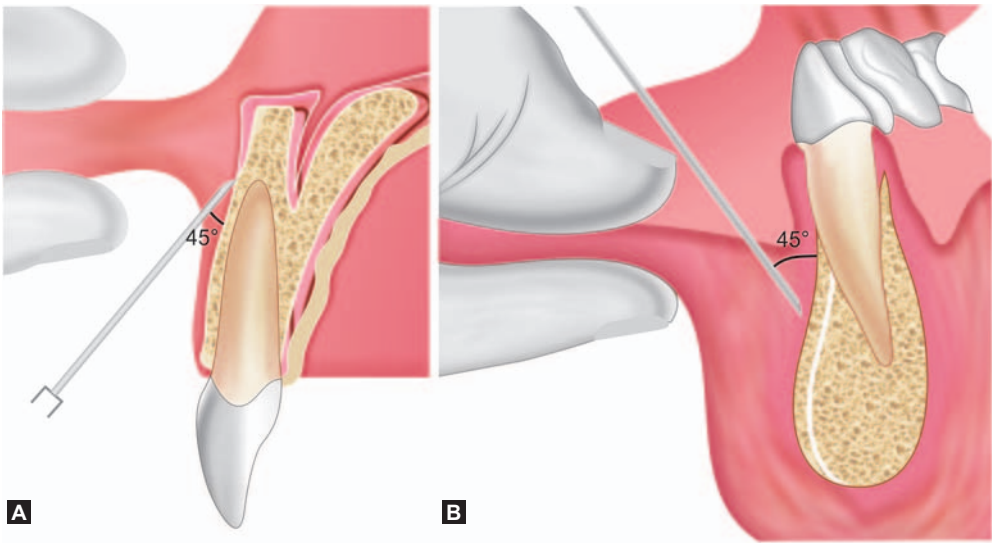
- The point of intersection of these two imaginary lines.
- Direction of needle 45° with the labial or buccal cortical plate of bone.

Procedure

Prepare the tissues at the site of injection. Clean with sterile dry gauze. Apply topical antiseptic. Apply topical anesthetic agent. Lift the lip, pulling the tissues taut. Hold the syringe parallel to the long axis of the tooth. Insert the needle at the height of mucobuccal fold over the target area. Advance the needle at or above the apical region of the tooth. Aspirate, if negative, deposit approximately 0.5 mL slowly over 20 seconds. Withdraw the syringe slowly. Recap the needle. Wait for 2–3 minutes, and commence the dental procedure.



Figs 9.10A and B: Anatomical landmarks for paraperiosteal infiltration (A) for maxillary teeth and (B) for mandibular teeth



Figs 9.11A and B: Penetration of needle for paraperiosteal infiltration (A) for maxillary teeth and (B) for mandibular teeth

Lingual Infiltration for Mandibular Teeth

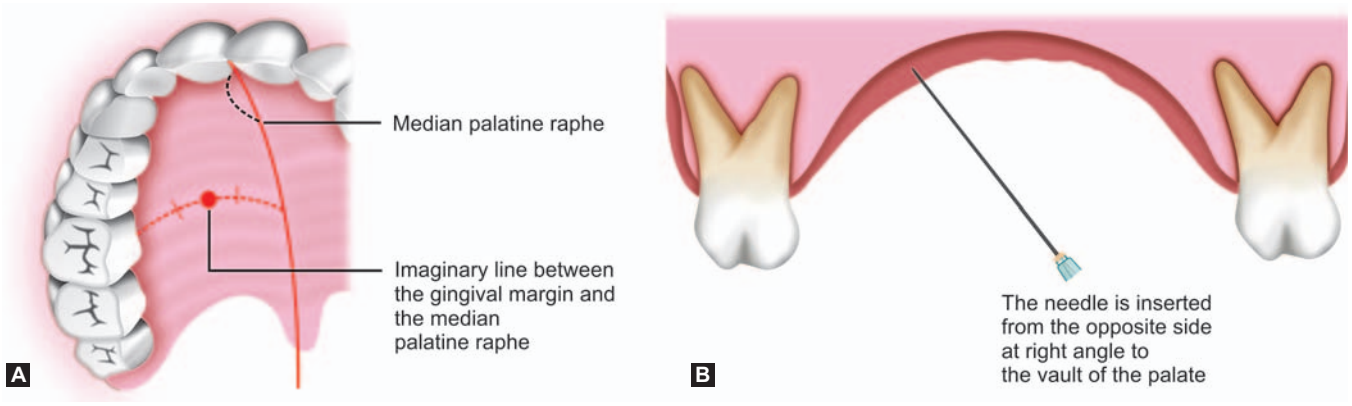
The point of needle insertion is 3–5 mm cervical to the free gingival margin along the long axis of the tooth.

Direction of the needle insertion: The syringe is directed from the corner of the mouth of the left side for the right side injection and reverse for the other side. *Terminal branches of the long buccal nerve also can be blocked by the infiltration method.*

Palatal Infiltration (Figs 9.12 and 9.13)

Point of needle insertion is midway between the gingival margin of the tooth and the median palatal raphe, along the long axis of the tooth.

Direction of needle insertion is perpendicular or 90° to the palatine bone. 2 mm depth of needle is inserted from the opposite side and 0.3 mL solution is deposited. Palatal injections are most painful, therefore warn the patient before.



Figs 9.12A and B: Diagrammatic representation of palatal infiltration technique

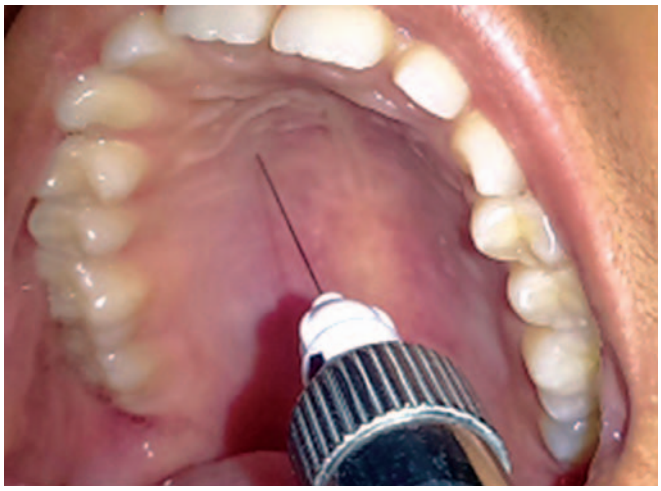


Fig. 9.13: Clinical picture of palatal infiltration

Do not deposit excess solution as it may cause blanching, sloughing/necrosis of the palatal mucosa.

Signs and Symptoms

- **Subjective:** Feeling of numbness in the area of administration
- **Objective:** On probing, absence of pain during treatment

Modified Mendel Nevin's Method: All maxillary anterior teeth can be anesthetized by inserting the needle over canine tooth on right side and then passing the needle horizontal toward other side canine (long needle). The infiltration of local anesthetic then starts from left side canine, gradually withdrawing the needle over each tooth apices and depositing the solution slowly. This is an excellent method for multiple extractions, alveolectomy, etc.

Supplementary Infiltration Techniques

Many a times, especially in endodontics, paraperiosteal infiltration is supplemented by various other methods depending on patient's response **(Figs 9.14A to D)**.

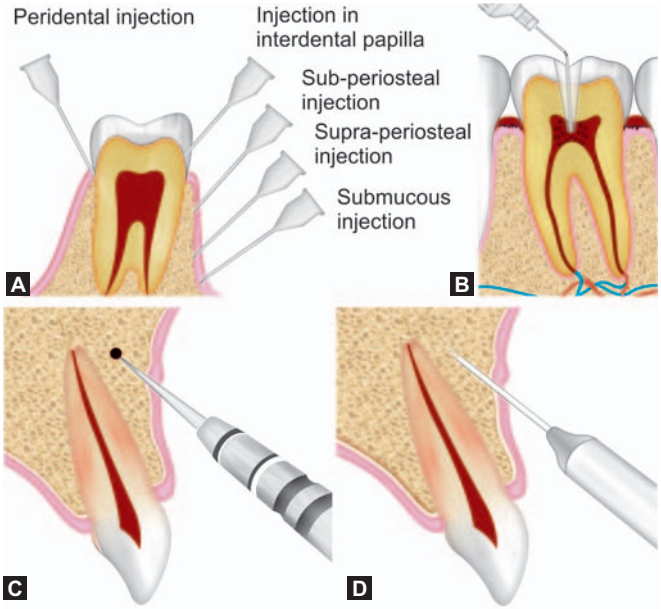
- Periodontal ligament injection (intraligamentary)
- Intraosseous injection
- Intraseptal injection/intrapapillary/intradental injection
- Intrapulpal injection.

Intraligamentary injection: Delivery of local anesthetic through the periodontal ligament to reach the periapical region. Pressure syringe is preferable as there is lot of resistant encountered. The 25–27 gauge, short needle is inserted mesial or distal to the tooth in the interproximal area at the depth of gingival sulcus. Advance needle apically until resistance is encountered. 0.2 mL solution is injected over 20 seconds.

Intraosseous injection is rarely used, where the bur hole is drilled below the apical area without damaging the root apex and then needle is introduced through it to deposit the solution.

Intraseptal injection used for hemostasis and additional anesthesia. At the center of the base of the interdental papillae, the needle is inserted at 45° with the buccal plate, with bevel toward bone. The needle is forced gently in the interseptal bone on either side of the tooth. 0.2–0.4 mL solution is deposited. Very quick onset and it causes blanching of the gingiva. Resistance is felt during injection.

Intrapulpal injection is useful in acute pulpitis and endodontic treatment. Needle is inserted into the pulp chamber or directly in the root canals. Local anesthetic is deposited under pressure, if required, the needle is bent to gain access. 0.2–0.3 mL is deposited to get profound and fast anesthesia.



Figs 9.14A to D: (A) Different supplementary infiltration techniques; (B) Intrapulpal injection; (C and D) Intraosseous infiltration

Nerve Blocks or Conduction Anesthesia

A nerve trunk supplying maxillary or mandibular area is blocked by local anesthetic at some point between the periphery and brain, thereby abolishing the sensation distal to the point where nerve is blocked. It provides larger anesthetic field as the area of distribution of that particular nerve is anesthetized. Techniques can be (1) intraoral method (2) extraoral method.

Techniques of Maxillary Anesthesia

The following techniques are used to achieve clinically adequate anesthesia of the teeth and soft/hard tissues in the maxilla.

- Paraperiosteal (infiltration)
- Periodontal ligament injection (intraligamentary)
- Intraosseous injection
- Intraseptal injection
- Posterior superior alveolar nerve block
- Infraorbital nerve block
- Nasopalatine nerve block
- Greater palatine nerve block
- Maxillary nerve block.

Posterior Superior Alveolar Nerve Block/ Tuberosity/Zygomatic Block

The posterior superior alveolar nerve block is effective for the anesthesia of maxillary third, second and first molar. However, the *mesiobuccal root of the maxillary first molar* is not consistently innervated by the posterior superior alveolar nerve. Therefore, a second injection, usually a paraperiosteal, is indicated following the posterior superior alveolar nerve block, when effective anesthesia of the first molar does not develop.

Nerves anesthetized: Posterior superior alveolar nerve, before it enters the posterior surface of the maxilla, while it is in the infratemporal fossa and its branches.

Areas anesthetized: Pulps of maxillary third, second and first molars, and buccal periodontium and bone overlying these teeth, buccal mucoperiosteum of the area.

Indications:

- Treatment involving two or more maxillary molars
- When paraperiosteal injection is contraindicated as in acute inflammation or infection
- When paraperiosteal injection has proved ineffective.

Contraindications:

- When the risk of hemorrhage is too great as with a hemophilic.

Advantages:

- Atraumatic
- High success rate
- Minimum number of injections required
- Minimizes total volume of anesthetic solution injected.

Disadvantages:

- *Risk of hematoma* as needle lies close to the pterygoid plexus of veins. Aspirate and inject and use short 25 mm needle.
- **Technique is somewhat arbitrary:** No bony landmarks during insertion.
- Second injection required for treatment of the first molar in 28% of patients.

Technique: The anatomical landmarks include mucobuccal fold and its concavity, zygomatic process of maxilla, infratemporal surface of maxilla, anterior border and coronoid process of the ramus of the mandible, and tuberosity of maxilla. The area of insertion is at the height of mucobuccal fold above the maxillary second molar. The needle is advanced slowly upward, backward, and inward. Half the length of the needle should be inserted. It should not touch the bone. Aspiration, if negative, then only solution injected. The target area is the posterior superior alveolar nerve. This nerve is located posterosuperior and medial to maxillary tuberosity **(Figs 9.15A and B)**.

Procedure: A 25 gauge short needle is recommended. For left posterior superior alveolar nerve block and right handed administrator, stand at 10 o'clock position facing

the patient. For the right posterior superior alveolar nerve block stand at 8 o'clock position. Prepare the tissues. Orient the needle toward the bone. Partially open the patient's mouth, pulling the mandible to the side of injection and maxillary occlusal plane at 45° to the floor. Retract patient's cheek, and move the forefinger over the mucobuccal fold in a posterior direction from the bicuspid area until the zygomatic process of the maxilla is reached. At this point, the left forefinger is rotated so that the fingernail is adjacent to the mucosa and its bulbous portion is still in contact with the posterior surface of the zygomatic process.

Now the hand is lowered with the finger keeping the bulbous portion still in contact with the zygomatic process so that the finger is in a plane at right angles to the occlusal surfaces of the maxillary teeth and at 45° angle to the patient's sagittal plane. The previously loaded syringe/needle is inserted into the tissue in a line parallel to the index finger and bisecting the fingernail. The direction of insertion is in an upward, inward and backward direction in one movement.

In an adult of normal size, penetration to a depth of 16 mm will place the needle tip in the immediate vicinity of the foramina through which the posterior superior alveolar nerve enter the posterior maxilla.

After aspirating in two planes, the operator slowly injects the contents of the cartridge over a period of 30–60 seconds. Wait for 3–5 minutes before commencing the dental procedure.

Infraorbital Nerve Block/Anterior Superior Alveolar Nerve Block

Nerves anesthetized:

- Anterior superior alveolar nerve
- Middle superior alveolar nerve
- Infraorbital nerve along with inferior palpebral, lateral nasal and superior labial branches.

Areas anesthetized:

- Pulps of maxillary central incisors up to the second premolar on the side of injection
- Pulp of mesiobuccal root of maxillary first molar on the side of injection
- Labial or buccal periodontium, mucoperiosteum and supporting alveolar bone of these teeth.
- Skin of lower eyelid, skin of lateral aspect of the nose, and skin and mucosa of upper lip.

Indications:

- Dental procedures involving more than two maxillary teeth, and their overlying buccal tissues.
- Inflammation or infection which contraindicates paraperiosteal injection.

Contraindications:

- Discrete treatment areas (one or two teeth only).
- Hemostasis of localized areas, when desirable, an additional local infiltration into the area is indicated.



Figs 9.15A and B: (A) Needle in position for posterior superior alveolar nerve block. Maxillary tuberosity (yellow arrow) and infratemporal surface of maxilla (white arrow). (B) Clinical picture of posterior superior alveolar nerve block; the cheek is retracted and the needle is advanced in inward, upward and backward direction

Advantages:

- Comparatively simple technique.
- Comparatively safe, minimizes the volume of solution used and the number of needle punctures required to achieve anesthesia.

Disadvantages:

- **Anatomical:** Difficulty in defining landmarks.
- **Psychological:** Initial fear of injury to the patient's eye.

Anatomical landmarks: The landmarks include supraorbital notch/foramen, infraorbital margin, infraorbital depression, infraorbital foramen, anterior teeth, pupil of the ipsilateral eye, mental foramen.

Needle pathway during insertion:

Bicuspid approach: The needle passes through the mucosa and areolar tissue and during insertion should pass beneath and lateral to the facial artery and facial vein **(Figs 9.16A to C)**.

Central incisor approach: The needle passes through the mucosa and areolar tissue and beneath the angular muscle during insertion should pass beneath and lateral to the facial artery and facial vein.

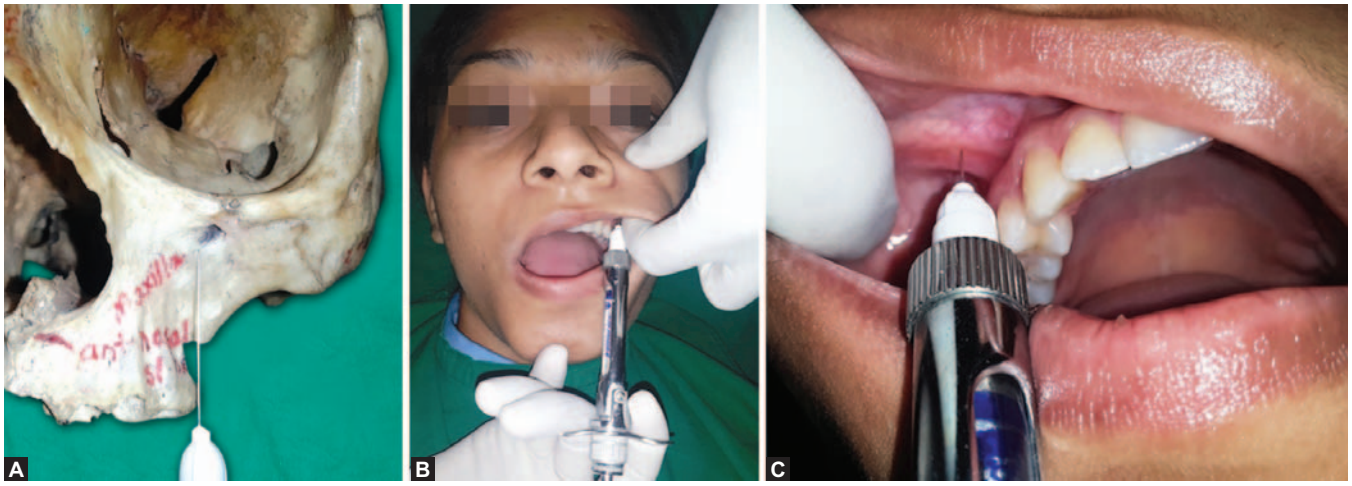
Technique: The patient is placed comfortably in the chair and tilted so that the maxillary occlusal plane is at an angle of 45° to the floor. Prepare the tissues at the injection site. Locate the infraorbital margin. Move your finger downward from the margin, applying gentle pressure to the tissues. As the finger continues inferiorly, a concavity will be felt. This is the infraorbital depression. The deepest part of the depression is the infraorbital foramen. Maintain your finger on the foramen or mark the skin at the site. Retract the lip, pulling the tissues in the mucobuccal fold taut, and increasing visibility.

Bicuspid approach: Insert the needle into the height of the mucobuccal fold over the first premolar with the bevel facing bone. Orient the syringe toward the infraorbital foramen. The needle should be held parallel to the long axis of the tooth as it is advanced to avoid premature contact with the bone. Advance the needle until bone is gently contacted.

Central incisor approach: The second direction bisects the crown of the ipsilateral central incisor from the mesioincisal angle to the distogingival angle. The area of insertion is about 5 mm away from the mucobuccal fold of ipsilateral canine, and guided into the position by the thumb marking the location of the infraorbital foramen.

In either approach, the needle should not penetrate more than 3/4th of an inch. Approximately, 2 mL of solution is slowly deposited in this area and the thumb is held in position until the injection is completed. The administrator will be able to feel the anesthetic solution as it is deposited beneath the finger on the foramen if the needle tip is in the correct position. Maintain firm pressure with the finger over the injection site both during and for at least 1 minute after the injection. Wait for 3–5 minutes after completion of the injection and commence the dental procedure (**Figs 9.17A and B)** show extraoral clinical picture of infraorbital block technique, which is rarely used in case of local intraoral infection.

Palatal anesthesia: The anesthesia of the hard palate is necessary for dental procedures involving manipulation of



Figs 9.16A to C: (A) Infraorbital nerve block by bicuspid approach. The needle is advanced parallel to the premolar teeth. The final position of the needle is in vicinity of the infraorbital foramen. Clinical pictures of infraorbital nerve block; (B) Extraoral landmarks; and (C) Intraoral landmarks

palatal soft and hard tissues. The palatal anesthesia is one of the most painful injections. To reduce the discomfort to the patient during palatal anesthesia:

- Provide adequate topical anesthesia at the site of injection
- Use pressure anesthesia at the site before and during needle insertion and the deposition of the solution
- Maintain control over the needle
- Deposit the anesthetic solution slowly.

Greater Palatine Nerve Block/ Anterior Palatine Nerve Block

Nerves anesthetized: Greater palatine nerve.

Areas anesthetized: The posterior portion of the hard palate and its overlying soft tissues, anteriorly as far as the first premolar and medially up to the midline of the palate.

Indications:

- When palatal soft tissue anesthesia is required for restorative therapy on more than two teeth.
- For pain control during oral surgical or periodontal surgical procedures involving the palatal soft and hard tissues.

Contraindications:

- Inflammation or infection at the site of injection
- Smaller areas of therapy.

Advantages:

- It minimizes needle penetrations and volume of solution.
- Minimal patient discomfort.

Disadvantages:

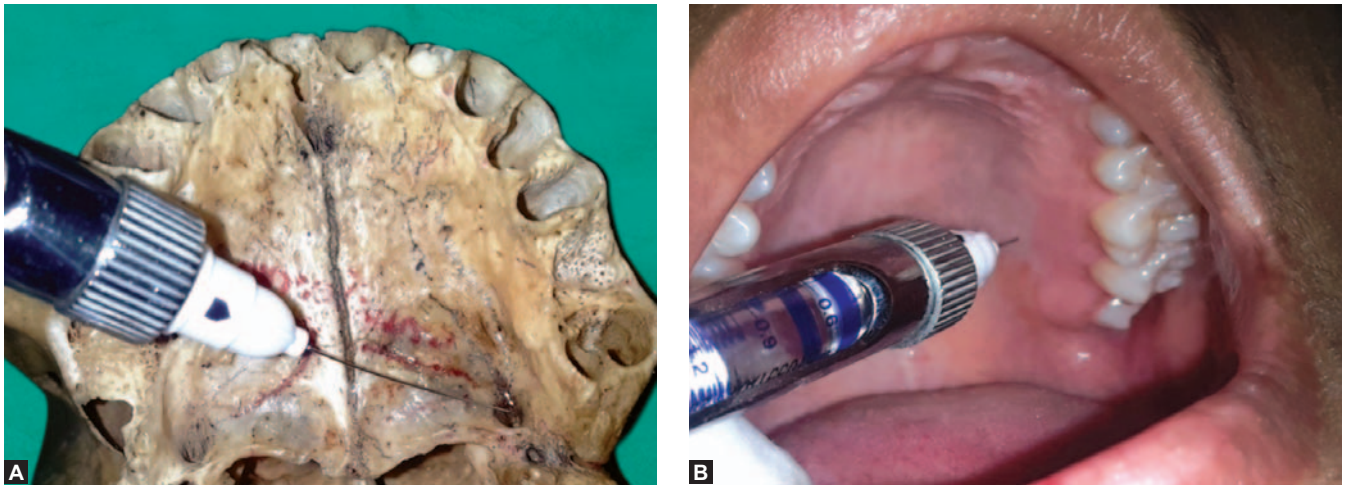
- It is a potentially traumatic.
- No hemostasis except in the immediate area of injection.

Technique: The anatomical landmarks include greater palatine foramen, maxillary second and third molars, palatal gingival margin of second and third maxillary molars, midline of the hard palate, and a line approximately 1 cm from the palatal gingival margin toward the midline of the palate **(Figs 9.18A and B)**.

Procedure: A 25 or 27 gauge needle is recommended. The area of insertion is in the soft tissues slightly anterior to the greater palatine foramen. The target area is the greater palatine nerve as it passes anteriorly between the soft tissues and the bone of the hard palate. The bevel of the needle is oriented toward the palatal soft tissues. Locate the greater palatine foramen with a cotton swab which is most frequently located distal to the maxillary second molar about 1 cm from the palatal gingival margin toward the midline. The greater palatine foramen is approached from the opposite side at right angle to the curvature of the palatal bone. The needle is inserted slowly until the palatal bone is contacted. Approximately 0.25–0.5 mL of solution is injected very slowly. Withdraw the needle slowly and cover it with its sheath. The nerve may be blocked at any point along its anterior course after emergence from the foramen.



Figs 9.17A and B: (A) Target area in extraoral infraorbital nerve block; (B) Extraoral approach for infraorbital nerve block (clinical picture)



Figs 9.18A and B: (A) Target area for greater palatine nerve block; (B) Clinical picture of greater palatine nerve block

Nasopalatine Nerve Block

Other common names: Incisive nerve block, sphenopalatine nerve block.

Nerves anesthetized: Nasopalatine nerves bilaterally.

Areas anesthetized: Anterior portion of the hard palate from the mesial of the right premolar to the mesial of the left first premolar.

Indications:
- When palatal soft tissues anesthesia is required for restorative therapy on more than two teeth.
- For pain control during oral surgical or periodontal surgical procedures involving palatal soft and hard tissues.

Contraindications:
- Acute inflammation or infection at the site of injection.
- Smaller areas of therapy (one or two teeth).

Advantages:
- Minimizes needle penetrations and volume of solution.
- Minimal patient discomfort from multiple needle penetrations.

Disadvantages:
- No hemostasis except in the immediate area of injection.
- Potentially the most painful intraoral injection.

Technique: The anatomical landmarks include maxillary central incisor teeth, incisive papilla in the midline of the palate, and incisive foramen.

Procedure: The nasopalatine nerve block is an extremely painful injection unless a preparatory injection is made.

Labial approach: The preparatory injection is made by inserting 1 inch 25 gauge needle into the labial intraseptal tissues in between the maxillary central incisors. The needle is inserted at a right angle to the labial cortical plate and passed into the tissues until resistance is felt. Then 0.25 mL of anesthetic solution is deposited. The needle is then withdrawn and reinserted slowly into the crest of the papilla. The needle is advanced slowly into the incisive foramen about 0.5 cm into the canal and about 0.25–0.5 mL of solution is injected.

Palatal approach: The tip of the needle is placed in the depression surrounding incisive papilla and small amount of solution is injected until the blanching of the papilla is seen. The needle is then advanced into the incisive foramen for about 0.5 cm into the canal and about 0.25–0.5 mL of solution is injected **(Figs 9.19A and B)**.

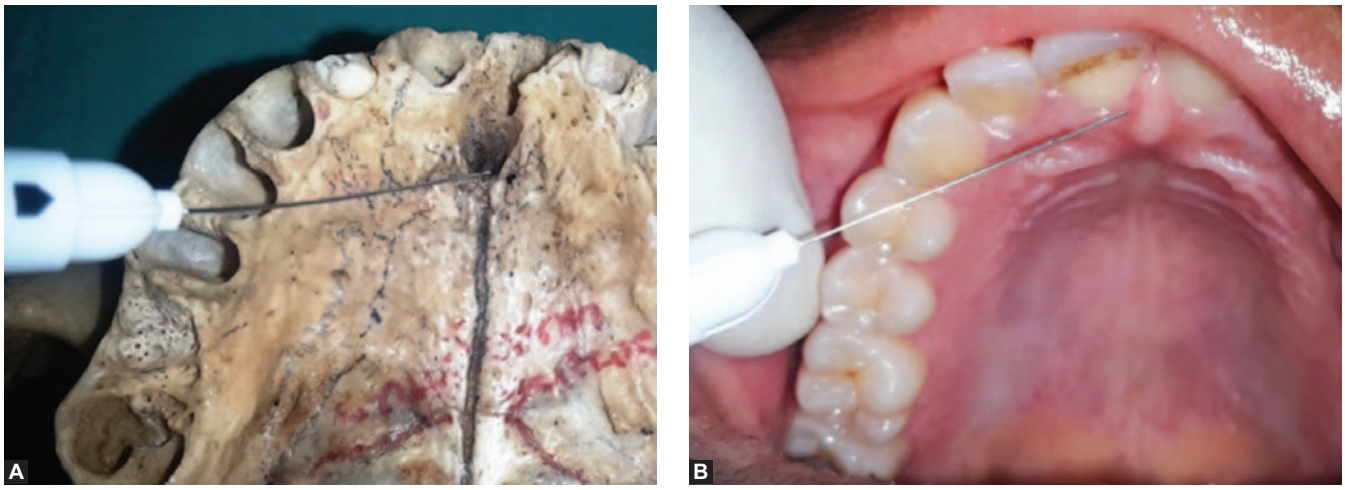
Signs and symptoms:
- Numbness in the anterior portion of the palate.
- No pain during dental therapy.

Extraoral Maxillary Nerve Block

Whenever intraoral anesthesia is not possible, due to extensive accident wounds or trismus or limited oral opening, operator may have to resort to extraoral injection technique.

Nerves anesthetized: Maxillary nerve and all its branches, peripheral to the site of injection.

Areas anesthetized: Anterior temporal and zygomatic region, lower eyelid, side of the nose, upper lip, maxillary teeth along with the investing structures, hard palate, part



Figs 9.19A and B: (A) Target area for nasopalatine nerve block; (B) Clinical picture of nasopalatine nerve block



Figs 9.20A and B: (A) Bony landmarks of extraoral maxillary nerve block showing needle tip at target area; (B) Clinical picture of extraoral maxillary nerve block with markings

of the soft palate, tonsils, nasal septum, floor of the nose, turbinates, lateral wall of the nose, part of pharynx.

Anatomical landmarks: Midpoint of zygomatic arch, zygomatic notch, coronoid process, lateral pterygoid plate.

Indications: When anesthesia of the entire distribution of the maxillary nerve is required for extensive surgery, with only one needle insertion and with minimum anesthetic agent. For diagnostic purpose, in case of neuralgia.

Technique (Figs 9.20A and B): The midpoint of the zygomatic arch is located and the depression in its inferior surface is marked. Coronoid process is located by opening and closing of the mouth. The center of the depression which is marked with ink extraorally is located and that becomes the point of needle insertion.

Needle used: 4 inch/8.8 cm long, 22 gauge needle is chosen and a marking from the tip of 4.5 cm is done on the needle, by inserting a rubber marker.

Insertion of the needle: The needle is inserted perpendicular to the skin and midsagittal plane in the center of depression marked earlier. Keep on injecting few drops as the needle is advanced, till it touches the lateral pterygoid plate. The needle should never be inserted beyond the rubber marker. The needle is slightly withdrawn and redirected in a slight forward and upward direction till the rubber marker depth. After aspiration, if negative, 1–2 mL local anesthetic solution is injected slowly. Aspirate after each 0.5 mL of the injection.

Signs and symptoms: Tingling and numbness of upper lip, side of the nose, lower eyelid, soft palate and pharynx may have gagging sensation.

Techniques of Mandibular Anesthesia

- **Infiltration:** Anterior labial infiltration and anterior lingual infiltration and long buccal nerve infiltration.
- **Nerve block anesthesia:** (i) Inferior alveolar nerve block, (ii) Mental nerve block, (iii) Long buccal nerve block.
- Lingual nerve block.

Pterygomandibular Block

Other common names: Inferior alveolar nerve block, mandibular nerve block.

Nerves anesthetized:

- Inferior alveolar nerve along with its terminal branches: (i) incisive nerve and (ii) mental nerve.
- Lingual nerve.
- Long buccal nerve **(Figs 9.21A and B)**.

Areas anesthetized:

- **Inferior alveolar nerve:** It supplies (i) mandibular teeth up to the midline, (ii) body of the mandible, (iii) inferior portion of the ramus of the mandible, (iv) buccal mucoperiosteum, mucous membrane, anterior to mandibular first molar, and (v) skin of the chin, skin of lower lip, and mucosa of lower lip.
- **Lingual nerve:** It supplies (i) mucosa of anterior two-thirds of the tongue, (ii) mucosa of floor of the oral cavity, (iii) lingual soft tissues and periosteum, (iv) sublingual and submandibular salivary gland.
- **Long buccal nerve:** It supplies (i) buccal mucoperiosteum in the region of mandibular molars or buccal mucoperiosteum posterior to mental foramen, (ii) adjacent part of vestibular mucosa, (iii) adjacent part of buccal mucosa, (iv) mucosa of retromolar fossa.

Indications:

- Procedures of multiple mandibular teeth in one quadrant.
- When buccal soft tissue anesthesia is required (anterior to mandibular first molar).
- When lingual soft tissue anesthesia is required.

Contraindications:

- Acute inflammation or infection in the area of injection.
- Patients who might bite either the lip or the tongue (young children or mentally handicapped adults).

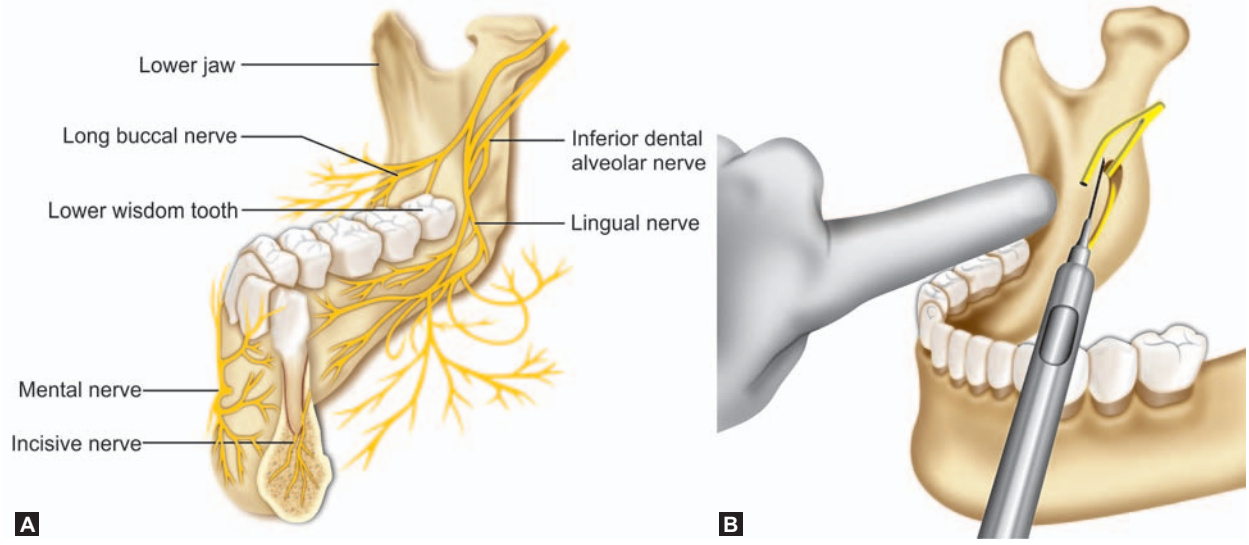
Anatomical landmarks:

Soft tissue landmarks:

- Sulcus mandibularis, mucobuccal fold in the region of mandibular premolars and molars
- Buccal pad of fat
- Retromolar triangle area
- Pterygomandibular raphe **(Fig. 9.22A)**.

Bony landmarks **(Fig. 9.21B):**

- External oblique ridge
- Internal oblique ridge
- Anterior border of ramus of the mandible



Figs 9.21A and B: (A) Nerves anesthetized by pterygomandibular block: inferior alveolar, lingual, long buccal, mental and incisive nerves; (B) Palpating the bony landmarks for the same

- Coronoid process
- Coronoid notch
- Occlusal plane of mandibular molars, and
- Contralateral premolars.

Approximating structures when needle is in final position:

- **Superior to the following:** Inferior alveolar vessels and nerve, insertion of the medial pterygoid muscle, mylohyoid vessels and nerve.
- Anterior to the deeper lobe of the parotid gland.
- Medial to the medial surface of ramus of the mandible.
- **Lateral to the following:** Lingual nerve, medial pterygoid muscle, sphenomandibular ligament.

Types of techniques: There are two techniques:

1. **Direct technique:** In this technique, the inferior alveolar nerve is anesthetized first, hence it is known as "direct technique".
2. **Indirect technique:** In this technique, the inferior alveolar is anesthetized in the third position. It is also known as three positional block technique.

Technique for locating the landmarks: A 25 gauge long needle is recommended. The target area is the inferior alveolar nerve as it passes downward toward the mandibular foramen, but before it enters the foramen **(Fig. 9.22B)**. For the right-sided block, the operator sits/stands (at 8 o'clock position facing the patient). For the left-sided block, the operator sits/stands at 10 o'clock position by the side of the patient.

The height of injection:

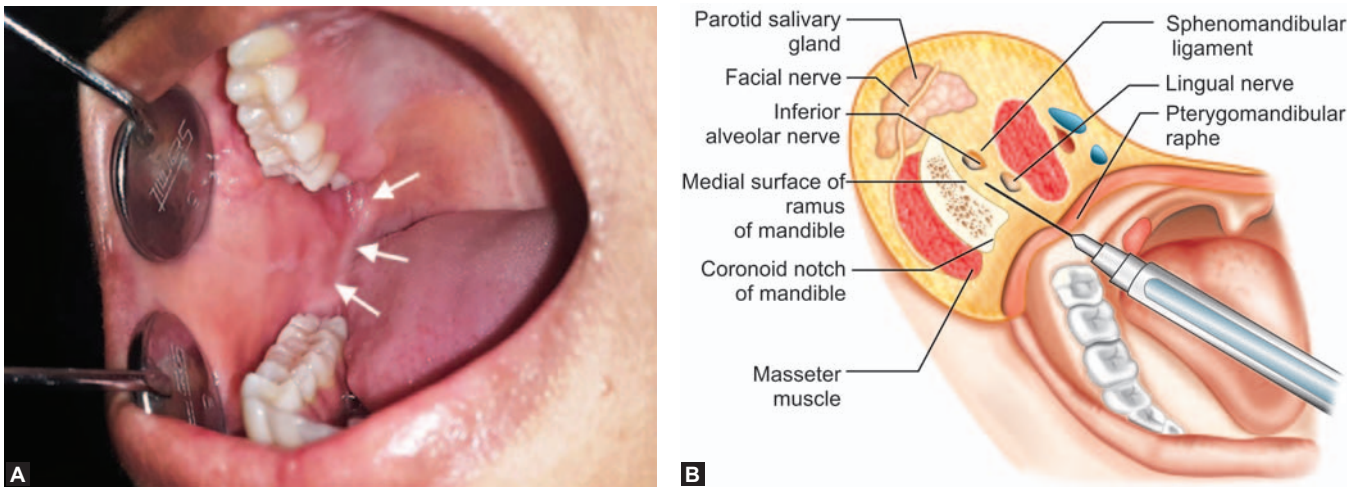
- Place the index finger or thumb of the left hand on the external oblique ridge or the anterior border of the ramus of the mandible.
- When the finger contacts the anterior border of the ramus, it is moved up and down until the greatest depth of the anterior border of the ramus is identified. This area is called the coronoid notch.
- An imaginary horizontal line extends from the coronoid notch to the pterygomandibular raphe and determines the height of injection and is parallel to and 6–10 mm above the occlusal plane of mandibular molars.

The palpating finger is then moved lingually across the retromolar triangle and onto the internal oblique ridge. The finger, still in line with the coronoid notch and in contact with the internal oblique ridge, is moved to the buccal side, taking with it the buccal sucking pad. This gives better exposure to the internal oblique ridge, the pterygomandibular raphe and the pterygotemporal depression.

When palpating the intraoral landmarks with the thumb/finger, the operator may place the index finger/thumb extraorally behind the ramus of the mandible, thus holding the mandible between the thumb and the index finger. In this manner, the anteroposterior width of the ramus may be assessed.

Direct technique: The syringe and the needle is then inserted at the previously described height of insertion from the opposite side the mouth, at a level bisecting the finger and penetrating the tissues of the pterygomandibular space.

The depth of the needle penetration can be determined by estimating when the tip of the needle has been advanced half the distance between the palpating thumb



Figs 9.22A and B: (A) Pterygomandibular raphe (arrow head) is an important landmark in inferior alveolar nerve block; (B) Various anatomical landmarks and their relation to the needle position for giving pterygomandibular block

and index finger. During insertion, the patient is asked to keep the mouth wide open. The needle is penetrated into the tissues until gently contacting bone on the medial surface of the ramus of the mandible.

The needle is then withdrawn about 1 mm, aspiration done, to avoid intravascular administration of the solution, and 0.8–1 mL of the solution is deposited slowly (in 60 seconds). The needle is then withdrawn slowly and when about one-half of its inserted depth has been withdrawn, the syringe is taken on the ipsilateral side, without withdrawing the needle outside the mucosa, 0.5 mL of the solution is injected in this area to anesthetize the lingual nerve **(Figs 9.23A to C).**

Long Buccal Nerve Block

The long buccal nerve is anesthetized with a separate insertion.

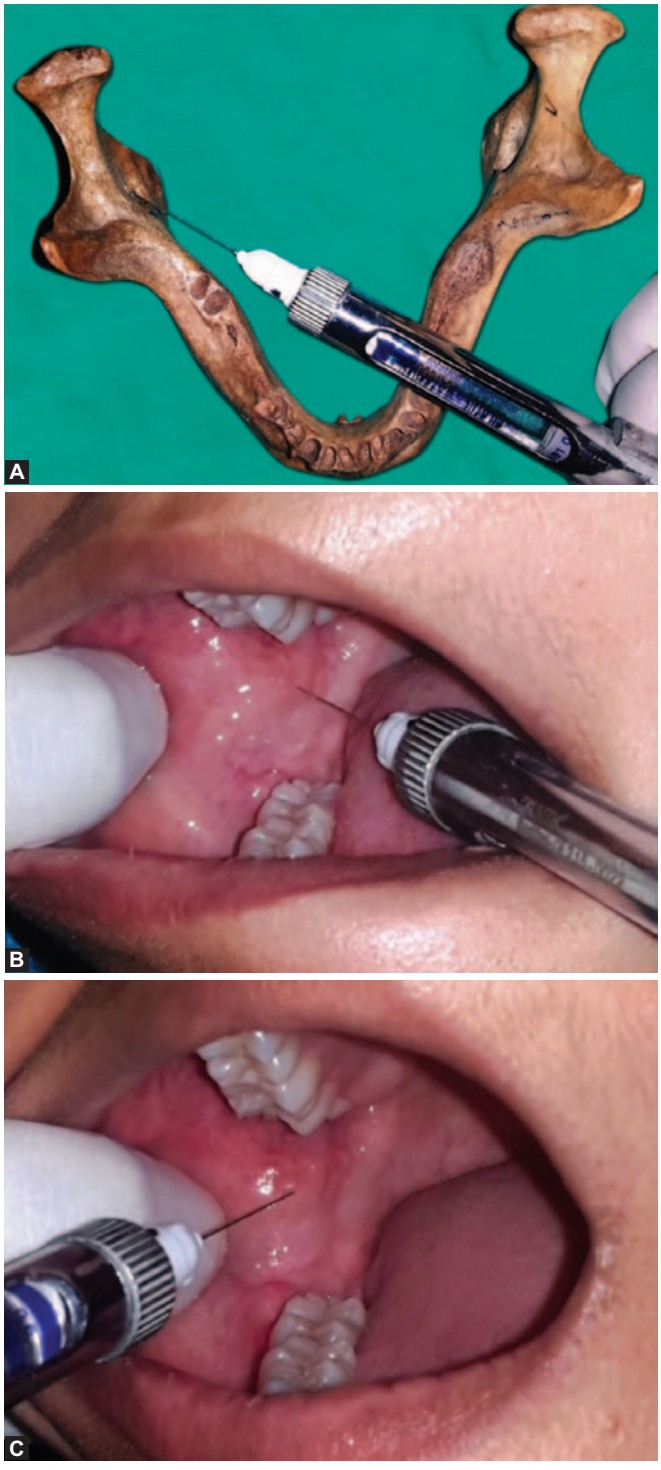
Long buccal nerve injection: Hold the syringe with a 25-gauge and 1 inch needle, ready to inject at an angle of 45° to the body of the mandible keeping the bevel of the needle facing the bone. The tissue in the mucobuccal fold is entered just distal to the most posterior tooth or the area to be subjected to surgery. About 0.25–0.5 mL of local anesthetic solution is deposited. The anesthesia is obtained within 2–3 minutes **(Figs 9.24 and 9.25)**.

Signs and symptoms:

- Tingling and numbness of the lower lip on the side of injection indicates anesthesia of the mental nerve, a terminal branch of inferior alveolar nerve.
- Tingling or numbness of one-half of the tongue on the side of injection indicates anesthesia of the lingual nerve.
- Absence of pain during dental therapy.

Failure of anesthesia:

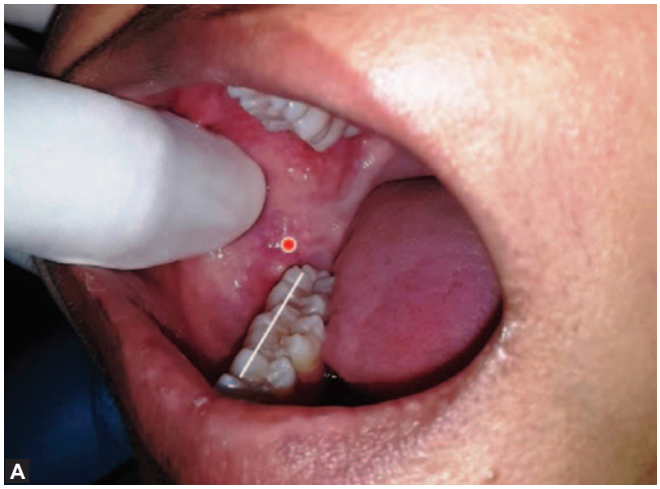
- Deposition of solution below the mandibular foramen.
- Deposition of solution too far anteriorly on the ramus.
- Accessory innervation to the mandibular teeth from, e.g. cervical plexus nerve C2, C3 branches (cutaneous coli), buccal nerve, and mylohyoid nerve. The mandibular anterior teeth may have cross innervations from incisive nerve on the other side. The lower premolars 20% of cases have additional nerve supply from the cutaneous coli nerve.
- Bifid inferior alveolar nerve with second mandibular foramen located more inferiorly.
- Incomplete anesthesia of central incisors due to innervation from the contralateral inferior alveolar nerve or mylohyoid nerve.



Figs 9.23A to C: (A) Position of needle at the target area (above lingulae, at the opening of the mandibular foramen) during inferior alveolar nerve block; (B) The syringe is directed from the contralateral side from the bicuspid region to block the inferior alveolar nerve first in the direct technique; (C) The needle is shifted to ipsilateral side to anesthetize lingual nerve in direct technique



Fig. 9.24: Target area in long buccal nerve block





Figs 9.25A and B: (A) Anatomical landmarks for long buccal nerve block (occlusal plane and mucosa distobuccal to last molar); (B) The needle is aligned parallel to the occlusal plane on the side of injection and the solution is deposited below the mucosa distal and buccal to the last molar

Errors during injection:

Too high injection:

- Anesthesia of the auriculotemporal nerve—numbness of ear.
- Injection into lateral pterygoid muscle—soreness, trismus.

Too low/posterior injection:

- Local anesthetic deposited into parotid gland—temporary facial nerve paralysis, parotitis.
- Local anesthetic deposited in medial pterygoid muscle—pain, trismus.
- Local anesthetic deposited into the posterior facial vein—toxicity.

Too medial injection:

Local anesthetic deposited into the constrictor muscle of pharynx—dysphagia.

Indirect technique: This technique of anesthetizing the branches of mandibular nerve is also known as "three positional nerve block technique" **(Fig. 9.26)**.

- **1st position**—The needle is in the first position for anesthetizing long buccal nerve of the right side, syringe going from the opposite side, after depositing local anesthetic solution, the needle is slightly withdrawn backward shown in **Figure 9.26** by short straight arrow as no. 2.
- **2nd position**—The syringe is shifted on the other side as shown with the long curved arrow mark toward no. 3, and needle is slightly advanced, as shown by short straight arrow going toward no. 4 in the **Figure 9.26**. The needle is inserted to deposit local anesthetic from the same side for anesthetizing lingual nerve.

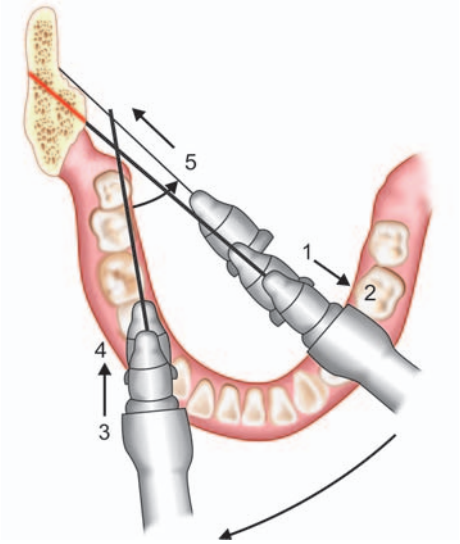


Fig. 9.26: Indirect pterygomandibular block

- **3rd position**—The syringe is then swung on the opposite side again as shown with short curved arrow. The needle is then further advanced and inserted from the opposite side for anesthetizing inferior alveolar nerve as shown no. 5. In this technique, only one prick of the needle is used and it is withdrawn within the space in three different positions.
  - **1st position**—the direction is from the opposite side—to inject between the external and internal oblique ridges—for long buccal nerve. Deposit 0.5 mL by directing the needle parallel to the occlusal plane.
  - **2nd position**—the direction is from the same side—for lingual nerve. Deposit 0.5 mL.
  - **3rd position**—the direction is from the opposite side—for inferior alveolar nerve. Rest of 1 mL solution is deposited.

All the steps of palpating the landmarks will be same as mentioned in direct technique. At least 2 minutes should be taken to deposit 2 mL of solution.

Wait for subjective symptoms. These are: (A) A feeling of warmth or tingling sensation in the lip, which starts at the corner of the mouth and spreads until it reaches the midline of the lip. The tingling changes into a gradually increased feeling of profound numbness; the lip may also feel swollen. (B) The tip and side of the tongue tingle and then become numb. For profound anesthesia, the operator must wait for 5–10 minutes.

Mental Nerve Block

Nerves anesthetized: Mental nerve, incisive nerve, part of inferior alveolar nerve.

Target area: Vicinity of mental nerve between lower first and second premolars.

Areas anesthetized: Labial mucous membrane and pulpal tissue from the first premolar to the midline, plus periodontium and supporting alveolar bone, skin of the lower lip and chin.

Technique (Figs 9.27A and B): 25–27 gauge, short needle with aspirating syringe is loaded. Palpate the mental foramen between the apices of first and second premolar with index finger. Bone around it is rough and the opening is directed posteriorly. Insert the needle in the mucobuccal fold between the two premolars directing the syringe toward the mental foramen. Advance the needle till foramen is reached. Depth of penetration is 5–6 mm. Aspirate if negative, then inject local anesthetics 1.5 mL. Wait for 3 minutes for anesthesia to set in.

Gow-Gates' Mandibular Nerve Block

Nerves anesthetized: The entire mandibular branch of trigeminal nerve is anesthetized. It includes the following: (i) inferior alveolar nerve along with its terminal branches: mental and incisive nerves, (ii) lingual, (iii) mylohyoid, (iv) auriculotemporal, and (v) long buccal nerve.

Areas anesthetized:

- All mandibular teeth up to the midline on the side of injection
- Buccal mucoperiosteum on the side of injection
- Mucosa of the anterior two-thirds of the tongue
- Mucosa of the floor of the mouth
- Lingual mucoperiosteum from the last standing molar tooth up to the central incisor in the midline



Figs 9.27A and B: (A) Target area in mental nerve block. The solution is deposited in the vicinity of the mental foramen; (B) Clinical picture of mental nerve block

- Body of the mandible, and inferior portion of the ramus, etc.
- Skin over the zygoma, posterior portion of the cheek and temporal regions, etc.

Indications:
- Surgical procedures on mandibular body and the ramus
- When buccal soft tissue anesthesia, from the third molar up to the midline, is required
- Surgical procedures in the tongue and the floor of the mouth
- When conventional inferior alveolar nerve blocks fail to act
- Restorative procedures on multiple teeth.

Contraindications:
- Presence of infection or acute inflammation at the site of injection.
- Young children and mentally challenged adults, who might bite either their lip or the tongue.
- Patients with restricted oral opening.

Anatomical landmarks:
- Extraoral landmarks
  - External ear
  - Intertragic notch of the ear
  - Corner of the mouth
- Intraoral landmarks:
  - Anterior border of the ramus of the mandible
  - Tendon of temporalis muscle
  - Mesiopalatal cusp of maxillary second molar.

Target area: Lateral side of the condylar neck, just below the insertion of the lateral pterygoid muscle **(Fig. 9.28)**.

Procedure:
- **Position of the patient:** The patient is placed in semi-supine position.
- **Position of the operator:** The operator stands in front of the patient for right-sided block, and by the side of the patient for left-sided block.

Identification of the landmarks (Figs 9.29 and 9.30):
- The operator visualizes the landmarks and an imaginary line is drawn from the corner of the mouth to the intertragic notch of the ear.
- The anterior border of the ramus and the coronoid process is palpated with the help of the thumb of the left hand. This helps in retraction of tissues and determination of the site of nerve penetration.

Configuration of the needle: The recommended gauge and length of the needle are 25 and 40 mm, respectively.

Site and height of penetration:
- The patient is advised to keep mouth widely open and to remain in that position until the injection is completed. This position moves the condyle anteriorly, thus facilitating the injection.
- The operator takes a preloaded syringe and aligns the barrel of the syringe with the plane extending from the corner of the mouth to the intertragic notch directing the syringe from the corner of the mouth on the opposite side.
- The needle is gently inserted into the mucous membrane just distal to the last maxillary molar

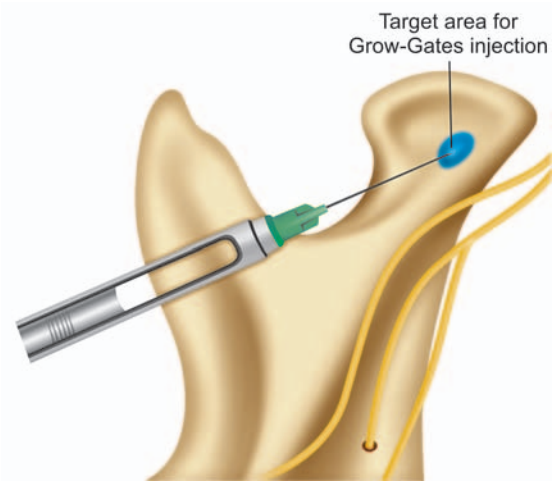
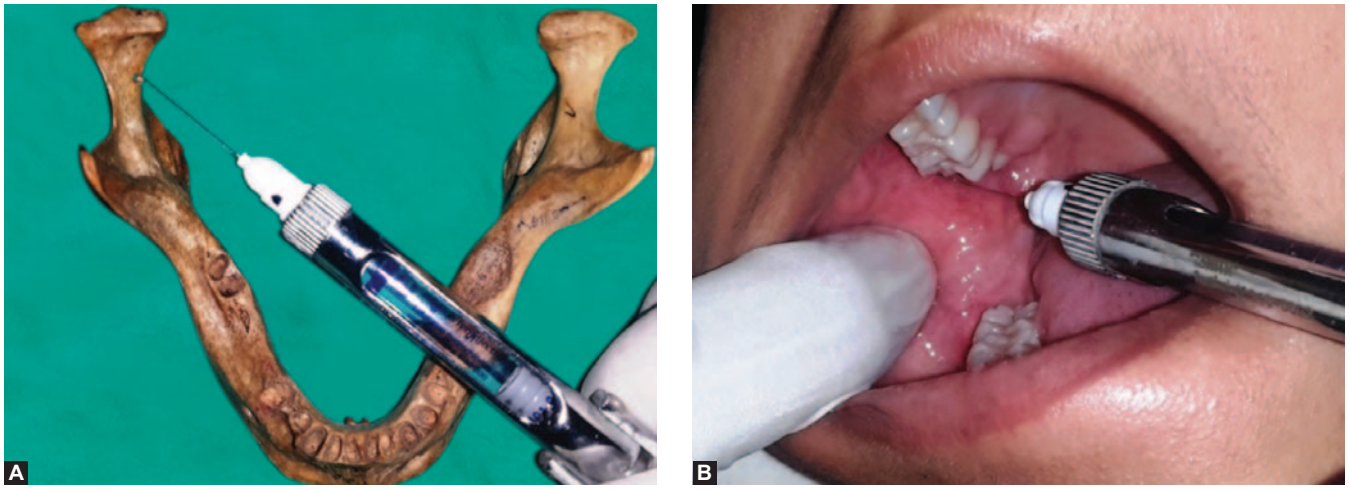


Fig. 9.28: Target area for Gow-Gates technique



Fig. 9.29: Extraoral landmarks in Gow-Gates mandibular nerve block (corner of mouth and tragus of ear)



Figs 9.30A and B: (A) Target are in Gow-Gates mandibular nerve block is neck of condyle; (B) Intraoral landmarks for Gow-Gates mandibular nerve block

tooth present, at the height of the mesiopalatal cusp of maxillary second molar. When the third molar is present, the site of penetration is distal to the third molar, lateral to pterygotemporal depression and medial to the tendon of temporalis muscle.

- **Depth of penetration:** The needle is advanced slowly until bone is contacted at the neck of the condyle. The average depth of soft tissue penetration is 25 mm.
- If bone contact is not established, the needle should be withdrawn slightly and redirected until the bone contact is made at the neck of the condyle. The average depth of soft tissue penetration is 25 mm.
- If aspiration is negative, then 2 mL of local anesthetic solution is deposited slowly over 60–90 seconds.
- Withdraw the syringe and keep the needle covered.
- Ask the patient to keep the mouth open for 2–3 minutes to allow adequate diffusion of local anesthetic solution, and bathing of the nerve trunk with the solution.
- The onset of anesthesia with this technique is somewhat slower, requiring 5–7 minutes.

Signs and symptoms:

- **Subjective:**
  - Numbness or tingling sensation of the lower lip
  - Numbness or tingling sensation of the tongue
- **Objective:** On probing and during surgical procedure absence of pain.

Complications:

- Hematoma
- Trismus
- Temporary paralysis of cranial nerves II, IV and VI.
- **Failure of anesthesia:**
  - Too little volume of local anesthetic solution deposited
  - Anatomical difficulties.

Akinosi (Closed Mouth) Mandibular Nerve Block/Vazirani-Akinosi Block

Initially described in 1960, by Vazirani and later described by Joseph Akinosi in 1977.

Nerves anesthetized: The entire mandibular branch of trigeminal nerve comprising of inferior alveolar nerve along with its terminal branches: mental and incisive nerves, lingual, and mylohyoid nerves, except the long buccal nerve.

Areas anesthetized:

- All mandibular teeth on the side of injection up to the midline.
- Body of the mandible and inferior portion of the ramus.
- Buccal mucoperiosteum and mucous membrane anterior to the mental foramen.
- Mucous membrane of the anterior two-thirds of the tongue and of the floor of the oral cavity.
- Lingual soft tissues and periosteum.

Indications:

- Limited mandibular opening
- Multiple procedures on mandibular teeth
- Inability to visualize the landmarks for inferior alveolar nerve block.

Contraindications:

- Presence of acute inflammation or infection at the site of injection.
- Young children and mentally challenged adults, who might bite either their lip or the tongue.
- Inability to visualize or gain access to the lingual aspect of the ramus.

Advantages:

- Relatively atraumatic
- Patient need not open their mouth
- Fewer postoperative complications (i.e. trismus)
- Lower aspiration rate than with inferior alveolar nerve block
- Provides successful anesthesia where a bifid inferior alveolar nerve and bifid mandibular canals are present.

Disadvantages:

- Difficult to visualize the path of the needle and the depth of insertion
- No bony contact, so the depth of penetration is somewhat arbitrary
- Potentially painful/traumatic if the needle is too close to periosteum.

Anatomical landmarks:

- Occlusal plane of teeth in occlusion
- Mucogingival junction of maxillary molar teeth
- Anterior border of ramus of the mandible
- Maxillary tuberosity **(Fig. 9.31).**

Technique (Figs 9.32A and B):

- **Needle:** The recommended length is 1½ inch or 38–40 mm, and the gauge is 25.
- **Bevel:** The position of the bevel of the needle in the closed mouth mandibular block is very significant. It must be facing away from the bone of mandibular ramus and toward the midline.
- **Height of injection:** With Akinosi's technique, it is below that of Gow-Gates' technique but above that of inferior alveolar nerve block.
- **Target area:** The soft tissues on the medial border of ramus of the mandible in the region of inferior alveolar nerve as it travels toward the mandibular foramen, lingual nerve, and mylohyoid nerves and vessels.

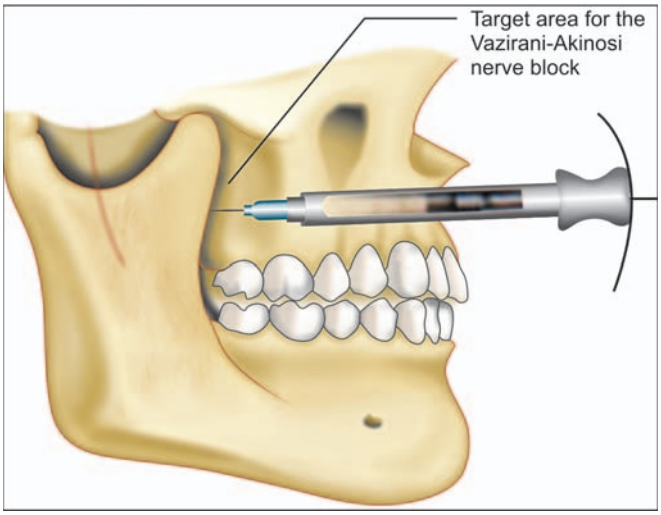


Fig. 9.31: Various landmarks and target area for Vazirani-Akinosi block





Figs 9.32A and B: Vazirani-Akinosi closed mouth mandibular nerve block technique. (A) The target area for deposition of the anesthetic solution is medial side of ramus of mandible (near midpoint of pterygomandibular space). (B) Clinical picture shows the syringe is held parallel to the maxillary occlusal plane with the needle at the level of mucogingival junction of second and third maxillary molars

Procedure:

- **Position of the patient:** The patient is seated in semi-reclining position with head, neck and shoulder adequately supported.
- **Position of the operator:** The operator stands in front of the patient for both right-sided as well as left-sided block.
- **Preparation of the tissues:** The site of penetration is prepared by topical application of antiseptic and anesthetic solutions.
- The patient is asked to bring teeth in occlusion. This aids in relaxation of cheek musculature and helps in good visualization of the landmarks. The operator retracts the patient's lips and cheek exposing the maxillary and the mandibular teeth on the ipsilateral side.
- The preloaded syringe with the recommended needle is taken and the barrel of the syringe is aligned parallel to the occlusal and sagittal plane but positioned at the level of the mucogingival junction of the maxillary molars.
- The needle penetrates the mucosa in the embrasure just medial to the ramus lateral to maxillary tuberosity and is inserted approximately 1½ inch or 25–30 mm. The tip of the needle lies in the target area in the mid-portion of pterygomandibular space, close to the branches of mandibular nerve.
- Following negative aspiration, about 2 mL of local anesthetic solution is slowly deposited approximately 1 minute.
- Motor nerves paralysis will develop as quickly or more quickly than sensory anesthesia. The patient with trismus will begin to notice increased ability to open the jaws shortly after the deposition of local anesthetic solution.
- Anesthesia of the lips and tongue will be noticed in 40–90 seconds and the surgical procedures can be usually started within 5 minutes.

Signs and symptoms: Tingling or numbness of the lower lip and tongue.

Failure of anesthesia:

- Failure to appreciate the flaring nature of the ramus which deflects the needle more medially, if internal oblique ridge is not negotiated by keeping the syringe nearly at an angle of 90° (perpendicular) to the medial surface of ascending ramus. This can be easily achieved by retracting the angle of the mouth posteriorly with the barrel of the syringe.
- Point of needle insertion is too low.
- Under-insertion or over-insertion of the needle as no bone is contacted in this technique, the depth of soft tissue penetration is somewhat arbitrary. Akinosi recommended a penetration depth of 25 mm in the average sized adult measuring from the maxillary tuberosity.

Complications:

- Hematoma, rarely.
- Trismus, rarely.
- Transient facial nerve paralysis due to over-insertion of the needle and deposition of the solution into the body of the parotid gland, near the posterior border of the ramus of the mandible.

COMPLICATIONS DUE TO THE USE OF LA

Local Complications

The complications arising from the use of local anesthetic agents are classified as (1) local complications and (2) systemic complications.

Local complications are again considered in 3 categories-

A. Complications arising from drugs or chemicals used

(1) Soft tissue injury. (2) Sloughing of tissues (Tissue necrosis)

B. Complications arising from injection techniques

(1) Breakage of anesthetic cartridge. (2) Breakage of Needle. (3) Needle-stick injuries. (4) Hematoma. (5) Failure to obtain local anesthesia

C. Complications arising from both

(1) Pain on injection, (2) Burning on injection, (3) Infection, (4) Trismus, (5) Edema, (6) Persistent paresthesia or anesthesia, (7) Persistent or prolonged pain, (8) Post-injection herpetic lesions or postanesthetic intraoral lesions, (9) Neurological complications: such as (a) facial nerve paresis or paralysis, and (b) visual disturbances: (i) diplopia, (ii) amaurosis or temporary blindness, (iii) permanent blindness.

These are discussed in detail along with management in Apendix II printed at the end of the book.

Systemic Complications

The systemic complications that occur due to the local anesthetic agents fall into following categories:

1. Vasodepressor syncope
2. Adverse drug reactions— such as (a) allergic reactions, (b) anaphylactic reactions, (c) toxic reactions (overdose), and (d) idiosyncratic reactions.

The management of systemic complications is discussed in the chapter covering medical emergencies in dental clinic.

CONCLUSION

Local anesthetic agents are relatively safe and free of side effects provided they are administered in an appropriate dosage and in an appropriate anatomical location.

Points to Remember

- Definition of pain
- Propagation of electrical impulses across the nerve-physiology of nerve conduction
- Definition of local anesthesia
- Theories for mechanism of action of local anesthetic agents
- Details of mechanism of action of local anesthetic agent
- Classification of local anesthetic agents
- Properties of an ideal local anesthetic drug/agent
- Lignocaine: hemistry and pharmacology
- Commercially prepared local anesthetic solution for clinical use in dentistry
- Pharmacology of specific vasoconstrictor agents
- Armamentarium
- Injection techniques for regional anesthesia
- Complications.

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Section 3

General Anesthesia and Sedation in Oral and Maxillofacial Surgery

10. Introduction to General Anesthesia and Sedation
11. Preanesthetic Evaluation
12. Preoperative Anesthetic Preparation and Premedication
13. Anesthetic Equipment
14. Pharmacology of Anesthetic Drugs
15. Sedation Techniques for Dentistry
16. Short Anesthesia in a Dental Chair
17. Tracheal Intubation for a Patient Undergoing Oral and Maxillofacial Surgery

CHAPTER 10 Introduction to General Anesthesia and Sedation

INTRODUCTION

- Anesthesiology—[Greek Word- *an-*, not + *aisthesis-*, perception + *logia*, study]
- General Anesthesia (GA), is a reversible condition, where the patient has no sensation, including pain from his body parts. While local and regional anesthesia is used to control pain during surgery for specific parts of the body, without affecting the brain function, general anesthesia is a procedure that puts the patient into a state of controlled sleep and unconsciousness.
- General anesthesia is mainly used for carrying out medical surgical procedures, however, the use of general anesthesia in Dentistry also is required in certain cases, and it is used to eliminate dental anxiety, relieve pain and immobilize the patient allowing dentist to focus on performing dental procedure more faster and for longer time, reducing the need for multiple dental visits.

DEFINITION

General Anesthesia

The American Society of Anesthesiologists (ASA) defines GA as a drug-induced reversible state of unconsciousness, during which patients are not arousable, even by painful physical stimulation. The ability to independently maintain ventilatory function is often impaired. Patients often require assistance in maintaining a patent airway, and positive pressure ventilation may be required, because of depressed spontaneous ventilation or drug-induced depression of neuromuscular function. Cardiovascular function may be impaired (partial or complete loss of protective reflexes).

General anesthetics agents are drugs, which produce reversible loss of all sensations and consciousness. It usually involves a loss of memory and awareness with insensitivity to painful stimuli, during a surgical procedure.

- It can be also described as "an artificial state of unresponsiveness, followed by amnesia, maintained by the continuing presence of chemical agents in the brain."
- The state of general anesthesia usually includes *analgesia, amnesia, loss of consciousness and autonomic reflexes and skeletal muscle relaxation.*
- No single anesthetic drug is capable of achieving all of these desirable effects without some disadvantages, when used alone.
- Thus, the modern practice of anesthesia involves the use of a combination of drugs.

Balanced Anesthesia

It is a term used to describe the multidrug approach (in smaller quantities) to managing the patient needs. It includes the administration of medications preoperatively for sedation and analgesia, the use of neuromuscular blocking drugs intraoperatively, and the use of both intravenous and inhaled anesthetic drugs. Balanced anesthesia takes advantage of drug's beneficial effects, while minimizing each agent's adverse qualities. It also gives greater control to the anesthesiologist.

HISTORICAL BACKGROUND

There is a long historical association between anesthesia and dentistry, as some of the initial anesthetic agents were used to carry out dental extractions. The first general anesthetic administered for a dental extraction is credited to Horace Wells. The history of maxillofacial surgery coincides with the development of endotracheal anesthesia by Stanley Rowbotham and Ivan Magill, Britain, who had been the pioneer of maxillofacial and major oral surgery in the world and British anesthesiologists

have made these more complex operations safe. General anesthesia was absent until the mid-1800s. In 1846, William Morton, successfully demonstrated the properties of ether to facilitate dental extraction in Massachusetts. Ether is no longer used in modern practice, yet considered to be the first "ideal" anesthetic agent. In 1860, Colton repopularized nitrous oxide for dentistry. Local anesthetics arrived later, the first being scientifically described in 1884. Safe provision of general anesthesia in dentistry outside the hospital set up was available in 1990.

Majority of the dental procedures can be performed on office basis, conducted under local anesthesia, which is inherently safe and most of the dentists do not routinely operate in operation theatres. Most dentists are skilled in techniques of local anesthetics and nerve blocks. In the past, complications have occurred, when dental chair anesthesia was common. Now with the introduction of new anesthetic agents and better understanding of the problems associated with anesthesia in dental chair, the techniques of anesthesia have changed, reducing the morbidity and mortality.

Pain is a major factor that brings patients to the dental clinic. The control of pain and anxiety is therefore, an essential part of the dental practice. To accomplish this objective, various techniques are used, including local anesthetics, and various types and combinations of sedative and general anesthetic agents. The choice of the most appropriate modality for a particular situation is based on the nature, severity and duration of the procedure; the age and physical and psychological status of the patient, the level of fear and anxiety. Dental patients are ambulatory, the procedures are usually shorter, the depth of anesthesia or level of sedation is often less, and it is the fear and apprehension of the patient, rather than the nature of the procedure, that frequently dictates the use of these techniques.

General anesthesia should not be used as a method of anxiety control but for pain control, because more specific methods (local anesthesia with or without conscious sedation and behavior management techniques) are available to manage anxiety. All general anesthetics are associated with some risks and modern dentistry is based on the principle that all potentially painful treatment should be performed under local anesthesia, if at all possible. **General anesthesia should be strictly limited to those patients and clinical situations, in which local anesthesia (with or without sedation) is not an option.**

Drugs, which are used to produce a state of sedation or general anesthesia, depress the central nervous system, which produce a progressive dose-related effects. Small doses produce light sedation. In this state, the patient remains conscious, with some alteration of mood, relief of anxiety, drowsiness and sometimes analgesia. As the dose is increased or as other drugs are added, greater central nervous system depression occurs, resulting in deepening of sedation and sleep from which the patient can be aroused. Finally, when consciousness is lost and the patient cannot be aroused, light general anesthesia begins. General anesthesia can be deepened by additional drug administration. Thus, depending on the patient's need, the correct procedure of sedation/general anesthesia can be chosen.

We now see that anesthesia in dentistry undergoing tremendous changes. The renaissance in office based anesthesia holds great promise for all of dentistry, allowing dentists to perform at a level of care that could not have been provided under ordinary clinical conditions.

SHORTFALLS OF GENERAL ANESTHESIA IN A DENTAL CHAIR

- Patient exhibits anxiety prior to surgery.
- Sharing the unprotected airway between anesthetist and the surgeon/dentist.
- Aspiration of blood or mucus can cause laryngospasm.
- Airway is contaminated with blood; good throat packing is essential.
- *Sitting position of the patient*: Increased chance of air embolism in sitting position.
- Reduced venous return, so more severe reaction to a vasovagal attack due to pain.
- Fainting due to cerebral hypoxia or cardiac arrest may be unrecognized.
- Difficulty in initiating cardiopulmonary resuscitation once cardiac arrest occurs.
- Dysrhythmias are common, due to stimulation of 5th cranial nerve.
- Atmospheric pollution by N_2O may be severe.
- Foreign body obstruction of the airway by needles or dentures, necessitating removal by bronchoscopy.
- Difficulty in administering postoperative analgesia.
- Anticipated difficult intubation in case of maxillofacial surgery.

Ambulatory Surgery

The brief nature of dental procedures means that majority of patients may be managed on an ambulatory basis. Modern anesthetic drugs permit rapid recovery of consciousness and early discharge. However, when in the opinion of anesthetist, patient is ready for discharge, he/she must be accompanied by a responsible adult.

The details of these shortfalls/problems and the anesthetic techniques are discussed in the following chapters.

Points to Remember

- Definition of general anesthesia
- History of general anesthesia
- Shortfalls/problems of general anesthesia in a dental chair.

CHAPTER 11 Preanesthetic Evaluation

INTRODUCTION

The majority of dental procedures are done in the dental office, usually without supplemental sedation or anesthesia. Complicated procedures and uncooperative or phobic patients may require anesthetic care in the operating room. Procedures for healthy adult patients can usually be facilitated with routine anesthetic care. Anesthesia for the mentally retarded, combative or pediatric patient presents a unique challenge.

Administration of an anesthetic agent always begins with preoperative evaluation of the patient and proper planning of the procedure by anesthesiologist.

OBJECTIVES OF PREANESTHETIC EVALUATION

- To obtain pertinent information about the patient's medical history and physical as well as mental condition.
- To determine the need for a medical consultation and the kind of investigations required.
- To identify the factors that significantly increase the risk of procedure and modify the procedure accordingly.
- To educate the patient about anesthesia, postoperative care, treatment of pain in the hope of reducing anxiety and thereby facilitating recovery.
- To choose the anesthetic plan to be followed, guided by the risk factors uncovered by medical history.
- To obtain informed consent.

The ultimate goal of preoperative medical assessment of a patient is to reduce the morbidity/mortality of anesthesia as well as surgery, improved operating room efficiency, patient safety through preoperative anticipation of intraoperative needs and proper communication with the patient will lead to his/her comfort.

Two functions of preoperative evaluation are closely related. Acquisition of a pertinent medical history and information about physical, medical and mental conditions, which affect all the decisions about investigations, consultations and discussions of care and plans with the patient. This will also determine the suitability of the patient for undergoing general anesthesia, but also will identify the necessity of using general anesthesia versus conscious sedation.

Routine Preanesthetic Evaluation

History

A review of previous records if available, personal interview with the patient and/or knowledgeable guardian to obtain the past/present history **(Table 11.1).**

- Current problems.
- Other systemic diseases, if any.
- **Treatment/medicines for the diseases:** Dose, duration and effectiveness.
- **Current medications being used:** Reason, dose, duration, effectiveness and drug interaction/side

Table 11.1: Mnemonic suggested for preanesthetic assessment

A—Affirmative history, airway examination (oral opening, pharynx)
B—Blood (hemoglobin), blood loss estimation (intraoperative), blood group-availability, breathing
C—Clinical examination, comorbidity/comorbidities
D—Drugs intake by the patient, details of previous anesthesia/surgeries
E—Evaluate investigations, end point to take up the patient for surgery
F—Fluid status, food intake time, fasting instructions
G—Give physical status grade, get consent from patient/guardian

effects. Full list of medication both prescriptions as well as over the counter self-medication, herbal products, natural supplements/alternative medicines (e.g. ginseng-interaction with general anesthetic drugs).
- History of known drug allergies and previous blood transfusions.
- **Social history:** (1) use of tobacco—smoking or smokeless tobacco or (2) alcohol consumption—frequency, quantity and duration, (3) drug abuse disclosure.
- **Prior anesthetic exposure:** Type and any adverse effects, postoperative nausea/vomiting.
- **Family history:** It can give clue for possible complications due to general anesthesia (GA). Malignant hyperthermia following GA is an inherited disorder with high mortality rate.
- **General health and review of organ systems:**
  - Cardiovascular system (hypertension, congenital heart disease, angina, breathlessness, activity level)
  - Respiratory system (cough, cold, sputum, wheezing, asthma, upper respiratory tract infection, tuberculosis, sleep apnea)
  - Central nervous system (headache, dizziness, visual disturbances, stroke, epileptic seizures)
  - Gastrointestinal system (nausea, vomiting, reflux, diarrhea, weight change)
  - Renal system (abnormal function)
  - Hepatic system (jaundice, hepatitis)
  - Endocrine system (obesity, diabetes mellitus, thyroid dysfunction, pheochromocytoma)
  - Hematologic system (excessive bleeding, anemia, any particular blood dyscrasias)
  - Musculoskeletal system (back or joint pain, arthritis, neuromuscular diseases)
  - Reproductive system (menstrual history, ovarian cysts, breast feeding, pregnancy (risk of teratogenicity due to GA durgs), higher risk of regurgitation and aspiration of gastric content.

Physical Examination

It broadly includes:
- General physical examination including vital signs
- Airway
- Examination of cardiovascular system
- Examination of respiratory system
- Examination of extremities
- Neurologic examination and examination of spine.

The history and physical examination complement one another. The examination helps to detect abnormalities not apparent from the history. While the history helps to focus the examination on the organ systems that should be examined closely. Examination of healthy asymptomatic patients should minimally consist of measurement of vital signs and examination of the airway, cardiovascular and respiratory systems and extremities using standard techniques of inspection, palpation, percussion and auscultation.

The preanesthetic evaluation means to increase this awareness of a situation or condition. It is not necessary to understand the causes of the condition or its indicated therapy. For instance, when the patient comes for dental treatment, the pulse should be examined to detect arrhythmias, or when a patient gives history of dyspnea, the dentist should be aware of its presence. If the overall evaluation indicates the need for further examination, the patient should be referred to a physician for more thorough examination, diagnosis and treatment.

Pulse rate and blood pressure (BP) should be checked to find out about any irregularity of pulse or whether there is any deviation from the normal values of both. If there is hypertension (the normal values 120–140 mm Hg of systolic and 60–80 mm Hg of diastolic in adult), the patient might need treatment to bring it to normal values and hence should be referred for further evaluation and management to physician.

The importance of examining the airway cannot be overemphasized. The oral cavity should be inspected closely for the presence of caries, crowns, loose teeth or dentures and particularly protruding upper incisors. The extent of mouth opening is assessed together with the degree of flexion of the cervical spine and extension of the atlanto-occipital joint. The presence of conditions like micrognathia (a short distance between the chin and the hyoid bone), a large tongue, limited range of movement of the temporomandibular joint or cervical spine, or a short neck suggest that difficulty may be encountered in endotracheal intubation. In trauma patients, cervical spine injury needs special consideration.

There are numerous causes of difficult laryngoscopy related to patients. The anatomical features associated with difficult laryngoscopy are:
- Short muscular neck
- Large breasts in females
- Gross obesity
- Protruding incisors (buck teeth)

- Long and high arched palate
- Receding lower jaw
- Poor mobility of mandible
- Increased anterior depth of mandible
- Increased posterior depth of mandible (reduces jaw opening, requires radiographs)
- Decreased atlanto-occipital distance (reduces neck extension, requires radiographs).

Many of these factors are normal anatomical variations, but there may also be presence of congenital, developmental or acquired deformities.

- **Congenital deformities:** Many of the syndromes like Down syndrome, Pierre Robin syndrome, Treacher Collins syndrome, Marfan syndrome are associated with airway abnormalities such as a small mouth, large tongue and cleft palate.
- **Acquired factors** can affect jaw opening, neck movements or the airway itself. Reduced jaw movements are a common cause of difficult laryngoscopy.
- **Trauma and infection** can cause reflex spasm of the masseter and medial pterygoid muscles (trismus). This typically occurs with dental abscess and fractures of the mandible and is usually relaxed by anesthetic agents.
- **Temporomandibular joint ankylosis** also produces immobility of mandible and trismus, but unlike in infection and trauma, this trismus is usually fixed and is not relieved by anesthetic induction agents and relaxants.
- **Any local soft tissue swellings or mass** can also reduce jaw movements.

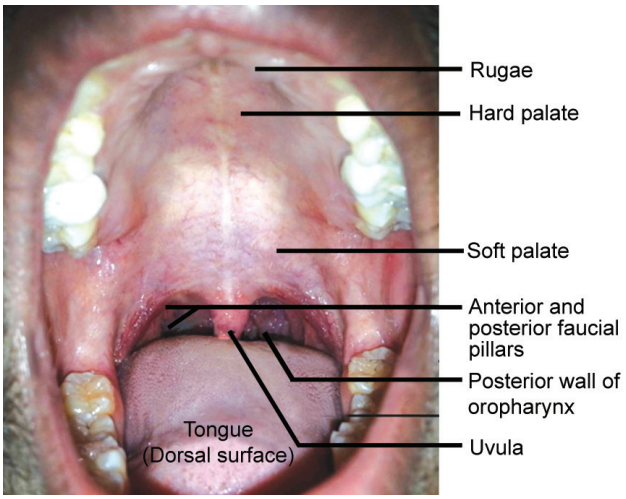


Fig. 11.1A: Normal view of oral cavity

- **Soft tissue edema of the face/upper airway from dental abscesses**, other infections, drug hypersensitivity and trauma can cause considerable anatomical distortion with life threatening airway obstruction.

Foreign bodies, tumors and scarring after infection, burns and radiotherapy can also cause difficult laryngoscopy. Hence, preoperative examination of the airway is essential **(Fig. 11.1A).** Many additional clinical tests to predict difficult laryngoscopy have been described. One of these is "Mallampati test," which is a simple classification of the pharyngeal view obtained during maximal mouth opening and tongue protrusion **(Fig. 11.1B).** This test is performed with the patient in the sitting position, head in a neutral

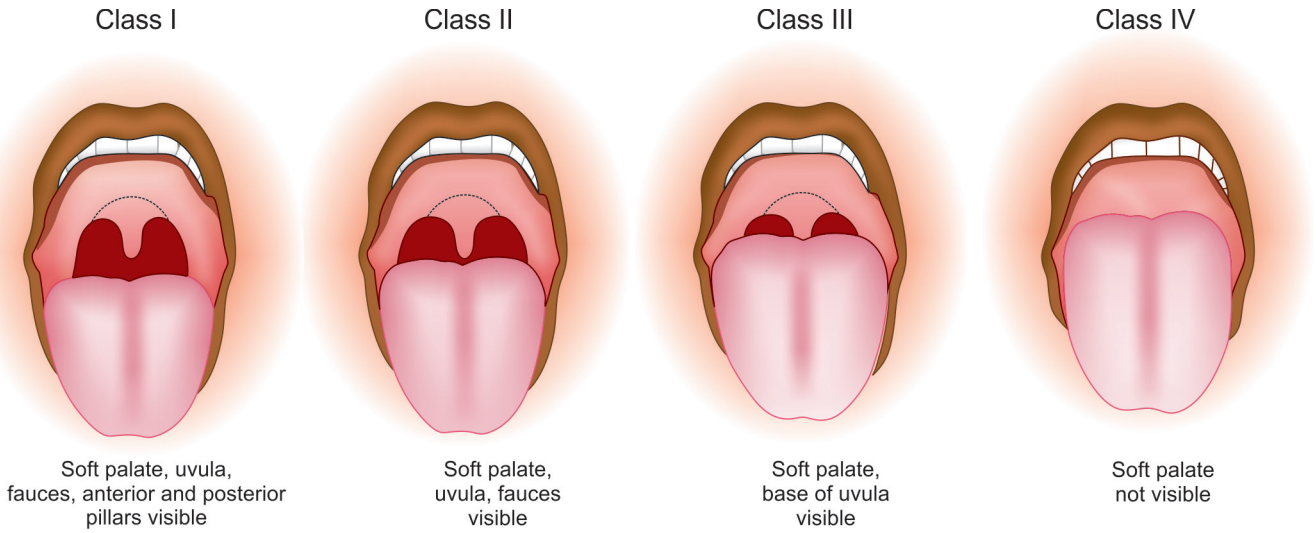


Fig. 11.1B: Mallampati grading

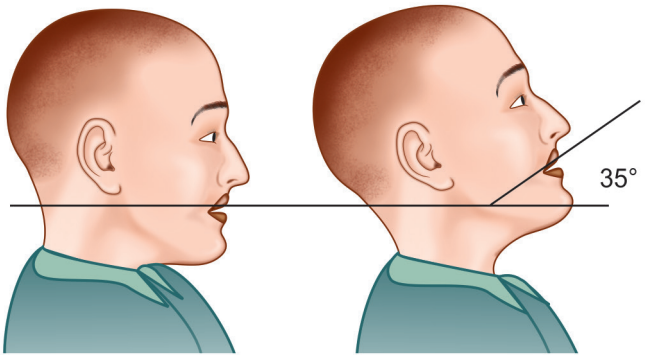


Fig. 11.2A: Atlanto-occipital extension

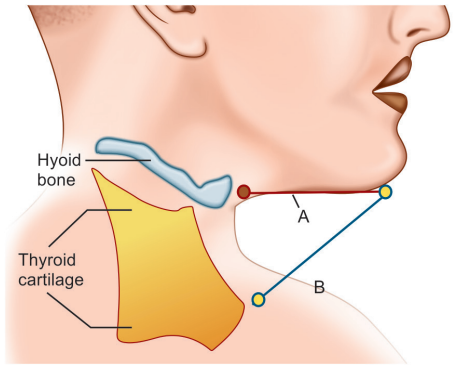


Fig. 11.2B: Mentohyoid distance—A; Thyromental distance—B

position, the mouth wide open and the tongue protruding to its maximum. Patient should not be actively encouraged to phonate, as it can result in contraction and elevation of the soft palate leading to an incorrect assessment. Classification is assigned according to the extent the base of tongue is able to mask the visibility of pharyngeal structures into four classes **(Fig. 11.1B):**

- **Class I:** Visualization of the soft palate, fauces, uvula, anterior and the posterior pillars.
- **Class II:** Visualization of the soft palate, fauces and uvula.
- **Class III:** Visualization of soft palate and base of uvula.
- **Class IV:** Only hard palate is visible. Soft palate is not visible at all.

In practice, this test suggests a higher incidence of difficult laryngoscopy if the posterior pharyngeal wall is not visualized. The predictive value of this test may be strengthened if the thyromental distance (thyroid cartilage, prominence to the bony point of the chin during full head extension, with mouth closed) is less than 6.5 cm **(Figs 11.2A** and **B** and **Table 11.2).**

Cardiovascular system: The most frequent diseases of the heart of concern are congenital heart diseases, valvular heart diseases, coronary artery diseases, arrhythmias and defects of the conductive system and congestive heart failure.

The anesthetist should suspect a congenital heart disease if there is general retardation of growth and maturation accompanied by cyanosis of the lips and nail beds. The fingers may or may not be clubbed depending on the severity of defects.

Table 11.2: Thyromental distance (Patil's test)

Tip of the thyroid to menton distance	*Difficulty level*
6.5 mm	No problem for laryngoscopy
6–6.5 mm	Difficult, but laryngoscopy possible
<6 mm	Very difficult/impossible laryngoscopy

The most common clinical manifestation of coronary artery diseases are angina pectoris, coronary thrombosis and myocardial insufficiency. The usual symptoms are substernal or precordial pain, angina attacks and dyspnea.

Valvular defects are usually recognized by the presence of characteristic murmur. Rheumatic fever is in itself responsible for a high percentage of valvular defects and any patient giving a previous history of this disease should be thoroughly questioned as to his ability to carry out normal activities without undue stress.

The most common symptoms of congestive heart failure are dyspnea on mild exertion, prominent and distended neck veins due to increased venous pressure, short spells of coughing due to pulmonary congestion and possibly edema of ankles.

Hypertension or high BP is not a disease, but a symptom of some underlying disease. Hence, it needs proper evaluation.

Hypertension may produce cardiac changes due to strain on the heart muscles and subsequent hypertrophy. Diastolic pressure in excess of 110 mm Hg is associated with an increased risk of myocardial ischemia. Gross hypertensive responses with ECG evidence of ischemia on some occasions are likely to occur in response to noxious stimuli during anesthesia in these patients. Episodes of marked hypertension, ischemic ST changes on ECG and the combination of hypotension and tachycardia are associated with an increased incidence of postoperative myocardial infarction.

Thus, the anesthetist should always be cognizant of the importance of the patient's cardiac status, while performing preanesthetic evaluation. A large percentage of the fatalities that occur during anesthesia in the dental

Table 11.3: These factors are among those placing the patient at greater risk for complications

Morbidity	*Organ system abnormalities*
Difficult airways	Sleep apnea, obesity, short neck, reduced mouth opening, large tongue, anatomical abnormalities of jaws
Risk of aspiration	Acute nasal/upper gastrointestinal bleeding, gastric outlet obstruction, delayed gastric emptying, achalasia
Reduced tolerance/paradoxical reactions to standard sedative	Tobacco, alcohol or substance abuse, previous adverse experience with sedation, neuropsychiatric disorders, allergies, drug reactions

office should well be due to underlying cardiac disease. In these particular patients, the margin of acceptable error and safety is greatly reduced.

Diseases of the respiratory system are of the utmost importance because of their implications on gaseous exchange.

The most commonly encountered conditions of the ventilatory mechanisms are upper respiratory tract infections, bronchitis, bronchiectasis, obstruction, asthma, wheezing and pulmonary emphysema. Auscultation of the chest should be done by dry or wet sounds. These patients need further evaluation and detailed examination by the physicians.

In physical examination, one should not forget to examine skin and mucous membrane for pallor to find out anemia, jaundice in case of impaired liver function and hepatitis, petechiae seen in blood dyscrasias, physical trauma and subacute bacterial endocarditis **(Table 11.3).**

Laboratory Tests

Routine preoperative laboratory studies for all patients undergoing anesthesia and surgery include: (1) a determination of hemoglobin and hematocrit values, (2) total and differential white blood cell count and (3) urinalysis.

What further investigations need to be carried out depends on many factors including patient's age, disease state, proposed surgery or preoperative drug therapy. Obviously specific laboratory tests should be done, when the history and physical examination suggest dysfunction of an organ system. **It is customary for all patients above the age of 40 years, undergoing general anesthesia, to have an electrocardiogram, chest X-ray and blood chemistry including blood sugar, serum electrolytes, creatinine, blood urea nitrogen,** in addition to the routine tests, even if they are asymptomatic. Although, it is recognized that the yield of these tests in terms of identification of an unsuspected disease is very small, they serve as useful baseline values for comparison, should the patient develop unexpected complications in the intraoperative and postoperative period.

The American Society of Anesthesiologists (ASA), 1962, has introduced a grading system as a simple description of the physical status of a patient requiring anesthesia and surgery. Despite its apparent simplicity, it remains one of the few prospective descriptions of the patient, which correlates with the risk of anesthesia and surgery **(Table 11.4).**

The advantages of this classification are twofold. First, it allows anesthesiologists and others to compare outcomes

Table 11.4: The American Society of Anesthesiologists (ASA) physical status scale

Class	*Description*
ASA Class I	A normally healthy individual
ASA Class II	A patient with mild-to-moderate systemic disease
ASA Class III	A patient with severe systemic disease, that is not fully incapacitating, but with some functional limitations
ASA Class IV	A patient with severe systemic disease, that is a constant threat to life
ASA Class V	A moribund patient who is not expected to survive 24 hours, irrespective of treatment
ASA Class E	Added as a suffix for emergency operation E — Emergency operation of any variety (used to modify one of the above classifications, i.e., ASA III-E)
ASA Class VI	A declared brain dead patient, whose organs may be removed for transplant donation purpose

(complications or death) within their own institutions. In the final analysis, outcome is one important measure of how well the physicians are providing care. Second and perhaps more important, it provides anesthesiologist with a quick summary of the physical status of a patient on a daily basis. Hence, at the conclusion of the preoperative evaluation, the anesthesiologist should assign each patient to one of the categories.

Points to Remember

- Objectives of preoperative preanesthetic evaluation
- Mnemonic for preanesthetic assessment
- Malampati test
- Patil`s test
- ASA classification of physical status.

CHAPTER 12 Preanesthetic Preparation and Premedication

INTRODUCTION

Preoperative preparation is the beginning of anesthetic process. A good or adequate preoperative preparation improves clinical outcome, increases patient's satisfaction and helps to reduce adverse events subsequently.

BASIC PLAN OF PREANESTHETIC PREPARATION

The basic plan of preoperative preparation is as follows:

- Patient's counseling or psychological preparation
- Premedication
- Preoperative instructions for:
  - Fasting guidelines
  - Guidelines for administration of current medication or pre-existing drug therapy.

The important considerations here are—requirements of surgery, techniques of anesthesia—local or general and patient's underlying medical condition.

Patient Counseling

Good psychological preparation is often as effective as pharmacological preparation. Majority of the patients undergoing surgical procedures have high levels of apprehension and anxiety. During preoperative visit, all the anticipated surgical events, risks and limitations, benefits and alternatives of anesthetic procedure should be discussed with the patient and his/her relatives. The information should provide answers to all questions asked by the patient and also should provide reassurance.

Procedure Carried Out Under Local Anesthesia

It is important to explain to the patient, signs and symptoms of local anesthetic toxicity. Patient can alert the surgeon early in such an event **(Box 12.1).**

Hypersensitivity Reactions

They can be in the form of allergy, anaphylaxis, toxicity and idiosyncrasy.

Allergic and idiosyncratic reactions are extremely rare with present amide type of local anesthetic agents, i.e. lignocaine and bupivacaine. Allergic reactions to additives and preservatives in local anesthetic preparations are known. If it occurs in dental chair, it could be disastrous. Skin sensitivity test may predict the susceptible individual. All patients undergoing treatment under local anesthesia ideally should undergo skin sensitivity test.

Skin sensitivity test: The skin sensitivity test is conducted as follows:It can be tested during preoperative visits or on the day of surgery. But, there has to be at least 2–3 hours' time gap between the test and the dental procedure.

For percutaneous testing, solution of a 1: 100 dilution of additive-free 1% lignocaine (0.5% for bupivacaine) is first injected intradermally to raise a 1 mm bleb.

If this is uneventful, a 1 mm bleb of 1: 10 solution of 1% lignocaine (0.5% for bupivacaine) is used 20 minutes later. If this is uneventful, 1 mL of undiluted lignocaine is injected subcutaneously.

Box 12.1: Local anesthetic toxicity (signs and symptoms)

- ❑ Tingling and numbness initially around lips, slowly spreading over to rest of the body
- ❑ Bitter, metallic taste or sensation in mouth
- ❑ Ringing in ears
- ❑ Light headedness
- ❑ Tremulousness
- ❑ Dysarthria
- ❑ Confusion
- ❑ Seizures

Hypersensitivity reactions

- ❑ They can be in the form of allergy, anaphylaxis, etc.

A positive test is a wheal of greater than 1 cm associated with erythema. If significant flare occurs to a specific drug, then an alternative drug should be used. This testing does not exclude allergy to preservatives and/or additives used in the local anesthetic solution. For a patient with known allergies or positive skin testing, it is safer to use preservative/additive free preparation. Each response is evaluated after 20 minutes of drug injection.

Consent

Written, informed, valid consent for anesthesia as well as for surgery is to be obtained prior to procedure. Also, special consent is to be obtained for medical problems due to medical diseases and for tracheostomy, if difficult intubation or airway is suspected. An adult who is mentally stable, well-oriented, not under influence of drugs or alcohol can sign the consent form himself. In case of mentally subnormal individuals, one of his parents or guardians should be signing the consent. In case of minors, one of the parents or guardians should sign the consent. Lastly, in case of patients from an orphanage, the Chief of the orphanage has to sign the consent form.

Premedication

Premedication can be defined as "preliminary medication", drugs with specific pharmacological actions, administered preoperatively from a couple of hours to a couple of minutes before the onset of surgery with specific goals to achieve **(Table 12.1)**. It is also the term applied to the use of drugs prior to the administration of an anesthetic agent to make anesthesia safer and more agreeable to the patient.

Table 12.1: Objectives of premedication 10 A's

Sl. No.	*10 A's*	*Objectives of premedication*
1.	Anxiolysis	Relief of apprehension or anxiety/sedation
2.	Analgesia	Smooth induction of general anesthesia (GA)
3.	Amnesia of perioperative events	Anterograde amnesia
4.	Antisialagogue effect	Reduction of salivary and bronchial secretions
5.	Antiemetic effect	Prevention of nausea and vomiting
6.	Antacid usage	Reduction of stomach acidity and volume
7.	Allergies	Prophylaxis
8.	Antiautonomic parasympathetic/ sympathetic reflexes care	Vagolytic actions
9.	Anesthetic induction	Smooth facilitation
10.	Antibiotic regime	Prophylactic/specific

Table 12.2: Routes of administration for premedication

Enteral	*Parenteral*
Oral	• Sublingual
Rectal	• Intranasal • Intramuscular (IM) • Intravenous (IV)

1. **Selection and dosage of the premedication drugs** will depend on the following facts:
   - Age of the patient
   - Weight of the patient
   - Physical status and type of anesthesia used
   - Anxiety and fear level of the patient
   - Preexisting medical conditions of the patient.
2. **Timing of the premedication** is decided depending on initial onset, peak effect, duration of action, and the route of administration of the drug **(Table 12.2).**

Oral Administration

It is the most commonly used route of drug administration. It is a popular mode of administration in children. Various formulations are tablets, capsules, syrups, linctuses, gels and lozenges, etc.

Advantages

- It is easiest, safest, most economical and convenient mode
- It obviates the need of syringes, needles and trained personnel.

Disadvantages

- Its dependence on patient compliance
- Considerable time is taken between administration of drug and attainment of therapeutic effect
- Potentially erratic and incomplete absorption from the gut
- Inability to titrate the drug level
- Inability to alter the sedation on demand
- May have prolonged action.

Sublingual Administration

Area underneath the tongue has vascular mucosa. Rapid absorption of drug takes place. This route also avoids

first pass effect of liver. Again concentrated solutions are required.

Rectal Administration

It is extremely valuable route to sedate young children, who otherwise spit the orally introduced drug. If the rectum is loaded, it becomes cumbersome to administer the drug and also the absorption becomes erratic. Midazolam and ketamine may be given by this route.

Intranasal Administration

Rapid absorption of drug takes place from the highly vascular nasal mucosa. It avoids first pass effect of liver. Concentrated solutions are needed to be used. Midazolam, ketamine, and fentanyl may be given by this route.

Intramuscular Administration

Advantages

- Rapid onset of action, effect begins in few minutes of administration
- More reliable absorption of drug than enteral routes
- Helpful in anxious children in whom securing an intravenous (IV) access is difficult
- Most premedication drugs can be given by this mode.

Disadvantages

- Prolonged effect of action
- Trained personnel required for administration
- All known risks associated with the injection
- Many children and a few adults have phobia of needles.

Drugs used in Premedication

Sedatives and Hypnotics

Benzodiazepines

They are most useful in anesthesia as premedication and can be used for intraoperative sedation:

- First introduced for the treatment of anxiety excellent anxiolytic, sedative **(Table 12.3)**
- Rapidly absorbed from the gastrointestinal (GI) tract after oral administration
- Hypnosis and unconsciousness may be produced with large doses
- Cause amnesia in 50% of patients, characteristically anterograde type
- May cause moderate depression of circulation and respiration; can cause agitation/restlessness

Table 12.3: Premedicant drugs

Group	*Drugs*	*Side effects*
Benzodiazepine	Diazepam, Midazolam, Oxazepam, Lorazepam	None in clinical doses
Opioids	Pethidine, Pentazocine, Morphine, Fentanyl, Buprenorphine	Respiratory depression, Dependence
Barbiturates	Thiopentone, Methohexitone	Prolonged action
Phenothiazines	Chlorpromazine, Promethazine, Trimeprazine	Restlessness in presence of pain, Residual sedation
Butyrophenones	Haloperidol, Droperidol	Extrapyramidal effects
Anticholinergics	Atropine, Glycopyrrolate, Scopolamine	Dry mouth, Increased body temperature
α_2-adrenoceptor agonists	Clonidine, Dexmeditomide	Hypotension, Bradycardia

- They are not analgesic and it is necessary to combine several drugs to achieve surgical levels of anesthesia.

Midazolam

It is sedative, anxiolytic and excellent amnestic agent. It is water soluble, rapidly metabolized drug. It is 3 to 5 times more potent than diazepam. When given intramuscularly (IM), the onset of action is seen within 5 to 10 minutes, with peak effect seen in 30 to 60 minutes. The mental function returns to normal within 4 hours of administration. Since it is water soluble, it does not produce phlebitis.

Dosage

- Intramuscular: 0.07–0.15 mg/kg
- Intravenous: 0.03–0.05 mg/kg—2 to 5 mg in 0.5 mg; increments, till desired effect is seen
- Intranasal: 0.3–0.4 mg/kg
- Oral: Sublingual 0.5–0.7 mg/kg
- Rectal: 0.5–0.75 mg/kg.

Diazepam

It is considered as "gold standard" with which other drugs are usually compared. The anxiolytic, amnestic and

sedative effects of diazepam, made it popular. 90% of the oral dose is absorbed in 30 to 60 minutes in adults and 15 to 30 minutes in children. It is metabolized by hepatic microsomal enigma style system to active metabolites. Diazepam is dissolved in organic solvent. Hence, it causes pain on IV and IM injection, and the absorption of the drug is unpredictable. With concomitant opioid administration, it may produce respiratory and cardiovascular depression. Due to its prolonged duration of action, it is not very suitable for day-care surgical set up. Oral diazepam is usually administered night prior to surgery for anxiolysis.

Dose

For adults and children over 12 years:

- Oral: 0.2–0.5 mg/kg
- Intravenous: 0.04–0.1 mg/kg.

Contraindications

- Elderly or patients with deranged liver functions, cirrhosis (prolongation of effect)
- Patients with chronic renal failure/with low serum albumin (prolongation of effect)
- Children below 12 years of age.

Flumazenil

Drug antagonizes sedative and amnestic effects of benzodiazepines. Dose is 0.1–0.5 mg. It is a short-acting drug and requires to be given in infusion form.

Barbiturates

They have been used in preoperative sedation since long ago. They are inexpensive and have both parental and oral preparation. They do not provide analgesia; in fact, in the presence of pain, they may produce deterioration or even antianalgesic effect. Also, there is possibility of cardiorespiratory depression and residual effects. Barbiturates should be avoided in porphyria. With all these limitations, they have largely been replaced by benzodiazepines, e.g. secobarbital-dose 50–200 g orally, pentobarbital-dose 50–200 g orally. The initial action occurs in 15–20 minutes, peak action in 45 minutes and the duration lasts for 2–4 hours.

These drugs are however not very suitable for day-care surgeries.

Butyrophenones

Droperidol falls in this group of drugs. It is mainly used as antiemetic. It also produces sedation and calms the patient. But, at times, there could be dysphoria and restlessness. Dose IV or IM 2.5–7.5 mg.

Phenothiazines

These drugs produce sedation, anticholinergic effects and also have antiemetic properties. They are always used with opioid analgesic agents. Commonly used drugs in this group are promethazine, perphenazine, chlorpromazine, etc. "Lytic cocktail" once popular combination for dental anesthesia, consisted of 50 mg pethidine, 25 mg promethazine, 10 mg chlorpromazine. With advent of new drugs, this combination is now abandoned.

- **Promethazine (phenergan):** Dose is 10–25 mg orally in similar doses given IM or IV. It is used for its antisialagogue, antihistaminic, antiemetic and sedative effects. It is especially useful in children. It is also a powerful tranquilizer.
- **Trimeprazine Tartrate (Vallergan):** Dose is 3–4 mg/kg, given 2 hours preoperatively. Available as syrup for oral administration to children, although now largely surpassed by benzodiazepine.
- **Diphenhydramine:** It blocks histamine receptors and has sedative, antiemetic properties, with an oral dose of 50 mg. The effect lasts for 3 to 6 hours. It is mainly used as premedicant in patients with known allergies. It also helps to reduce postoperative shivering.

Analgesic Agents

Ketamine

It is a phencyclidine derivative, which is also a potent IV induction agent. It also possesses analgesic properties. It rarely causes respiratory depression at clinical doses and keeps the upper airway reflexes intact. It, however, stimulates the cardiovascular system producing tachycardia and hypertension. Its major disadvantages are:

- Increased salivation
- Emergence delirium (more common in adults and females).

Because of these effects, it is discouraged in a day-care set up. However, it is a very popular choice of premedication in children, especially those who are anxious and achieving parental separation, while carrying the patient to the operating theater is difficult. It is usually combined with an administration of vagolytic agent to combat with the increased secretions produced by ketamine.

Dose

- Oral: 8–10 mg/kg
  - Intramuscular: 4–5 mg/kg
  - Intravenous: 0.5–1 mg/kg
- Rectal: 1–1.5 mg/kg.

Opioids

They have sedative and analgesic action rather than anxiolytic. They have higher incidence of side effects as compared to benzodiazepines. Respiratory depression, postoperative nausea and vomiting are fairly common. They are also known to cause cardiovascular depression. They tend to produce spasm of sphincter of Oddi, which can rapidly lead to upper quadrant pain. They may cause flushing, dizziness and miosis (pupillary constriction).

Morphine

It is well absorbed after IM injection with onset of analgesia after 15 to 30 minutes. Peak effects are seen in 45 to 90 minutes, with analgesia lasting for 4 hours. It may cause orthostatic hypotension, pruritus, respiratory depression, nausea and vomiting. It is habit-forming and addictive drug.

Fentanyl

It is 50 to 125 times more potent than morphine. The incidence of respiratory depression is high. This drug has to be used with caution. The dose is 1 to 2 μgm/kg. It has rapid onset within 30–60 seconds and shorter duration of action (30 to 60 minutes). It can be used intranasally, orally and also transdermally as patches. Overdose or rapid administration can lead to respiratory depression, apnea, rigidity and bradycardia; if these remain untreated, respiratory arrest, circulatory depression or cardiac arrest can happen.

Reversal agent: Narcan (naloxone).

Pethidine

The dose is 50–100 mg IM/IV. The effect of single dose lasts for 2 to 4 hours. It increases heart rate and causes orthostatic hypotension. It is 1/10th as potent as morphine.

Pentazocine

1/30th as potent as morphine. IM/IV injections rarely cause respiratory depression. It also raises heart rate and systemic blood pressure.

Buprenorphine

It is highly potent drug. Dose is 3–6 mg/kg, IM/IV. Respiratory depression is very common.

Anticholinergic Agents

They are used for premedication including atropine, glycopyrrolate and scopolamine. Actions common to them are vagolytic effects, antisialagogue actions, sedation and amnesia.

Vagolytic Effects

Atropine, glycopyrrolate and scopolamine increase heart rate by blocking acetylcholine action on muscarinic receptors in sinoatrial (SA) node. Atropine is more effective than glycopyrrolate and scopolamine in increasing heart rate and is very useful in preventing intraoperative bradycardias resulting from vagal stimulation or stimulation of carotid sinus. (Excessive vagal stimulations can be due to surgical stimulation or due to the use of certain drugs, like halothane, alfentanil with vecuronium, etc. Excessive vagal activity can cause bradycardia.) Atropine is also very effective in preventing vasovagal attacks.

Antisialagogue Actions

It includes drying of salivary, gastric, tracheobronchial as well as secretions of sweat glands. Glycopyrrolate is more potent and longer-acting drying agent and is less likely to increase heart rate. Scopolamine is more effective antisialagogue than atropine. In the presence of heart disease or cardiac arrhythmias glycopyrrolate is a better drug than atropine, as an anticholinergic premedicant. All three drugs take about 20 to 30 minutes for drying action. Hence, should be given 30 minutes prior to planned procedure.

Sedation and Amnesia

Glycopyrrolate does not cross blood-brain barrier and hence does not cause sedation or amnesia. Both atropine and scopolamine cross blood-brain barrier. Atropine can cause delirium in elderly. Scopolamine has good amnesic and sedative actions. So, in elderly subjects, it is better to use glycopyrrolate instead of atropine. Scopolamine is not freely available yet.

Side Effects

- Pupillary dilatation and cycloplegia: This could be harmful in glaucoma patients
- Tachycardia and cardiac arrhythmias
- Delirium, confusion and restlessness
- Inspissations of existing secretions in trachea and bronchi
- Increase in body temperature.

Dose

- Atropine: 0.12 mg/kg or 10–15 µg/kg.
- Glycopyrrolate: 4–8 µg/kg.

In children, atropine is better than glycopyrrolate. In elderly, glycopyrrolate is more useful than atropine. In young adults depending upon basal pulse rate—if low pulse rate, then atropine is preferred, if pulse rate is high (>100 beats/min) glycopyrrolate is preferred. In the presence of fever, anticholinergic premedication should be avoided. Instead, other drying agents, like promethazine, can be used.

Aspiration Prophylaxis

All routine minor and major surgeries do not require aspiration prophylaxis. Indicated conditions include obesity, pregnancy, diabetic patients, alcoholics, patients on long-term steroid therapy, ascites, hiatus hernia, patients with history of gastroesophageal reflux, etc.

Several pharmaceutical agents have been used to alter gastric pH and fluid volume. They include histamine receptor (H_2 receptor) blocking agents, gastrokinetic drugs, clear antacids and anticholinergic agents.

Histamine Receptor Blocking Agents

Cimetidine, ranitidine and famotidine are the commonly used H_2-receptor blockers. These drugs raise the gastric pH by blocking histamine-mediated secretions of gastric hydrogen ion. The drug regimen started night before surgery is usually more effective in raising gastric pH than single dose preoperatively, on the day of surgery. As with most of the drugs, parenteral administration produces more rapid onset of action than the oral route. Although, these drugs reduce acidity, they have no effect on volume of gastric secretions or stomach emptying time. Cimetidine is known for drug interactions and side effects. Other drugs have largely replaced its use. Ranitidine is equally effective, has fewer side-effects and has longer duration of action.

Doses

Cimetidine

150–300 mg orally or parenterally. 60–90 minutes prior to surgery and repeated 8 hourly.

Ranitidine

50–100 mg orally, 50–100 mg parenterally, on the night before surgery and 1 hour prior to surgery. Action lasts for about 9–10 hours. It is known to prolong sedative effect of midazolam. But, a single dose of either drug usually does not exhibit clinically significant adverse effects.

Famotidine

40 mg at bedtime and 40 mg on the morning of surgery. Onset occurs in 1 hour and persists for 10–12 hours. The drug is administered orally.

Gastrokinetic Drugs

Metoclopramide

It is a dopamine antagonist that stimulates upper GI motility, increases gastroesophageal sphincter tone and relaxes pylorus and duodenum. It has been shown to reduce gastric fluid volume and reduce risk of aspiration. At times it can precipitate extrapyramidal reactions. Also rapid injection can cause abdominal cramping.

Dose

- Orally 10 mg 30–60 minutes prior to surgery.
- Parenterally 5–20 mg, given over 3–5 minutes, 15–30 minutes prior to surgery.

Antacids

These are used to neutralize the pH of gastric fluid already present in stomach. A single dose of clear antacid given 15–30 minutes prior to anesthesia is effective in raising gastric fluid pH above 2.5. Particulate or colloid antacid suspensions are more effective than nonparticulate (clear) antacid in elevating gastric pH above 2.5. But in the event of aspiration of gastric contents into lungs, particulate antacids are known to cause major injury to lung parenchyma. 30 mL of 0.3 mg sodium citrate solution is commonly used for this purpose.

Antiemetics

Some anesthesiologists include antiemetics with premedication as routine practice, while some believe in giving just prior to emergence or during recovery period. For routine dental surgery, sedative techniques and anesthesia do not require regular antiemetic administration. But, for major maxillofacial surgeries, it is advisable to give antiemetics as during surgical procedure some amount of blood enters stomach that can irritate the stomach mucosa and induce vomiting postoperatively. The drugs used as antiemetics include: droperidol, metoclopramide, phenothiazine like prochlorperazine and ondansetron.

Prochlorperazine is the most commonly used. Phenothiazine is used to prevent nausea and vomiting. Ondansetron is another popularly used antiemetic drug. It belongs to the category of 5-HT (serotonin) receptor blockers. Usual dose is 4–8 mg orally or IV. Sublingual preparations are also available for faster and better absorption. The effect lasts for 4 to 8 hours.

Premedication for Outpatient Day Surgery

All patients need to receive anticholinergic agent either atropine or glycopyrrolate 30 minutes prior to the procedure and diazepam 0.25 mg/kg orally on night before surgery to reduce anxiety.

For short procedure under local anesthesia, diazepam/midazolam can be given orally, 60 to 90 minutes prior to the procedure to allay anxiety.

For procedures, which require longer periods of drilling, etc. instead of diazepam, midazolam may be given (0.05–0.1 mg/kg) IM or 0.03–0.05 mg/kg IV, 30 minutes prior to surgery. If patient is already in pain, then preoperatively pethidine (1.5 mg/kg), or fentanyl 100 mg, or pentazocine 0.5 to 0.6 mg/kg may be added to midazolam. But this does delay the recovery time.

Premedication for Maxillofacial Surgery

Along with atropine or glycopyrrolate, pethidine and promethazine (50 mg + 25 mg) should be given 30 minutes prior to surgery. Instead of pethidine, pentazocine or buprenorphine (3–6 mg/kg) or fentanyl may be given. Promethazine helps in drying secretions, sedation and acts as antiemetic. It also prevents histamine release after opioids.

Table 12.4: ASA Preoperative Fasting Guidelines

Ingested Material	*Minimum Fasting Period*
Clear fluids*	2 hours
Breast milk	4 hours
Non-human milk	6 hours
Infant formula feeds	6 hours
Light meal**	6 hours
Heavy meal#	8 hours

*__Clear fluids__ include water, fruit juices without pulp, carbonated beverages, clear tea, and black coffee, coconut water (Non-clear fluids include—milk (breast milk, formula milk, orange juice, etc.)

**__Light meal__ typically includes toast (without butter or cheese), dry biscuit and clear liquids

#__All fried and fatty meals__ are included in heavy meals. All Indian foods are considered as heavy meals

Premedication for Children

The vagus activity is predominant in children. Also the air passages being small, presence of secretions can have deleterious effects. So, anticholinergic premedication becomes mandatory. But most of the children have fears or phobias of needle pricks. So, syrup trimeprazine or promethazine or midazolam intranasally or orally (0.6 mg/kg) should be given. Once sedated, anticholinergic agents should be given IM/IV.

Ketamine hydrochloride is also a popular drug for children.

Preoperative Instructions

Fasting Guidelines

These are the latest fasting guidelines as per (American Society of Anesthesiologists (ASA) and are accepted universally. These guidelines are essentially same for adults as well as pediatric patients **(Table 12.4).**

Preexisting Drug Therapy

Antihypertensives

All antihypertensives except monoamine oxidase (MAO) inhibitors should be continued till the day of surgery. The usual morning dose should be given with sip of water and postoperatively as soon as orals would be resumed. If oral route is not available, in such instances, other route or different drug can be given parenterally, which should be started on consultation with physician. Sudden withdrawal of these drugs can precipitate hypertensive episode during preoperative period **(Table 12.5).**

Angina Prophylaxis

These drugs should also be continued in perioperative period or else, it can precipitate ischemic episode. If oral route is not available, transdermal patch of glyceryl trinitrate is to be placed on chest wall or forehead. Effect usually lasts for almost 24 hours.

Psychotropic Drugs

Many of these drugs potentiate effects of anesthetic agents. Major tranquilizers and tricyclic antidepressants have anticholinergic side effects. In the presence of catecholamines and under anesthesia, they potentiate ventricular tachyarrhythmias. Also, sudden withdrawal can precipitate severe reactions. Hence, the drugs to be

Table 12.5: Concurrent drug therapy

To be continued perioperatively	*To be discontinued*	*To be modified perioperatively*
Antiarrhythmics, antiasthmatic, antiplatelet: aspirin, antilipidemics: statins	Diuretics: on the morning of surgery	Insulin-sliding scale, oral anticoagulants, heparin-dose modification
Antibiotics, antiepileptic, antihypertensive, antipsychotics	Oral antidiabetic: on the morning of surgery; aspirin/ clopidogrel depending on bleeding time (BT), clotting time (CT), partial thromboplastin time (PTT), etc.	Steroid cover: doses and route of administration
β blockers		
Calcium-channel blocker	Monoamine oxidase (MAO) inhibitor: 1 week prior	Angiotensin-receptor blockers and angiotensin-converting enzyme (ACE) inhibitors. Discontinue on the day of surgery and replace with other drugs
Cardiac drugs, diuretics		
Eye drops (timodal)	Oral contraceptive pills: 1 month cycle	
Sedative/tranquilizer/anxiolytics		
Immunosuppressants		

continued till the day of surgery with extreme caution in mind. Avoid adrenaline in local infiltration.

Lithium is known to potentiate action of muscle relaxants used in anesthesia. They should be omitted 48 to 72 hours prior to surgery. Patients should be shifted on some other drugs on consultation with psychiatrist.

Monoamine oxidase inhibitors also should be discontinued 2 to 3 weeks before surgery. They adversely react with opioid analgesics and can give rise to cardiovascular instability. These patients too, should be shifted on some other drugs on consultation with psychiatrist.

Anti-Parkinsonism Drugs

Drugs, like levadopa, potentiates ventricular arrhythmias as well as orthostatic hypotension. Hence, it is prudent to omit these drugs 24 hours prior to surgery. If stopped for longer period, there would be reappearance of Parkinson symptoms and there is definite risk of aspiration. So, the drugs need to be restarted as soon as possible in postoperative period.

Anticonvulsants

These drugs also to be continued till the day of surgery. Sudden withdrawal of drugs can precipitate convulsions in postoperative period. Most of the drugs are fairly safe. If oral route is not available in postoperative period, patient should be switched over to injectable drugs. Phenobarbiturate and eptoin can potentiate sedative actions of anesthetic agents. Most of these drugs are microsomal enzyme inducers, hence they can fasten the metabolism of anesthetic drugs and muscle relaxants, which has to be kept in mind.

Alcohol

It should be stopped prior to surgery. There is possibility of acute alcohol withdrawal symptoms in postoperative period. Patients should be given good dose of benzodiazepine sedation. In chronic alcoholics as well, there are chances of induction of enzyme systems, which leads to faster metabolism of anesthetic drugs.

Antidiabetic Agents

All oral antidiabetic drugs to be stopped on the day of surgery, restarted as soon as patient switches back to orals. If oral route is not available, patient should be switched over to crystalline insulin and managed on "sliding scale".

In case of insulin-dependent diabetic, morning dose to be omitted and managed on "sliding scale" with IV insulin, on consultation with treating physician.

Antituberculous therapy: Aminoglycosides potentiate action of muscle relaxants. They can be continued perioperatively, but this interaction has to be kept in mind while administering muscle relaxants.

Antibiotics

All antibiotics can safely be given.

Steroids

Long-term steroid therapy calls for replacement during anesthesia, either with short-acting hydrocortisone or long-acting dexamethasone. Oral regimens need to be converted to IV forms on the day of surgery and immediate postoperative period. Routine oral doses are restarted as soon as patient is fit to consume orals.

Contraceptive Pills and other Hormones

Estrogen-containing Pills

Estrogen-containing pills have additive effects under anesthesia on antithrombin III and can precipitate thrombotic episode. Ideally, they should be stopped at least 4 weeks before major elective procedure. But for minor surgery, routine of contraceptive pills need not be disturbed.

Hormone Replacement Therapy (HRT)

The hormones content of these pills are very low. It does not require any alteration in schedule of this drug.

Progesterone (Postponement) Pill

Needs no alteration in schedule of this drug.

Other Instructions

Smoking

Ideally should be stopped 4 to 6 weeks prior to the surgery to decrease the incidence of postoperative pulmonary complications. Stopping 1 to 2 weeks before the surgery also benefits the patient by enhancing the ciliary activity of respiratory mucosa and by reduction in the sputum volume. Not smoking for 12 to 24 hours prior to the surgery may benefit the patient by eliminating in circulating nicotine and carbon monoxide from the blood. Nicotine causes tachycardia and peripheral vasoconstriction. With high levels of carbon monoxide in blood, patients are susceptible for hypoxic episodes.

Dentures

Chances of aspiration of loose dentures or slipping from the position can cause obstruction of the airway; hence all removable dentures should be removed prior to induction of anesthesia.

Cosmetics

Lipsticks, nail varnishes and *mehendi*, other cosmetics may interfere with observation of cyanosis or pallor and may also interfere with estimation of oxygen saturation. Patients are instructed to defer their use.

Artificial Limbs

Should be removed as metal component of the artificial limb may induce electrical burns.

Artificial Eyes and Contact Lenses

Dislodgements can cause corneal abrasions or injury to surrounding delicate structures of eye. Removal is a must.

Hearing Aids

Should be kept in place, so as to maintain effective communication with the patient.

Emptying the Bladder

Prior to surgery, ensure that the patient's bladder is emptied. Patient should be accompanied by a responsible adult, who will also escort him home, especially important in ambulatory surgery.

Points to Remember

- Local anesthetic toxicity—signs and symptoms
- Routes of administration for premedication
- Different premedicant drugs and their use, dosage
- ASA fasting guidelines
- Modification of pre-existing drug therapy
- Overall other important instructions to the patient.

CHAPTER 13 Anesthetic Equipment

INTRODUCTION

With advancing technology, not only the procedure of anesthetizing a patient, but even monitoring a patient during general anesthesia has vastly been simplified over the years with the introduction of newer equipment. The practice of anesthesia has shifted from purely clinical to a clinical cum technologically based art. Many a times due to mechanical fault with the anesthetic equipment, or a failure to recognize a technical snag by the anesthesiologist, or improper handling of the anesthetic equipment or misuse of the equipment, or the physical principles of which the anesthesiologist did not understand, we have seen a patient being lost. Hence, it is essential for the anesthesiologist to have a thorough knowledge of the physical and mechanical aspects of the anesthetic equipment, their functioning and maintenance, so that in the event of mechanical failure or fault, he can use his skill and continue with safe and smooth anesthesia. The art of anesthesia is essentially not only clinical but also practical.

At the same time, one should not forget that most of the anesthetic equipment that are used to give general anesthesia, are basically part of the equipment that are also needed for resuscitation of a patient, in the event of any catastrophe, that might even occur during the surgical procedures under local anesthesia. For this reason any person, who deals with patients under local anesthesia, should have a basic knowledge of anesthetic equipment.

The basic equipment that an anesthesiologist needs for general anesthesia falls into four groups:

1. Anesthetic and resuscitation
2. Monitoring
3. Oxygen delivery
4. Intravenous infusion equipment.

ANESTHESIA AND RESUSCITATION EQUIPMENT

Anesthesia Machine

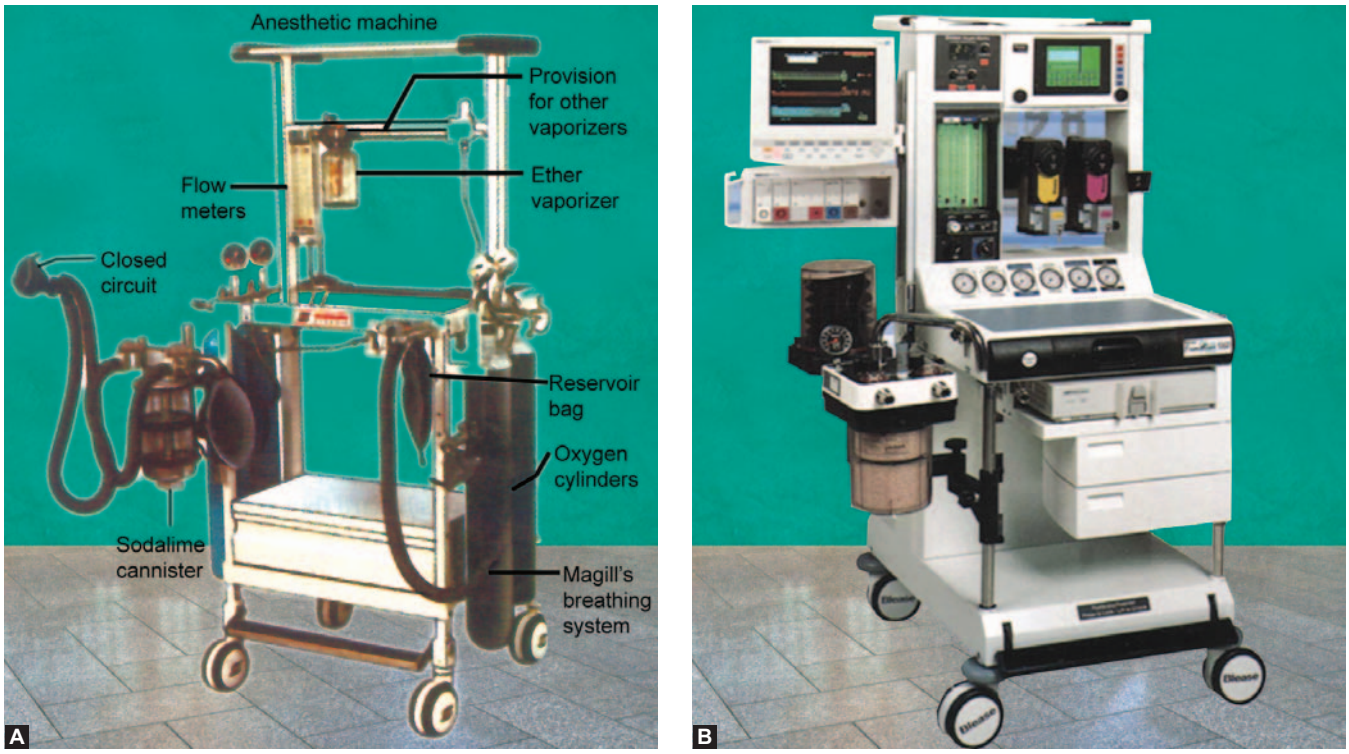
Anesthesia machine is an equipment, by which the operator can deliver a desired concentration of a mixture of anesthetic agents (gases as well as liquids) in an inhalational (gaseous) form with oxygen and/or air, which serves as a vehicle to carry this mixture to its outlet **(Figs 13.1A and B).**

In its simplest form, an anesthesia machine consists of a metallic frame, having a facility to connect central pipelines as well as cylinders of gases like oxygen, nitrous oxide, air, etc. flow meters, vaporizers and a facility to deliver high flow of oxygen (oxygen flush or emergency oxygen knob) in the event of any leak or an emergency situation. It also has a working platform to keep various drugs and small equipment, and at times, a tray on the top to keep various monitors.

Newer anesthesia machines are continuous flow machines (e.g. Boyle machine), oxygen, nitrous oxide, air, etc. have individual flow meters for setting desired flow of each gas.

Vaporizers are meant for setting desired percentage output concentration of the liquid anesthetic agents like halothane, isoflurane, etc. (ether and Trilene in older models of the machines). Flow meters for gases and vaporizers for liquid anesthetic agents are gas/agent specific and the one meant for a particular gas or anesthetic agent cannot be used for the other. They are highly specific, precise and most expensive constituents of the anesthesia machines.

Most dangerous hazard of an anesthesia machine (but fortunately rare, due to constant vigilance of anesthesiologists) is the delivery of a hypoxic gas mixture



Figs 13.1A and B: (A) An older anesthetic machine; (B) New anesthetic machine with all the monitors, ventilator, vaporizers, etc.

(gases with an oxygen percentage less than that of air, e.g. when an oxygen cylinder is getting over and the patient receives gases other than oxygen). This can lead to hypoxic brain damage and coma, even cardiac arrest and death can occur. To avoid this hazard most of the newer anesthesia machines have devices, which in the event of delivery of a hypoxic gas mixture activate an alarm either auditory or visual, which tells the operator that a hypoxic gas mixture is being delivered, so that immediate action can be taken.

State-of-the-art technology: Anesthesia machines have been evolved from simple pneumatic devices to complex computer based integrated systems with numerous controls, displays, indicators and alarms. The prevailing trend is to incorporate and integrate ventilators and vigilance aids, such as airway pressure monitors, respirometers, respiratory gas monitors, pulse oximeters, electrocardiograms and automatic blood pressure monitors into the machine **(Fig. 13.1B).**

Breathing System (Circuit)

Breathing system is an assembly of equipment that not only carries anesthetic mixture from the outlet of anesthesia machine to the patient, but also allows to monitor and control patient's breathing **(Fig. 13.1A).**

The essential components of any breathing system, consist of: (1) a bag mount with a reservoir bag (1.5 to 2 liter capacity); (2) long (1 meter) corrugated rubber or plastic tubing/s (breathing tube/s); and (3) an expiratory valve, ordinary spring loaded/nonrebreathing valve, which is connected to a mask or an endotracheal tube (ETT) attached to the patient.

Working of a breathing system: It is the excursions (rhythmical inflation and deflation) of the reservoir bag, that allows visual monitoring of adequacy or inadequacy of patient's own breathing and the reservoir bag also allows one to assist or control (take over) patient's breathing, in case the breathing is inadequate.

- Corrugated tubings are flexible and help to prevent kinking and if made up of plastic, are light in weight and thereby cause less drag on the mask or ETT.
- An expiratory valve can be simple spring-loaded valve (e.g. Heidbrink valve) or a nonrebreathing valve (NRV) as seen on most of the resuscitation bags (e.g. Ambu, Laerdale, Penlon, etc.). A nonrebreathing valve allows to control patient's breathing for longer periods, without increasing patients inspired or arterial carbon dioxide tension and it also allows a smooth transition from spontaneous to controlled breathing or vice versa.

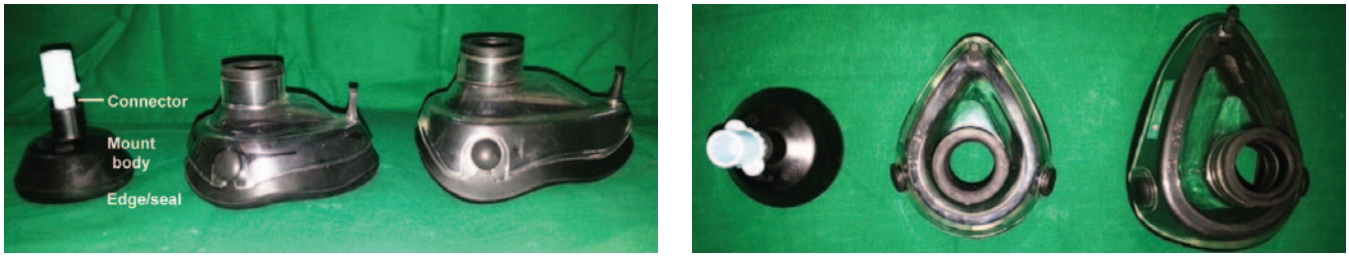


Fig. 13.2: Face masks

At the same time, open systems are less economical than the closed systems, there is also increased heat and moisture loss from the patient's body and they increase theatre pollution.

Theatre pollution with open systems can be reduced by using scavenging system that gets rid of exhaled gases entering into the operation theatre atmosphere.

Breathing system can be (1) reusable or (2) disposable. It can have (a) a single simple corrugated tubing (e.g. Magill's system) or (b) can have a coaxial tubings, i.e. one tubing within the other (e.g. Bain system) or (c) It can have double tubings, inspiratory and expiratory (e.g. closed circuit).

- It can allow entire exhaled gases to vent to the atmosphere (e.g. Magill's system with NRV)
- It allows minimal/partial rebreathing (e.g. Magill's system with Heidbrink valve or Bain system)
- It can allow exhaled gases from the patient to be reused (rebreathed) after getting rid of carbon dioxide from the exhaled gases (e.g. circle absorber/carbon dioxide absorber/closed system).

Closed system is economical as low flow of anesthetic gases are required, there is less heat and moisture loss from the patient's body and operation theatre pollution is almost nil, as compared to open systems.

Anesthetic Mask

Mask is an integral part of any anesthetic breathing system/circuit during the induction phase (beginning) of anesthesia or any resuscitation procedure. A mask allows administration of gases from the breathing system, without introducing any invasive apparatus (e.g. ETT) into the patient's airway. It is placed on the patient's face covering his/her mouth and nose (face mask) or only on the nose (nasal mask). Face masks are designed to fit the patient's face perfectly without any leaks, whereas nasal masks are designed to fit snugly around the nose without any leaks **(Fig. 13.2).** Nasal masks are smaller in size than face masks and generally used only for conservative dentistry for dental chair anesthesia.

- **Parts:**
  - **Connector or mount:** The mount is usually constructed of hard rubber, but may be made up of plastic or metal. It is the mount to which a breathing system/circuit is attached.
  - **Body:** The body of the mask may be made up of rubber, neoprene, plastic or silicone. Some masks have transparent body which is useful, as it allows observation of the patient for vomitus, secretions, blood, lip color and condensation of exhaled moisture.
  - **Edge or seal:** The edge or seal is the part of the mask that comes in contact with the face. It is anatomically shaped and to achieve a snug fit on the face, it is fitted with an air-filled cuff, which also has a soft cushioning effect or a flap, which takes up the contour of the face.
- **Sizes:** 1, 2, 3, 4, 5.
  - Masks come in variety of sizes and shapes. A variety of masks should be kept readily available, so that the selection of an appropriately fitting mask becomes possible for the operator.

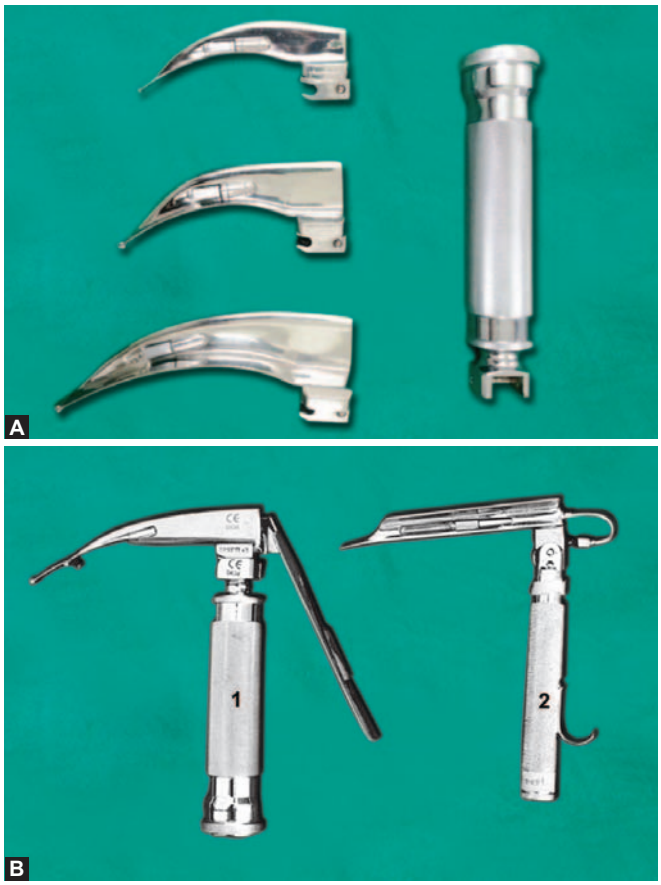
Laryngoscope

Function

Laryngoscope is designed for doing direct laryngoscopy (directly viewing the vocal cords) and to pass an ETT into the larynx under vision.

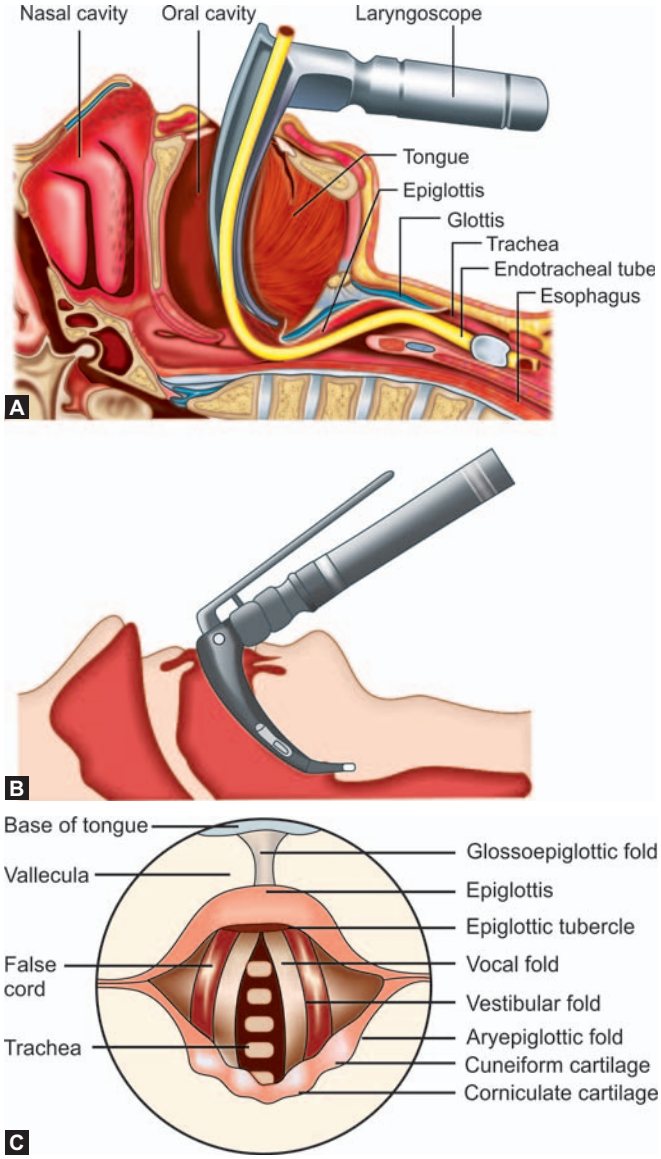
- **Parts:** Handle, blade with light bulb.
- **Sizes (for the blades):** Neonate (infant), pediatric (child), adult and extra large.

The handle is a hollow cylinder containing two 1.5 volt batteries. During use it forms generally a right angle with the blade, but it may form an acute or an obtuse angle in some varieties of laryngoscopes.



Figs 13.3A and B: Laryngoscope and detachable blades; (B-1) Curved blade; and (B-2) Straight blade

The blade may be attached to the handle with a hook on connection or secured by a screwed connection. The blades are interchangeable. Laryngoscope blades can be curved (e.g. MacIntosh laryngoscope—most popular) or straight (e.g. Magill laryngoscope—useful for neonates and small children) **(Figs 13.3A and B).** The blade includes: (a) base, (b) tongue plate, (c) flange, (d) web, (e) tip and (f) a bulb socket. The base is slotted to engage the hinge pin of the handle. The tongue plate or spatula serves to manipulate the tongue and other soft tissues to visualize the larynx. The flange is parallel to the tongue plate and connected by a web. It helps to deflect the interfering soft tissues and to guide the ETT. The tip of the blade is blunt and thick to prevent trauma to the soft tissues. It elevates and secures the epiglottis directly (with straight blade) or indirectly (with curved blade). The bulb socket is meant for fitting the light bulb. It has an electrical connection to the hook on the base. As the blade is locked on the handle (at 90°), electrical connection is made complete and the bulb is illuminated.



Figs 13.4A to C: (A and B) Supine position for intubation with laryngoscope; (C) View of the larynx at laryngoscopy

Method of insertion: (Figs 13.4 and 13.5). The patient should be supine, with flexion of the lower cervical spine and extension of the head at the atlanto-occipital level. The head should rest on a small pillow or a ring. This position, popularly known as 'sniffing the morning air position', brings the passage from the incisor teeth to the larynx in a straight line. The mouth of the patient is then opened by the right hand of the operator and the locked blade (handle and blade at right angle to each other) of the laryngoscope is introduced between the upper and the lower sets of teeth from the right side of the mouth.

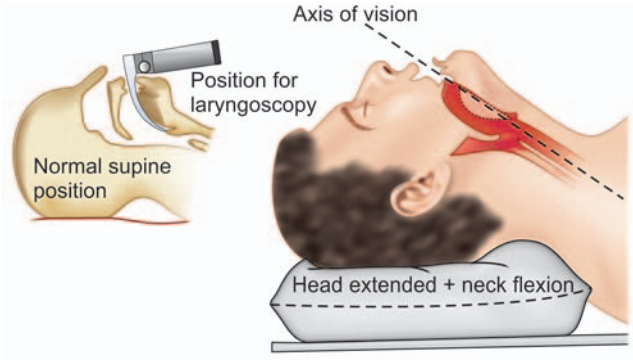


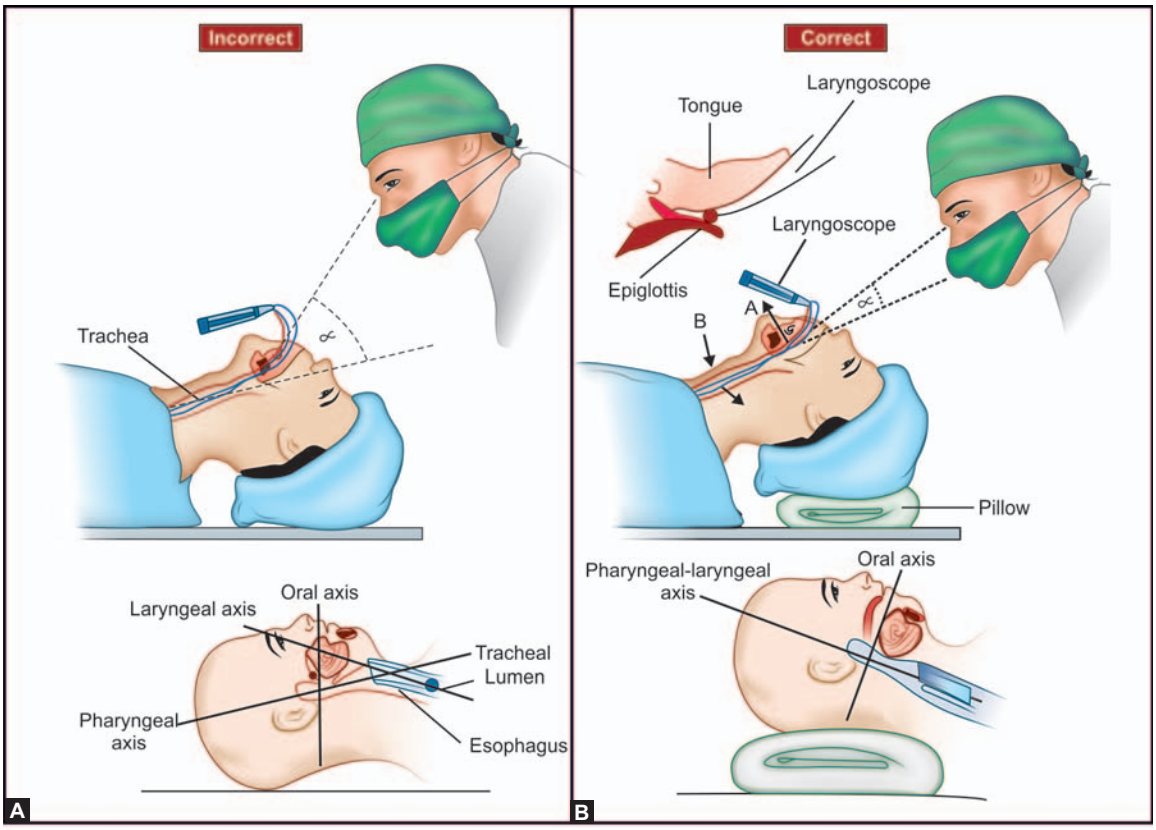
Fig. 13.5: Laryngoscopic vision in supine position and with extension at atlantoaxial level and flexion of lower cervical spine

The blade is then advanced into the mouth towards the glosso-epiglottic fold in such a way, that the tongue is pushed to the left side in the patient's mouth. The blade is advanced till the epiglottis is visualized. The tip of the curved blade is advanced up to the junction of the base of the tongue with the epiglottis and the blade is then lifted upward and forward along the axis, as to carry the base of the tongue and the epiglottis forward. The laryngeal inlet will now come into the view. The tip of the straight blade is passed posterior to the epiglottis, so as to pick up the epiglottis with the tip of the blade and the blade is then lifted anteriorly, thereby elevating the epiglottis directly to expose the laryngeal inlet **(Figs 13.6A and B).**

Endotracheal Tubes

Endotracheal tube is a specially designed tube with one end straight and the other being obliquely cut (beveled end) **(Figs 13.7A to E)**. Beveled end enters the trachea through the laryngeal inlet. It is used for the surgical procedures in which it is not feasible to administer anesthetic gases via mask, procedures which are long-lasting, procedures in which there are chances of having blood, secretions, pus, vomitus, etc. in the oral cavity or where patient needs to be given muscle relaxants and controlled breathing. It is always passed with direct laryngoscopy under vision after anesthetizing the patient, except in cases, where patients are unable to open mouth, e.g. temporomandibular (TM) joint ankylosis or when a difficult intubation is expected.

Sizes: 2, 2.5, 3, 3.5, 4,.....10, 10.5 (internal diameter in mm).



Figs 13.6A and B: Incorrect and correct procedures for laryngoscopy

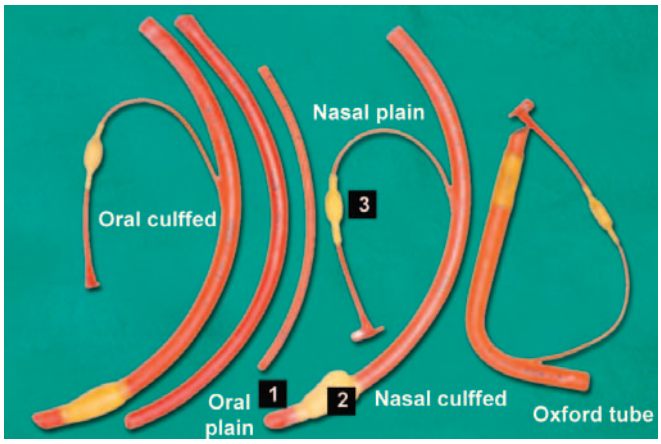


Fig. 13.7A: Red rubber reusable endotracheal tubes. Nasal and oral tubes. Parts of a tube: (1) Bevel, (2) Cuff, (3) Pilot balloon

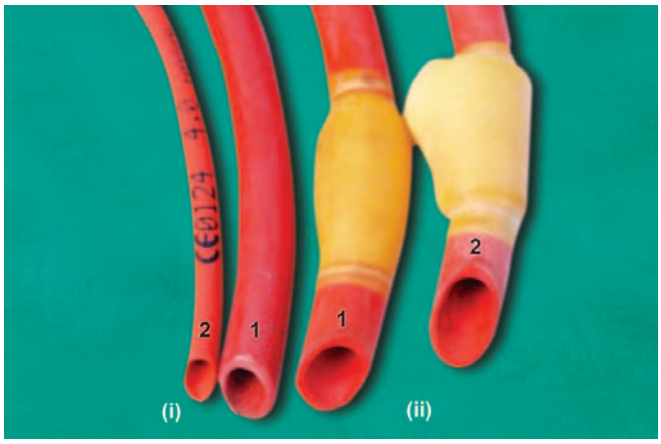
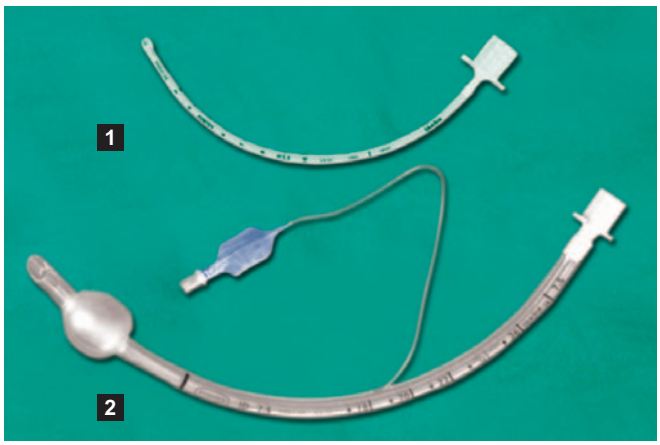


Fig. 13.7B: Bevels of reusable endotracheal tubes. (i) Plain and (ii) Cuffed: (1) Oral tube, (2) Nasal tube



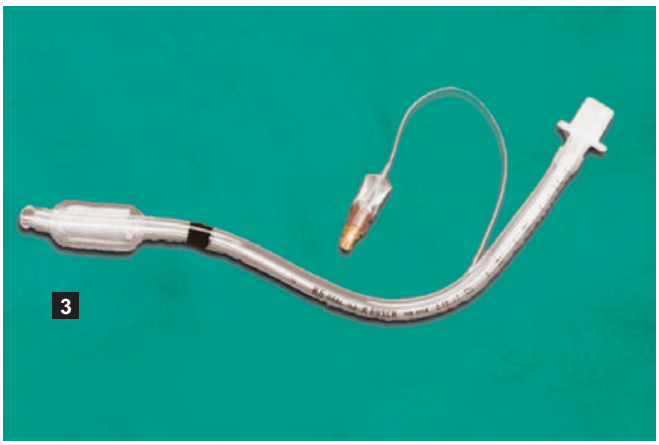


Fig. 13.7C: Disposable endotracheal tubes: (1) Pediatric oral uncuffed tube; (2) Nasal cuffed tube; and (3) Oral cuffed tube

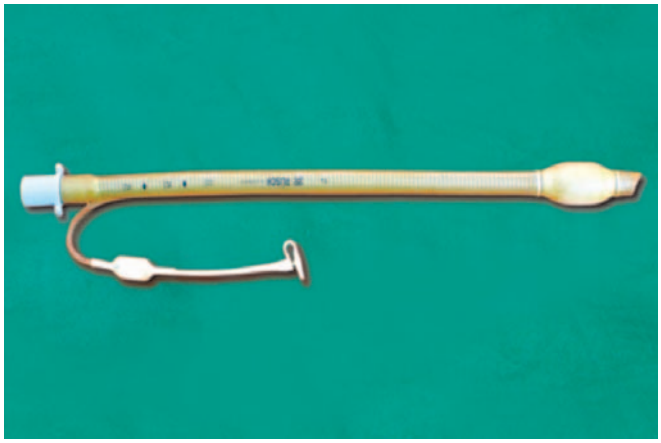


Fig. 13.7D: Flexometallic (armured) tube

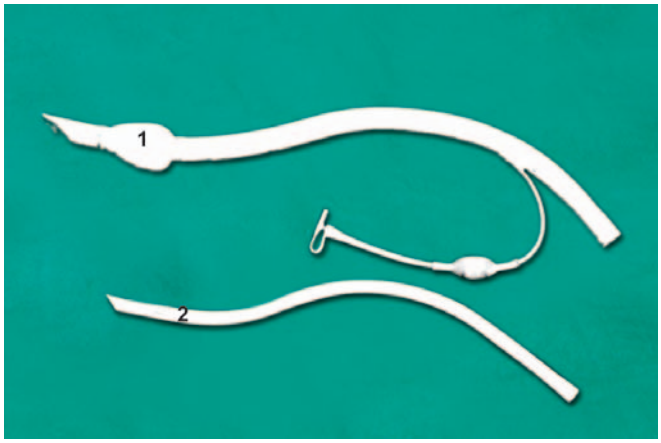


Fig 13.7E: Tehran tubes for difficult intubations: (1) Cuffed tube, (2) Plain tube

Endotracheal tubes (ETTs) may be: (a) plain or (b) cuffed. They can be made up of plastic (generally PVC), red rubber or latex. They may be disposable or reusable. The cuffs may be of low volume-high pressure or high volume-low pressure types. Endotracheal tubes may be introduced orally or nasally. When a nasal tube is required, one designed for the purpose is more appropriate. They are characterized by a longer bevel giving a softer tip, a streamlined cuff and no side port.

When the anesthesiologist is not in the immediate proximity to the patient's head, the precurved disposable oral (south pole) or nasal (north pole), ring-Adair-Elwyn (RAE) tubes have been found to be useful. This type permits the breathing circuit to be led away from the patient and minimizes the potential for kinking and obstruction under the drapes, as it presents a low profile, while emerging from oral or nasal cavity. Other precurved ETTs are Oxford (L-shaped) tubes used for cleft-palate surgery and Tehran (S-shaped) tubes used nasally for difficult intubation, especially in cases of TM joint ankylosis or retrognathic/micrognathic jaw surgeries.

Another variety called armored tubes are made of latex and embedded (reinforced) with spiral rings made of nylon or metal (flexometallic) and are nonkinkable. They may be used orally or nasally. A metal or plastic stylet is required to be used during intubation for oral route but not for nasal route. For laser surgery various 'laser-resistant' tubes are available. Each has its own advantages and disadvantages.

Airways

The purpose of introducing an airway is to lift the tongue and epiglottis away from the posterior pharyngeal wall and prevent them from obstructing the space above the larynx. It is therefore useful in maintaining a patent airway in any unconscious or heavily sedated patient, where tongue fall occurs due to relaxation of the muscles of the floor of the mouth and pharynx. It is made up of metal, rubber or plastic. It can be passed orally (oropharyngeal airway) or nasally (nasopharyngeal airway).

Oropharyngeal (Oral) Airway

(Placed from Lips to Pharynx)

- **Parts:** Flange, bite portion, air/suction channel (curved portion)
- **Sizes:** 1, 2, 3, 4.

The bite portion lies between the teeth/lips and the flange lies outside the lips. The flange prevents an airway from slipping into the mouth and it also serves as a means to fix the airway in place. The pharyngeal end rests between the posterior wall of the oropharynx and the base of the tongue, and by pressure along the base of the tongue, pulls the epiglottis forward.

In addition to maintaining an open airway, it may be used to obtain a better mask fit, to prevent a patient from biting and occluding an orotracheal tube, to protect the tongue from being bitten, to facilitate oropharyngeal suctioning through the air or suction channel or to provide oxygen through the same channel.

Methods of insertion: There are two methods. After lubrication with a jelly, it is introduced between the teeth (upper and lower incisors) after opening the jaw with one hand.

1. With concave side facing the upper lip, then advanced gently till the junction of the bite portion and the curved section is near the incisors, the airway is then rotated through 180° and slipped behind the tongue, so that it lies posterior to the tongue.
2. With concave side toward the tongue, while depressing and pushing forward the tongue with a tongue depressor (tongue blade), the airway is advanced and gently allowed to slide behind the tongue.

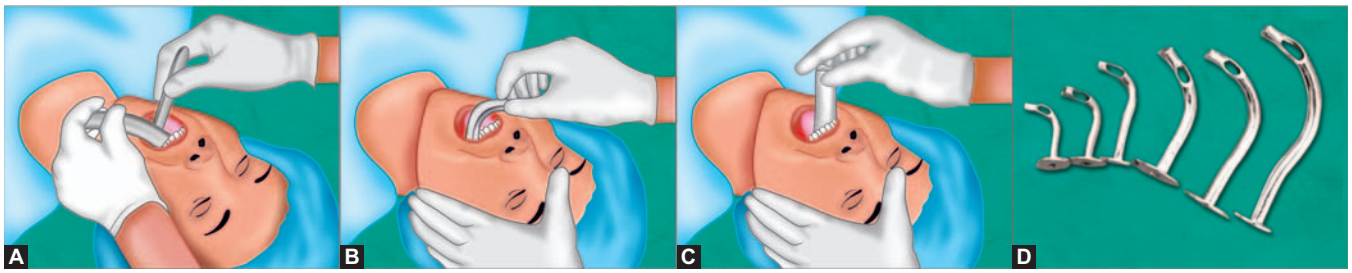
Pharyngeal and laryngeal reflexes should be depressed before placement of an oral airway to avoid coughing or laryngospasm. Unlike other maneuvers to maintain a patent airway, including chin lift, jaw thrust, and tracheal intubation, insertion of an oral airway does not cause movement of the cervical spine. Selection of the correct size is very important, as too small an airway may cause the tongue to kink and push part of it against the roof of the mouth, causing obstruction, and too large an airway may cause obstruction by displacing the epiglottis posteriorly and may traumatize the larynx. The correct size can be estimated by holding the airway next to the patient's mouth in such a way that the tip of an airway rests cephalad to the angle of the mandible. The correct size will allow to feel the expiratory blast (flow) while the airway is in situ **(Figs 13.8A to D).**

Nasopharyngeal (Nasal) Airway

Parts: Flange or a movable disc attached to a tube

- **Sizes (diameter):**
  - 7.0/7.5 for adult males
  - 6.5/7.0 for adult females
  - Same/one size smaller than an appropriate ETT for children.

It resembles a shortened ETT with a flange or a movable disc at the proximal end to prevent its migration into the nose. An ordinary ETT which is cut short, can also



Figs 13.8A to D: Method of their insertion of oropharyngeal airway. (A) Insertion of an oral airway using a tongue blade; (B) The airway may be placed upside down; (C) Airway rotated as it is advanced; (D) Different sizes of metallic oropharyngeal airways

be used as a nasopharyngeal airway. A safety pin is used as a flange. The flange lies outside the nostril and the tube in the nasal cavity. The pharyngeal end of the tube may be straight or beveled and it lies below the base of the tongue, but above the epiglottis **(Figs 13.9 and 13.10).**

Nasal airways are used after oral, pharyngeal or maxillofacial surgery to keep the airway patent or to maintain the airway and administer anesthesia during conservative dentistry. It is preferable in patients with loose teeth or in patients with trauma or pathology of the oral cavity or when patient cannot open his mouth.

Method of insertion: It should be lubricated thoroughly along its entire length. Each nostril should be inspected for its size and patency. Vasoconstrictors may be applied before insertion to reduce bleeding. The airway is held in the hand on the same side, as it is to be inserted with the bevel against the septum and inserted perpendicular, in line with the nasal passage. It is then gently advanced posteriorly. If the resistance is felt during insertion, the other nostril or the smaller size should be used.

A nasal airway is better tolerated in the patient with intact airway reflexes than an oral airway. The airway length may be advanced by sliding it in or out till the pharyngeal end rests below the base of the tongue but above the epiglottis. If it is inserted too much inside, laryngeal reflexes may be stimulated and if it is too much outside, airway obstruction may not be relieved. The correct placement will allow to feel the expiratory blast (flow).

Contraindications to the use of a nasopharyngeal airway include patients with hemorrhagic disorders, coagulopathy, a history of epistaxis requiring medical treatment or patients on anticoagulants; or patients with skull base fracture, and any pathology, sepsis or deformity of the nose or nasopharynx.

Laryngeal Mask Airway

Laryngeal mask airway (LMA) is a device which is midway between mask and ETT. Just as mask makes an airtight seal around the face, LMA makes an airtight low-pressure seal around laryngeal inlet after inflation of the cuff **(Fig. 13.11).**

- **Parts:** Mask, tube at an angle of 30°, black line on tube to face upper incisors and pilot balloon.

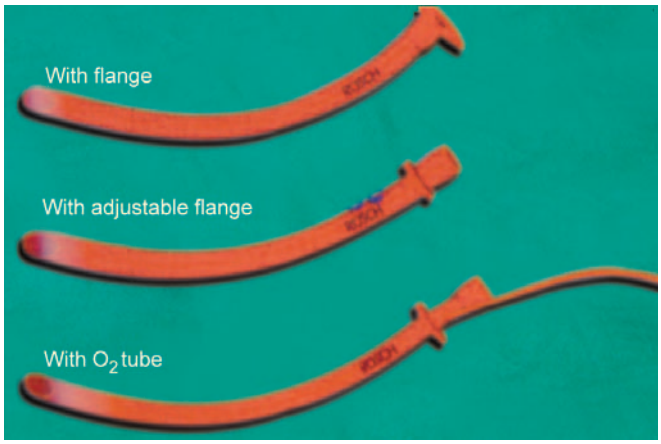


Fig.13.9: Nasopharyngeal tubes (airways)

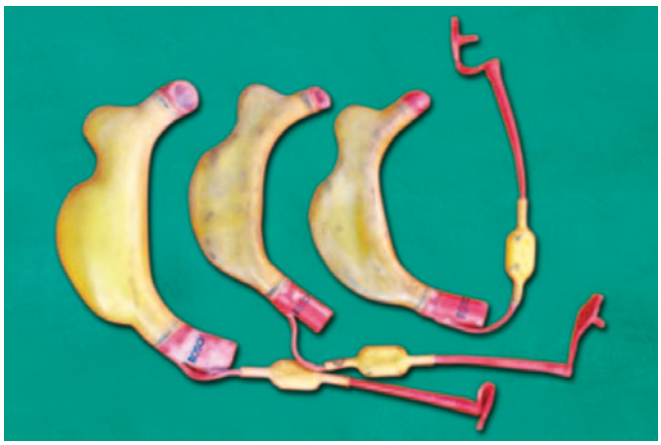


Fig. 13.10: Special cuffed nasopharyngeal airways

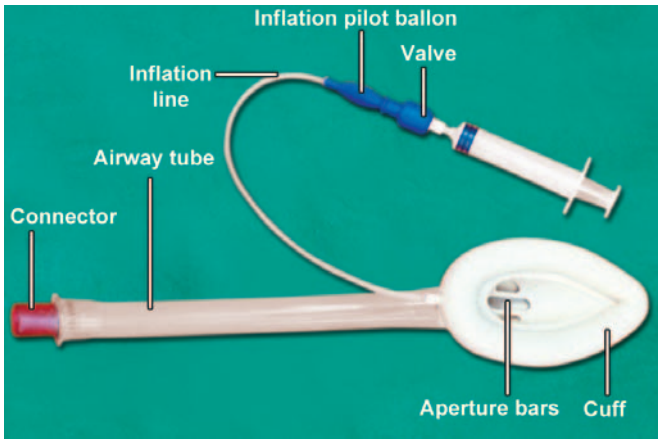


Fig. 13.11: Laryngeal mask airway



Fig. 13.12: Magill's forceps: Inset—View of blades

- **Versions:** Plain, reinforced, and intubating, proseal LMA.
- **Sizes:** 1, 1.5, 2, 2.5, 3, 4, 5.

It is to be autoclaved before every use. Deeper level of anesthesia is required for insertion to avoid laryngospasm. It can be passed with/without use of muscle relaxants.

Method of insertion: With patient in position as for laryngoscopy and with cuff deflated, it is held like a pen and with its aperture facing anteriorly, it is pressed against hard palate and advanced till it goes beyond the base of the tongue. Cuff is inflated and then connected to the breathing circuit.

Advantages

- No laryngoscopy required
- Less postoperative sore throat
- Useful in failed intubation to ventilate the patient
- Intubating LMA is useful in intubating patients with difficult airway.

Disadvantages

- Does not prevent aspiration
- Can cause gastric distention.

Magill's Forceps

Magill's forceps is often used for guiding an ETT, from the pharynx into the larynx during nasal intubation. It is also used to pack the throat with a roller gauze during oral and pharyngeal surgery, to pick up a broken or dislodged tooth lying in the oral cavity or to pass a Ryles (nasogastric) tube. It is L-shaped and it has no catch. It is available in two sizes—adult and pediatric **(Fig. 13.12).**

Mouth Prop (Bite Block)

The mouth prop is a small rounded or rectangular piece of instrument made up of metal, plastic or rubber **(Fig. 13.13).**

A mouth prop is placed between the occlusal surfaces of upper and lower molar teeth, following introduction of an ETT to prevent them from occluding an ETT and to avoid biting the tongue and to keep the mouth open for suctioning. As a mouth prop/bite block does not extend into the pharynx, it is usually less irritating than an oral airway. A variety of bite blocks have been developed. Some have a channel for ETT passage; some have string, so that it can be easily retrieved. The curved portion of an oral airway can be removed or shortened, modifying the remaining portion as a bite block. A barrel of a plastic syringe fitted around the ETT or a roll of gauze piece can be used as a makeshift bite block.

The mouth prop is generally used by the surgeons for many surgical procedures to keep the mouth open or stretch open the already relaxed jaw. It is also used to forcibly open a clenched jaw (trismus), or when patient's airway is at stake (blood or vomitus in the pharynx), or to place an airway, when patient's breathing is obstructed or when the patient is biting on an ETT.

Resuscitation Bag

Resuscitation bag is an assembly of equipment consisting of a self-inflating bag, a nonrebreathing valve and a face mask **(Figs 13.14).** There are varieties of resuscitation bags available in the market. Some have a reservoir bag for oxygen; the others have small-corrugated tubing for the same purpose. Each of them has a nipple for connecting an oxygen source. They are generally reusable, but even disposable resuscitation bags are also available.



Fig. 13.13: Mouth props: (A) Rubber; (B) Metallic





Figs 13.14A and B: (A) Resuscitation bag; (B) Its use on the patient

- **Sizes:** Three sizes are available; for infant, child and adult.

As it is useful for ventilating a patient in emergency situation, it should always be available in the operation theatre as handy as possible. If any problem occurs with anesthesia machine or a breathing system, which cannot be diagnosed or corrected quickly, a resuscitation bag will allow the user to ventilate the patient with room air (with or without oxygen) till the problem is solved. It is also useful and should be available during patient transport. It can also be used for administering anesthesia in the absence of an anesthesia machine, e.g. in rural set-up or field situations.

Method of using: After proper positioning of the patient, the mask has to be placed on the patient's face and the bag can be intermittently compressed and released while watching the inflation and deflation of the patient's chest. The exhalation blast can be heard or felt from the expiratory port of the nonrebreathing valve **(Fig. 13.15).**

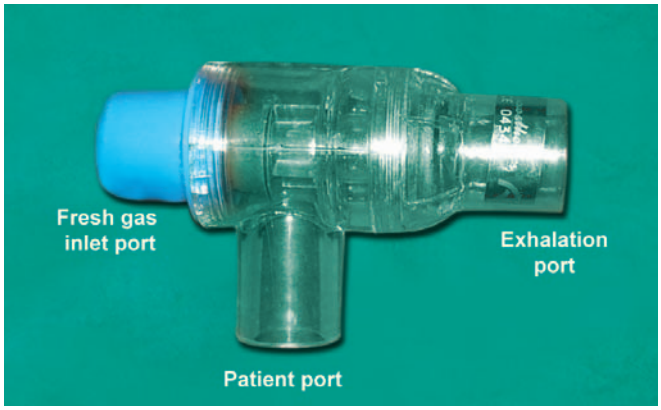


Fig. 13.15: Nonrebreathing valve

MONITORING EQUIPMENT

Under anesthesia, it is the duty of an anesthesiologist to maintain the vital parameters of the patient within normal limits. Hence, it becomes his moral responsibility not only to monitor vital parameters of the patient, but also to diagnose and treat the conditions which make them deviate from their normal range. Not all, but few of the important monitors that are helpful for this purpose, are discussed below in brief.

Blood Pressure Monitor

Blood pressure monitor is available in various forms:

- Simple sphygmomanometer/aneroid dial
- Noninvasive automatic blood pressure monitor (NIBP)
- Invasive direct arterial blood pressure monitor (IABP)

Blood pressure is generally monitored on the right or left upper arm. It is necessary to monitor patient's blood pressure as most of the anesthetic agents are vasodilators and/or myocardial depressants, giving rise to hypotension.

Cardioscope

Cardioscope not only allows to monitor the electrocardiogram (ECG) of the patient, but it also allows to monitor patient's heart rate, rhythm, the type of arrhythmias and ST-segment changes (important to diagnose myocardial ischemia) **(Fig. 13.16).** It has minimum three leads and maximum twelve leads. Generally, a three lead ECG is monitored under anesthesia. These leads are attached on the anterior chest wall, one near the right shoulder, one near the left shoulder and one near the lower end of sternum on the right side. Drugs used for anesthesia have effects on rate,

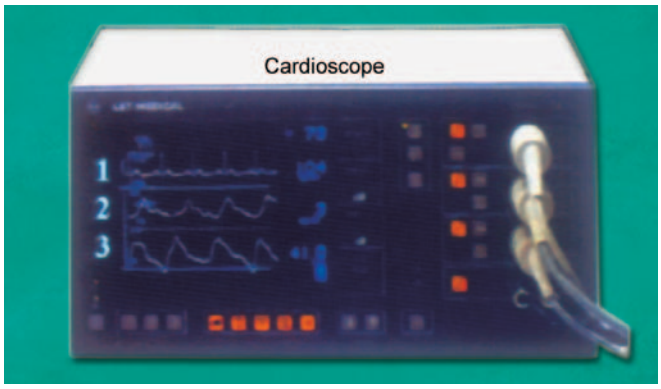


Fig. 13.16: Cardioscope—Triple channel monitor: (1) Electrocardiogram (ECG); (2) Direct arterial pressure; (3) Central venous pressure



Fig 13.17: Pulse oximeter

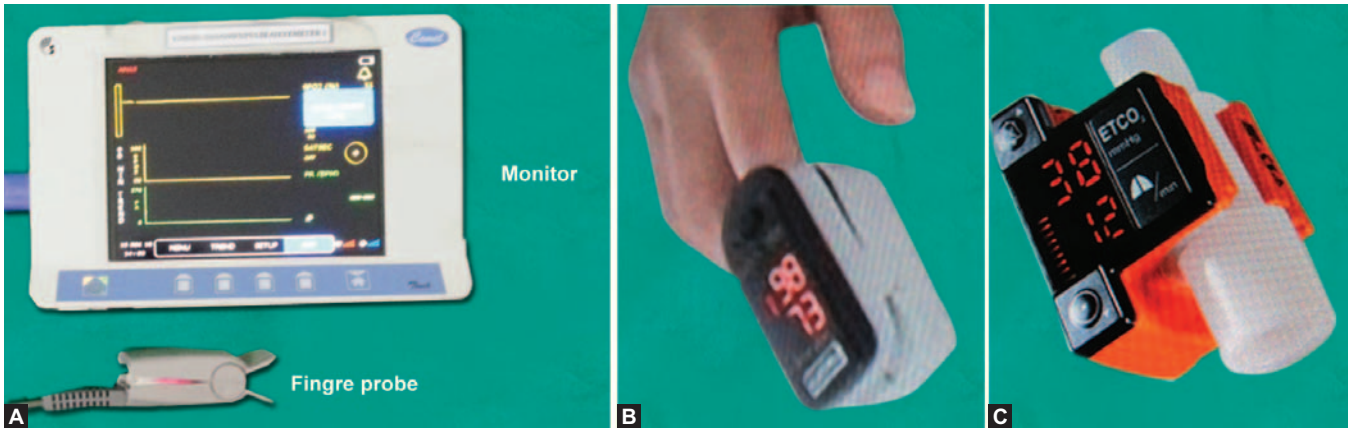
rhythm and contractility of the heart and hence it is vital to monitor these parameters under anesthesia. It also alarms the anesthesiologist about cardiac arrest well in advance as generally slowing of the heart rhythm or intractable arrhythmias occur before cardiac arrest. Cardioscope with a defibrillator is useful as it allows to defibrillate the heart on the spot, if the need arises.

Pulse Oximeter

Pulse oximeter is noninvasive equipment that allows to monitor continuously the oxygen saturation of the patient and also the heart rate. It has a small probe which can be attached on any of the fingers or toes or on the ear lobule. Hypoxia can occur under anesthesia if the patient breathes an hypoxic mixture of gases or the breathing circuit gets disconnected and it is not noticed in time. It is important to know that hypoxia can lead to brain death, coma and even cardiac arrest. Pulse oximeter is therefore a useful monitor to prevent such complications and protect the patient from such catastrophe **(Fig. 13.17).**

Capnometer/Capnographs

Capnometer is an equipment that continuously records the carbon dioxide tension (in mm Hg or %) of the expired gas mixture (only numerical values as in capnometer or numerical value with graphical recording as in capnograph) **(Figs 13.18A to C).** *It is popularly known as an end tidal CO_2 monitor ($ETCO_2$).* It is a noninvasive monitor having a probe or an adapter that can be attached to an ETT, a face-mask or a nasal catheter. It allows the anesthesiologist to monitor whether the patient is breathing adequately (if on spontaneous breathing) or whether the patient is being ventilated adequately (if he/she is on controlled breathing), if the ETT has inadvertently entered the esophagus, the breathing circuit has got disconnected, the breathing



Figs 13.18A to C: (A) Capnograph ($ETCO_2$ monitor); (B) Finger held portable capnometer; (C) Other model of capnometer

circuit is functioning well and not allowing too much rebreathing, etc.

Respiratory Gas Monitor

Respiratory gas monitor is an equipment that allows the anesthesiologist to monitor the contents and the concentration of the inspired as well as expired gas mixture and thereby the concentration of the anesthetic gases, oxygen and carbon dioxide of the inspired gases. It is a noninvasive monitor having a probe or an adapter that can be attached to an ETT, a face mask or a nasal catheter. This helps preventing delivery of a hypoxic gas mixture and also high concentration of anesthetic gases. It is something more than a capnometer and obviates the need to use a capnometer.

OXYGEN DELIVERY EQUIPMENT

It is a well-known fact that patients under general anesthesia as well as in the postoperative period are prone to hypoxia due to some specific reasons. Under anesthesia, it is a routine practice to give a mixture of anesthetic gases containing at least 30% oxygen. Postoperatively, it is very easy to give an oxygen enriched room air via a T-piece system (one of the breathing systems) to those patients who have ETT *in situ*. However, for those patients, breathing spontaneously without having face-mask or ETT *in situ*, it is very important to have equipment that can deliver oxygen enriched air. For both type of patients, oxygen cylinder and oxygen flow/meter are needed. For those having no ETT *in situ*, either an oxygen mask or a catheter is required **(Figs 13.19 and 13.20).**

Oxygen Cylinder

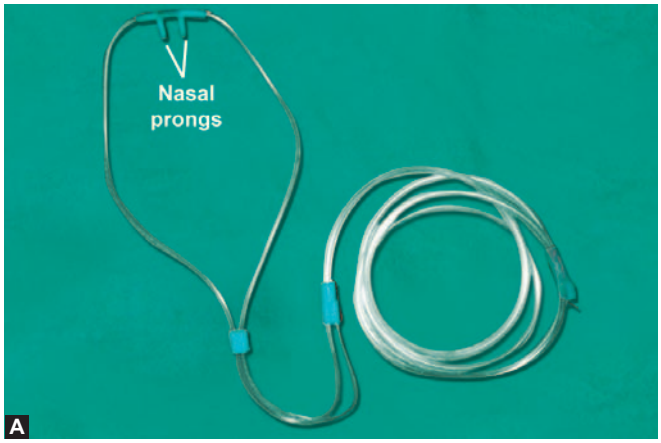
Oxygen cylinders are available in various sizes. They are black in color with a shoulder painted white. Those meant to be used on anesthesia machines have a flushed valve whereas those used in the wards have a bull-nose valve. It is not possible to use a flushed valve cylinder in the wards. On the ward cylinder, oxygen flowmeter can be attached and there is also a facility to attach a humidifier to the flowmeter.

Oxygen Flowmeter

Oxygen flowmeter allows the operator to deliver a desired flow of oxygen to the patient. Generally, 3 to 4 liters per minute of flow is given, but it varies from patient to patient, depending upon the type of oxygen delivery



Fig. 13.19: Oxygen therapy with mask: (1) Oxygen mask, (2) Oxygen cylinder, (3) Oxygen flowmeter, (4) Wolfe's bottle for humidifying oxygen





Figs 13.20A and B: (A) Nasal prongs for oxygen therapy; (B) Combined oxygen therapy + $ETCO_2$ monitoring, nasal prongs in situ

system (poly mask, venti mask, nasal cannula, nasal catheter, T-piece, etc.), type of surgery done, age of the patient and general condition of the patient.

Oxygen Mask

These are generally face masks of different varieties. Poly mask is a semioval-shaped mask, available in two sizes, for children and for adults. It is a loosely fitting mask around the mouth and nose through which moderate flow of oxygen (3–6 liters) can be delivered. Too little oxygen flow will allow rebreathing and too high flow may obstruct exhalation. Oxygen percentage cannot be judged and not more than 35% can ever be given. Venti masks are designed to work on Venturi principle. Here the delivered oxygen flows through a jet and entrains room air from the surrounding entrainment port while it approaches the patient. Various flow rates of oxygen with its approximate delivered oxygen concentrations are written on the device and hence it becomes easy for the operator to choose the mask and deliver the desired concentration of oxygen.

There are some oxygen face masks that have a reservoir bag for oxygen, and some have even directional valves. Recommended flow rate is 10–15 liters/min of oxygen. With reservoir bag, one can deliver up to 65% oxygen and if they have directional valves also, then one can deliver even up to 90% oxygen.

Nasal Catheter/Prongs

Nasal prongs are the most simplest, commonly used and easily available devices **(Fig. 13.20A and B).** But, not more than 1–3 liters of oxygen per minute can be delivered, as high flow makes the patient uncomfortable due to wheezing sound and a feeling of dry mouth. (Generally with oxygen flow rate of 1–2 liters/min, these devices provide 24–28% oxygen).

If a nasal catheter is used, its tip should be advanced up to the fold of the soft palate. If it is introduced too far, it can produce gaseous distension of the stomach. Nasal prongs (two short plastic prongs that fit into the external nares) are preferred by some as they are comfortable for the patients.

INTRAVENOUS INFUSION EQUIPMENT

Infusion equipment includes intravenous cannulation devices like scalp needles and cannulae (available from small–25G to big–16G sizes), three ways, infusion sets and infusion fluids.

Scalp Needle

Scalp needle is a modified hypodermic needle. To the stainless steel needle (a beveled needle without a hub), a plastic flange and a thin tube has been attached. At the end of the tube is a port (hub) to which a syringe nozzle, a three-way or an infusion set can be attached. When nothing is to be injected, the port can be kept closed by a blocker, which is attached to the port. The flange allows better fixation of the needle to the hand and the tubing makes injection of drugs comfortable and painless for the patient.

Intravenous Cannula

Intravenous (IV) cannula is a plastic cannula with a hub into which fits a metal stylet, which has a bevel at one end, and a hub at the other end **(Fig. 13.21).** While puncturing the vein, the entire set (with the beveled end of the stylet) enters the vein. As soon as the stylet punctures the vein, blood is observed entering the hub of the stylet. The whole set is then further advanced about 1 to 2 mm, so that even the cannula enters the vein, the stylet is then kept steady and only the cannula is advanced further into the vein. The stylet is then removed and only the plastic cannula remains in the vein. This device is more useful and comfortable as compared to hypodermic needle or a scalp needle, as it prevents counter puncturing of the vein while taking an intravenous line and also post insertion when patient moves the site of cannulation.

Bivalve (Three-way)

Bivalve or three-way is a device that is attached to the needle before attaching an infusion set. This device has three ports. One is attached to the IV needle, one to the infusion set and the third port remains free, which can be closed or blocked when not in use. It is this third port,

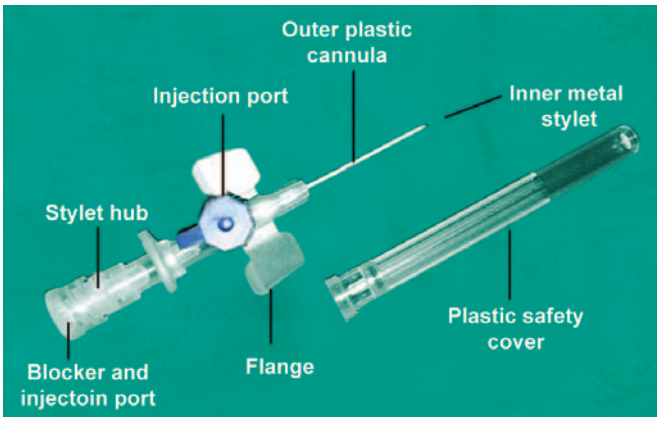


Fig. 13.21: Intravenous cannula

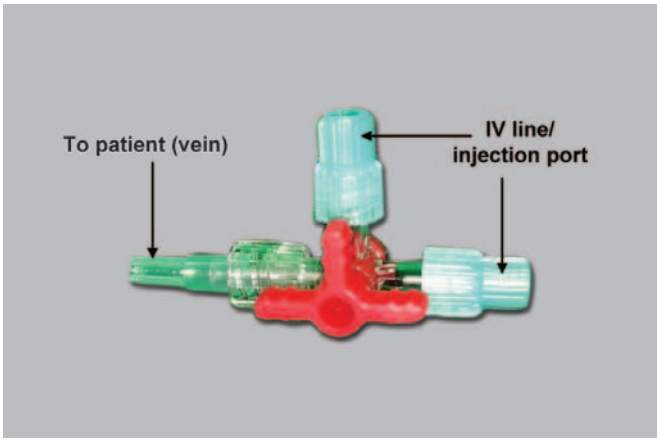


Fig. 13.22: Bivalve (three-way)

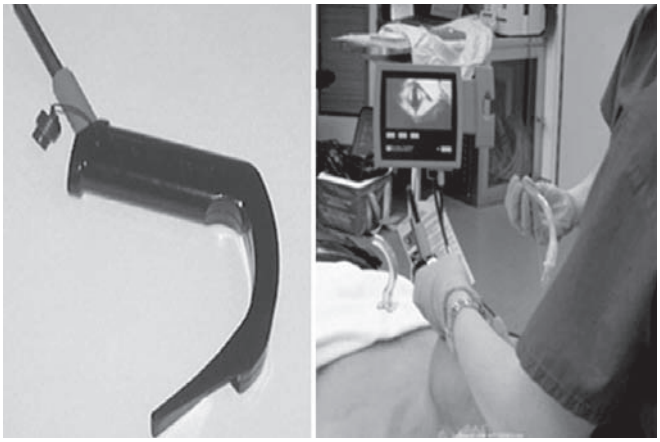


Fig.13.23: Glide Scope

which allows administration of drugs or any other fluid either simultaneously, or singularly depending upon which way the shaft of the three-way has been turned **(Fig. 13.22).**

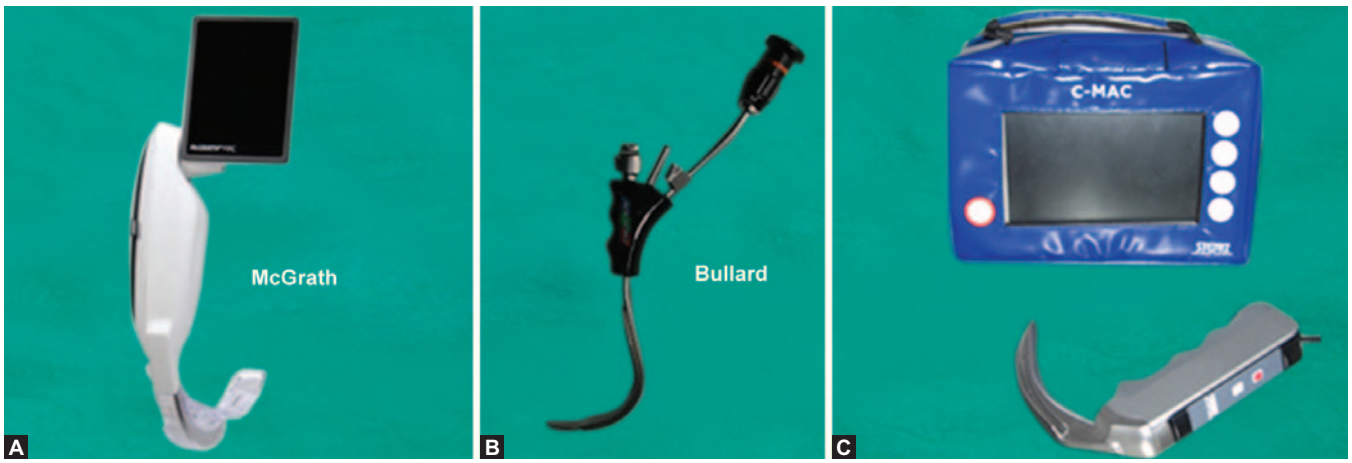
Infusion Set

Infusion set consists of a plastic tubing having one sharp end that can enter the infusion bottle (fluid) and the other that will fit the hub of a needle, cannula or a three-way. Closer to the end that fits a bottle, in a chamber called Murphy's chamber, which has a dropper through which the infusion fluid drips into Murphy's chamber. This chamber should be half-filled with air and half with the infusion fluid. This will allow one to see the rate at which the fluid is given to the patient. This can be an ordinary dropper or a microdropper. With ordinary dropper, 15 drops make 1 ml (cc); while with a microdropper 50 drops make 1 ml of a solution. Microdrip set is useful in children and for continuous infusion of some drugs. The set has a drip controller, which allows on/off as well as the drip rate to be set.

Before connecting the set to the needle, the fluid should be allowed to run so as to fill the entire set and half of Murphy's chamber with the fluid so that no air enters the venous line.

Intravenous Fluids

A variety of fluids are available. The ones, which are generally used under anesthesia are: 5% dextrose (glucose), normal saline (0.9% sodium chloride solution) and Ringer's lactate solution. These are called crystalloids. Others known as colloids, e.g. Haemaccel, Hetastarch, etc. are used when blood loss needs to be replaced and blood is not available immediately.



Figs 13.24A and B: Various newer fiberoptic laryngoscopes: (A) McGrath laryngoscope; (B) Bullard rigid fiber optic laryngoscope; (C) C-Mac Laryngoscope



Fig. 13.25: Airtraq optical laryngoscope



Fig. 13.26: PENTAX Air Scope



Fig. 13.27: Truview Laryngoscope

NEWER ADVANCES

Fiberoptic Laryngoscopy

The flexible fiber-optic bronchoscope or rhinoscope is used for tracheal intubation. The patient can remain conscious during the procedure, so that the vocal folds can be observed during phonation. Surgical instruments passed through the scope can be used for performing procedures, such as biopsies of suspicious masses.

Other available fiber-optic devices include the Bullard scope, Upsher scope, and the WuScope. These devices are widely employed for tracheal intubation, especially in the setting of the difficult intubation.

Video Laryngoscope

Video laryngoscopes employ digital technology such as the Complementary Metal-oxide Semiconductor, Active Pixel Sensor (CMOS APS) to generate a view of the glottis, so that the trachea may be intubated.

- **Glide Scope:** It was the first commercially available video laryngoscope. It incorporates a high resolution digital camera, connected by a video cable to a high resolution LCD monitor. It can be used for tracheal intubation to provide controlled mechanical ventilation, as well as for removal of foreign bodies from the airway.It is useful for difficult airway intubation. **(Fig. 13.23)**
- **McGrath laryngoscope:** It is an anatomically shaped video laryngoscope. It has a camera embedded in a camera stick. A single use plastic blade covers the steel camera stick. It is light weight and easily portable **(Fig. 13.24A).**
- **Bullard rigid fiberoptic laryngoscope:** It is an S-shaped rigid scope with anatomically curved blade. A sheath is provided for introduction of fiber-optic bundles for illumination and visualization. A working channel for suction and oxygen insufflations is present **(Fig. 13.24B).**
- **C-Mac laryngoscope:** It has a MacIntosh reusable blade with an integrated camera in the laryngoscope blade. A magnified image is displayed on the screen **(Fig. 13.24C).**
- **Airtraq optical laryngoscope:** It is a disposable optical laryngoscope with two parallel conduit—one optical, and the other tune guiding channel. To use it, ETT is preloaded on the channel next to the optical pathway, and the device is inserted in the midline **(Fig. 13.25).**
- **PENTAX Airway Scope (AWS):** The ETT is attached to the blade and tip of tube is captured on display screen before insertion of device. It is portable and water resistant **(Fig. 13.26).**
- **Truview laryngoscope:** It is reusable video and optical laryngoscope with a straight blade. Laryngoscope is supplied with a preshaped stylet on which tube is loaded. It has an oxygen port on the blade for oxygen insufflations. It can be converted to video laryngoscope by connecting a magnetic camera to blade **(Fig. 13.27).**

Points to Remember

- Anesthesia and resuscitation equipment-their names and uses
- Monitoring equipment-their names and uses
- Oxygen delivery equipment-how to use it
- Intravenous infusion equipment-various parts and uses.

CHAPTER 14 Pharmacology of Anesthetic Drugs

INTRODUCTION

Whenever any surgery is planned under general anesthesia, following are the main phases:—(1) Induction; (2) Maintenance and; (3) Recovery.

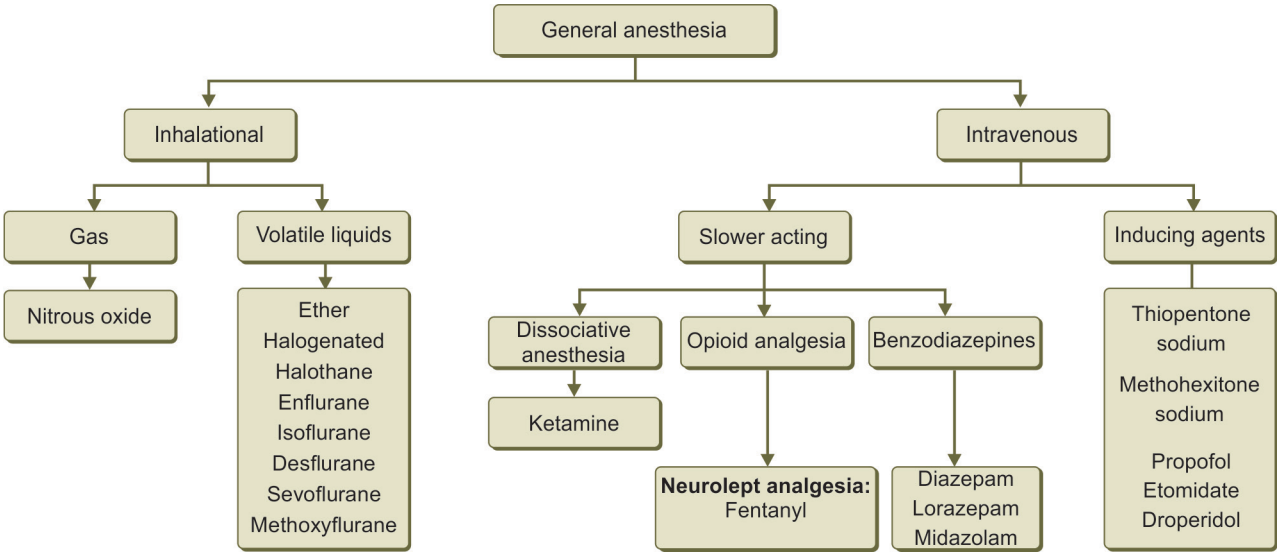
- **Induction (Induction time):** It is the period of time which begins with the onset of administration of general anesthesia to the development of surgical anesthesia (Induction time). Preoxygenation, Induction, Muscle relaxants, Mask ventilation, Intubation and ETT position confirmation are the steps to be followed.
- **Maintenance:** Sustaining the state of general anesthesia. Usually done with an admixture of Nitrous oxide and halogenated hydrocarbons.
- **Recovery:** At the end of surgical procedure, administration of anesthetic agents is stopped and consciousness regains (recovery time) known as Emergence.

Induction of anesthesia is usually accomplished by either intravenous (IV) route or the inhalational (gaseous) route, however, in specific circumstances it may be administered by intramuscular, oral and rectal route. Intravenous route is commonly used for older children and adults. Inhalational route is commonly used for smaller children, who are scared of needle pricks. Drug which has short duration of action, is commonly used for dental anesthesia as most of the cases are day-care patients **(Flowcharts 14.1 and 14.2).**

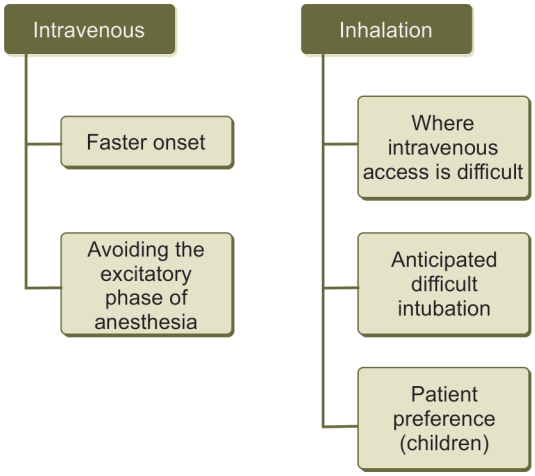
PROPERTIES OF AN IDEAL ANESTHETIC AGENT

- **For the patient:** It should be pleasant, nonirritating, should not cause nausea or vomiting. Induction and recovery should be fast with no after-effects.

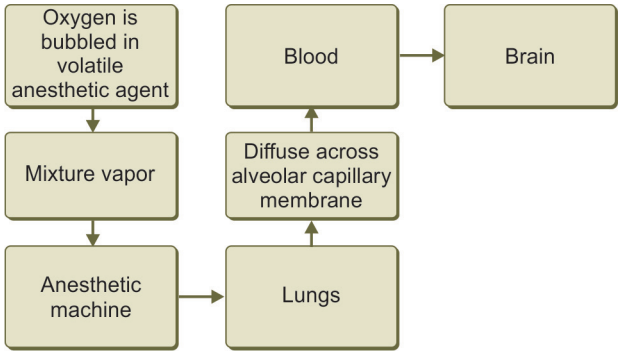
Flowchart 14.1: Various drugs/agents used for general anesthesia purpose



Flowchart 14.2: Comparison of intravenous and inhalation methods for induction of anesthesia



Flowchart 14.3: Pathways of an anesthetic agent



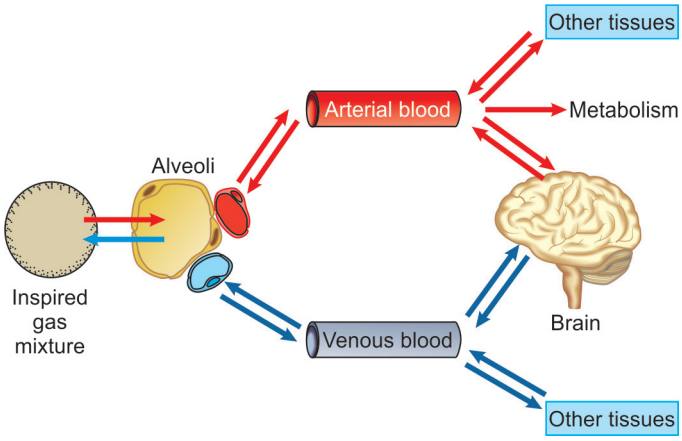


Fig. 14.1: Pathways of an anesthetic agent

- **For the surgeon:** It should provide adequate analgesia, immobility and muscle relaxation. It should be noninflammable and nonexplosive, so that cautery may be used.
- **For an anesthetist:** Its administration should be easy, controllable and versatile.
  - Margin of safety should be wide—no fall in blood pressure. Heart, liver and other organs should not be affected.
- It should be potent, so that low concentrations are needed and oxygenation of the patient does not suffer.
- Rapid adjustments in depth of anesthesia should be possible.
- It should be cheap, stable and easily stored.
- It should not react with rubber tubing or soda lime.

INHALATIONAL INDUCTION AGENTS

Inhalational induction is slower. It is dependent on the inspired anesthetic agent and its concentration, alveolar ventilation, the blood-gas partition coefficient and cardiac output. If solubility in blood (blood-gas partition coefficient) is less, then anesthetic agent is more potent and onset of anesthesia is faster. To be acceptable, the smell of the anesthetic agent should be pleasant and not too pungent. They are commonly used for maintenance of anesthesia. To use inhalational agent, carrier gas is required, e.g. oxygen or oxygen and air. Vaporizers are required to give inhalational agents. *The classical description of the stages of general anesthesia refers to the clinical changes observed during ether anesthesia. With the newer anesthetic agents, these signs are not observed due to speed of induction and loss of consciousness.*

Minimum Alveolar Concentration

The anesthetic vapor mixed in carrier gas (commonly oxygen and nitrous oxide) is delivered to the patient during anesthesia with the help of anesthesia delivery apparatus. It is carried via respiratory passage to the alveoli, and blood to the brain **(Fig. 14.1** and **Flowchart 14.3).**

The MAC of an anesthetic agent is "minimum alveolar concentration" in the alveoli (this in fact reflects the concentration in the brain), which produces lack of reflex response to skin incision in 50% of patients.

Volatile anesthetic agents are rapidly removed from the body via lungs during expiratory process and little evidence of metabolism can be demonstrated following short exposure. Comparative analysis of all important volatile gases/agents is given in **Table 14.1.**

Table 14.1: Differences between commonly used volatile anesthetic agents

	Nitrous oxide	*Halothane*	*Isoflurane*	*Sevoflurane*
MAC value	1.04	0.75	1.17	1.8
Blood/gas partition coefficient	0.46	2.54	1.46	0.69
Boiling point (°C)	−89	50.2	48.5	58.5
Cardiovascular system				
Blood pressure	N/C	↓↓	↓↓	↓
Heart rate	N/C	↓	↑	N/C
Cardiac output	N/C	↓	N/C	↓
Respiratory system				
Tidal volume	↓	↓↓	↓↓	↓
Respiratory rate	↑	↑↑	↑	↑
CNS				
Cerebral blood flow	↑	↑↑	↑	↑
Intracranial pressure	↑	↑↑	↑	↑
Cerebral metabolic rate	↑	↓	↓↓	↓↓
Seizures	↓	↓	↓	↓
Neuromuscular blockade	↑	↑↑	↑↑↑	↑↑
Renal				
Renal blood flow	↓↓	↓↓	↓↓	↓
Urine output	↓↓	↓↓	↓↓	↓
Glomerular filtration	↓↓	↓↓	↓↓	↓
Hepatic blood flow	↓	↓↓	↓	↓
Remarks	Nonirritant, analgesia, amnesia, PONV+, reduces MAC	Pleasant induction, arrhythmias in presence of adrenaline, hepatitis, myocardial depression	Stable CVS, pungent odor, PONV+	Rapid smooth induction and quick recovery, suitable for day cases, less PONV

N/C, no change; ↑, increase; ↑↑, moderate increase; ↑↑↑, significant increase; ↓, decrease; ↓↓, moderate decrease; ↓↓↓, significant decrease

Abbreviations: MAC, minimum alveolar concentration; CNS, central nervous system; PONV, postoperative nausea and vomiting; CVS, cardiovascular system.

Ideal Inhalational Agent

The following properties are desirable in an inhalational anesthetic agent:

- It must be possible to obtain pure compound.
- It should be stable (it should not be broken down by light or alkali, i.e. soda lime).
- It should not undergo metabolism in the body and should be free of organ toxicity.
- It should not form flammable mixture with air, oxygen or nitrous oxide (nonflammable, nonexplosive agent).
- It should have low blood/gas partition coefficient.
- It should be reasonably potent, allowing the use of high concentration of oxygen.
- No long-term adverse effects, if breathed in low concentration for a prolonged period (occupational hazard to theater personnel).
- Decrease cerebrovascular resistance, resulting in increased perfusion of the brain.
- It should be pleasant to smell.
- Cardiovascular side effect should be minimal.
- It should possess analgesic property, in addition to hypnotic property.
- It should be readily reversible.
- No teratogenic or carcinogenic effect should be there.

Table 14.2: Guedel`s clinical signs of anesthesia (specially with ether anesthesia)

Stage	Eyes			Respiration			Airway reflexes abolished	CVS		Muscle tone	Remarks
					Muscle tone						
	Reflexes abolished	Pupil size	Movement	Rate	Intercostal	Diaphragm		Heart rate	Blood pressure		
I. Analgesia	None	N	N	N	N	N	None	↑	N	N	Good for venipuncture, labor pains, dental analgesia
II. Excitement	Eyelash, eyelid	Dilated	Divergent	Irregular	↑	↑	Swallowing	↑↑	↑	↑↑	Tachycardia, tachypnea, aspiration risk +
III. Surgical planes											
Plane 1	Conjunctival	N	N	N	N	N	Vomiting and pharyngeal	↑	N	↑	Risk of aspiration +
Plane 2	Corneal	N	N	↓	↓	N	Laryngeal	N	↓	↓↓	Risk of aspiration + airway obstruction due to tongue fall
Plane 3	Pupillary light	Dilated	None	↓↓	↓↓	↓	Carinal	↓	↓↓	↓↓↓	Ideal to intubate, surgical stage needs IPPR
Plane 4	All	Fully dilated	None	Nil	↓↓↓	↓↓↓	All	↑ or ↓	↓↓↓	↓↓↓	Respiratory arrest and CVS collapse
IV. Death	Respiratory arrest Medullary paralysis (Due to overdosage of an anesthetic drug)										Active cardiopulmonary resuscitation

N, normal; ↑, increase; ↑↑, moderate increase; ↑↑↑, significant increase; ↓, decrease; ↓↓, moderate decrease; ↓↓↓, significant decrease

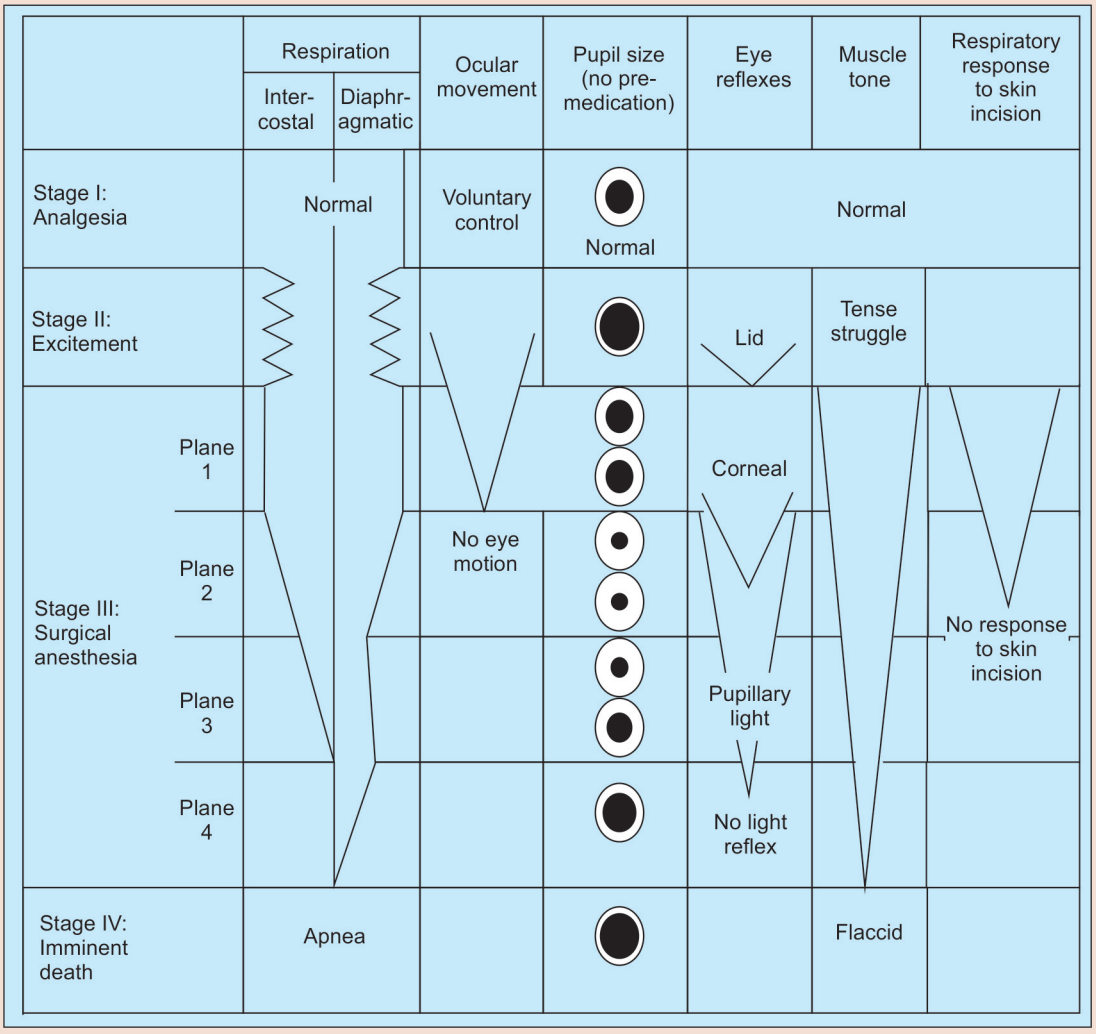
Abbreviations: CVS, cardiovascular system; IPPR, intermittent positive pressure respiration.

Ether (CH_3CH_2-O-CH_2CH_3)

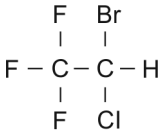
It is known as diethyl ether. Originally prepared in 1540 by Valerius Cordus, who called it sweet oil of vitriol. It is a colorless volatile liquid of molecular weight 74, specific gravity of 0.719 and boiling point 35°C. Its blood/gas partition coefficient is 15, MAC for anesthesia is 3.04. Ether vapor is inflammable in air and explosive with oxygen. Therefore, it cannot be used, when the cautery is being used for surgical procedures. It is largely unaltered in the body, 85–90% being eliminated by lungs. The clinical signs of stages of anesthesia described by Guedel were seen during ether anesthesia **(Tables 14.2 and 14.3).**

It stimulates the sympathetic system yielding to increase the heart rate and to depress the vagus nerve. Blood pressure falls in the deeper planes of anesthesia. A functioning of sympathetic nervous system is essential for maintenance of normal blood pressure during ether anesthesia. Respiratory movements first increase due to stimulation of respiratory center and later on it decreases as the anesthesia deepens. It stimulates salivation, therefore atropine premedication is essential. Its vapor is irritant to respiratory tract producing cough and laryngeal spasm. On induction, it induces analgesia followed by excitement and then anesthesia. It increases the cerebrospinal fluid pressure. Blood sugar level rises with ether anesthesia, therefore it should be used cautiously in diabetic patients. Postoperative nausea and vomiting occurs in 50% of the patients. It can be administered either by open ether technique, face mask anesthesia or via ETT using anesthesia machine. It has a wide margin of safety. It is not used any longer in modern anesthesiology and therefore remains only of historic importance.

Table 14.3: Stages of general anesthesia—especially with ether anesthesia



Halothane (Fluothane) (Prototype) (2-bromo-2-chloro-1, 1, 1-trifluoroethane)



Holathane

- Synthesized first in 1951
  - Volatile liquid, easily vaporized, stable, and non-flammable. It can be used with simple Goldman vaporizer, or highly specific vaporizer like flutec, which gives exact concentration of vapor at any temperature, pressure and gas flows (Liters/min).
  - Most potent inhalational anesthetic agent, MAC of 0.75%, boiling point 50°C.
- Colorless liquid, pleasant smell and nonirritating to respiratory tract, decomposed by light. So should be stored in container away from light and heat. Halothane is supplied in amber colored 250 mL glass bottles, stabilized with thymol 0.01% (w/w).
- Potent anesthetic, 2–4% for induction and 0.5–1.5% for maintenance.
- It has low blood/gas solubility coefficient of 2.5 and thus induction of anesthesia is relatively rapid.
- **Pharmacokinetics:** 60–80% eliminated unchanged. 20% retained in body for 24 hours and metabolized. 20% metabolized in liver by oxidative pathways.

Dosage, Administration and Supply

- The induction dose varies from patient to patient. The maintenance dose varies from 0.5% to 1.5%.
- Halothane may be administered with either oxygen or a mixture of oxygen and nitrous oxide.

Indications

Halothane is indicated for the induction and maintenance of general anesthesia.

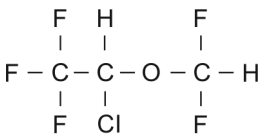
Advantages

- Potent anesthetic, rapid smooth speedy induction and recovery.
- Neither flammable, nor explosive, sweet smell, nonirritant.
- Not hepatotoxic in pediatric patient, and combined with its pleasant odor, this makes it suitable in children for inhalation induction.
- Minimal stimulation of salivary and bronchial secretion.
- Pharyngeal and laryngeal reflexes—bronchodilatation
- Produce adequate muscle relaxation.
- It has no toxic effect on the kidneys.
- Low incidence of postoperative nausea and vomiting.
- Controlled hypotension.
- Inhibits intestinal and uterine contractions.
- It causes moderate skeletal muscle relaxation—less requirement for nonpolarizing muscle relaxant.

Disadvantages

- Halothane anesthesia progressively depresses respiration.
- Weak analgesic (thus is usually coadministered with N_2O, opioids).
- It may cause tachypnea and reduce tidal volume and alveolar ventilation.
- It may cause decrease in mucociliary function, which leads to sputum retention.
- It causes bronchodilation. Hypoxia, acidosis, or apnea may develop during deep anesthesia.
- Halothane anesthesia reduces the blood pressure, and causes bradycardia (atropine may reverse bradycardia).
- It causes myocardial relaxation and hypotension.
- It also causes dilation of the vessels of the skin and skeletal muscles.
- It sensitizes the myocardium to catecholamines leading to cardiac arrhythmias.
- **Cardiac arrhythmias (especially with epinephrine)** can be serious, if hypercapnia develops due to hypoventilation and an increase in the plasma concentration of catecholamines—direct vagal stimulation, direct depression of sinoatrial (SA) node and lack of baroreceptor action. Halothane is a strong cardiovascular depressant and vagomimetic and causes atropine sensitive bradycardia. To minimize its effects, avoid hypoxemia and hypercapnia, avoid concentration of adrenaline higher than 1 in 1,00,000.
- **Gastrointestinal tract:** Inhibition of gastrointestinal motility.
- Causes severe postoperative nausea and vomiting.
- Postoperatively, shivering is common; this increases oxygen requirement which cause hypoxemia.
- Two types of hepatic dysfunction seen with its use: possibility of hepatitis, 1 in 10,000 patients.
  - **Type 1 hepatotoxicity:** Mild, associated with derangement in liver function test, this results from metabolite of halothane in liver, results from reductive (anaerobic) biotransformation of halothane, rather than the normal oxidative pathway.
  - **Type 2 hepatotoxicity:** Fulminate (uncommon); severe jaundice, fever, progressing to fulminating hepatic necrosis.
- Repeated administration over a short period of time has been implicated to produce halothane hepatitis; high mortality 30–70%.
  - **A careful anesthetic history:** History of unexplained jaundice or pyrexia after previous exposure of halothane.
  - Repeated exposure of halothane within 3 months should be avoided.
- Another dreaded complication is malignant hyperthermia, which is characterized by the following:
  - Rapid rise in body temperature
  - Massive increase in oxygen consumption
  - Increased production of carbon dioxide.

Isoflurane



Isoflurane

- Isomer of enflurane (1-chloro-2, 2, 2-trifluoroethyl difluoromethyl ether).

- It is an halogenated ether derivative.
- Colorless, volatile liquid, pungent odor and stable. No preservative.
- Induction dose is 1.5–3% and maintenance dose is 1–2%, by special vaporizer.
- **Respiratory system:** It causes dose dependent depression of vetilation.
- **Cardiovascular system:** It is a myocardial depressant (vitro vs clinical); coronary vasodilatation; does not sensitize the myocardium to the effect of catecholamines.
- **Uterus:** Relaxation of uterine muscles.
- **Central nervous system:** Cerebral blood flow is increased while the cerebral metabolism is reduced.
- **Muscles:** Relaxation (dose-dependent).

Advantages

- Rapid induction and recovery.
- Little risk of hepatic or renal toxicity.
- **Cardiovascular stability:** Does not induce cardiac arrhythmias, less myocardial depression and no myocardial sensitization to adrenaline.
- Low nausea and vomiting.
- Produces adequate muscle relaxation.
- Noncardiotoxic, nonhepatotoxic, non-nephrotoxic, non-tissue toxic.
- A very stable molecule that undergoes little metabolism.
- No dilatation of pupil and no loss of light reflex in deep anesthesia.
- No seizure and preferred in neurosurgery.

Disadvantages

- Pungent odor. Irritating vapor, therefore not commonly used for induction. Maintenance only.
- Coronary vasodilatation.
- Volatile anesthetic.
- Requires special vaporizer.
- Respiratory depression.

Sevoflurane

- New drug, nonflammable, pleasant smell, MAC value is 2% and stable.
- The most commonly used agent is sevoflurane, because it causes less irritation than other inhaled gases (inhalation induction agent).
- Metabolized by liver, releasing fluoride ions; thus, like enflurane, it may prove to be nephrotoxic.
- Rapidly eliminated and allows rapid awakening.
- **Respiratory:** Nonirritant, may cause depression.
- **Cardiovascular system:** Same as isoflurane (slightly lower effect).
- **Central nervous system:** Same as halothane and isoflurane.
- **Muscle relaxation:** Same as isoflurane.

Advantages

- Fast onset and offset of effect.
- Nonirritating, useful for inhalational induction, especially in children.
- Well tolerated (nonirritant, sweet odor), even at high concentrations, making this the agent of choice for inhalational induction.
- Rapid induction and recovery (low blood: gas coefficient) the fastest for induction.
- Does not sensitize the myocardium to catecholamines as much as halothane.
- Does not result in carbon monoxide production with dry soda lime.

Disadvantages

- Less potent than similar halogenated agents.
- Postoperative agitation may be more common in children then seen with halothane.
- About 5% is metabolized and elevation of serum fluoride levels has led to concerns about the risk of renal toxicity.

Nitrous Oxide (N_2O), "Laughing Gas"

Nitrous oxide is the only inorganic gas used for anesthesia. It was first prepared by Priestley in 1772. Anesthetic properties were suggested by Sir Humphrey Davey in 1799. Colton demonstrated its effects to Horace Wells in 1844, who used it in dentistry and had one of its own tooth extracted painlessly.

It is manufactured by heating ammonium nitrate in an iron retort to 240°C.

$$NH_4NO_3 = 2\ H_2O + N_2O$$

- The issuing gas is collected, purified and compressed into metal cylinders at 51 atm (750 lbs/sq. inch). Impurities in nitrous oxide = nitric oxide and nitrogen dioxide (Piped gas supply or blue cylinders). Both these substances are toxic to body and can cause disturbances in breathing and circulation leading to cardiac arrest.
- Eighty-eight percent of pediatric dentists use N_2O, and about 58% of general dentists use N_2O.
- As a single agent used with O_2 in dental extraction and in obstetrics.

- Sweet smelling, nonirritating, colorless gas, nonflammable, and tasteless.
- Minimum alveolar concentration = 105%, lower water solubility, not metabolized in the body.
- It is a potent analgesic, but a weak anesthetic, in the sense that it does not produce adequate muscular relaxation. Rapid onset and recovery.
- Does not depress respiration, and no muscle relaxation.
- Rapid elimination, primarily through the lungs, small amount through skin, sweat glands, urine, and intestinal gas.
- No effect on cardiovascular system (CVS) or on increasing cerebral blood flow.
- The least hepatotoxic, teratogenic, bone marrow depression.
- **Second gas effect:** N_2O can concentrate the halogenated anesthetics in the alveoli, when they are concomitantly administered, because of its fast uptake from the alveolar gas.
- **Diffusion hypoxia:** The rapid outpouring of insoluble N_2O can displace alveolar oxygen, resulting in hypoxia. All patients should receive supplemental O_2 at the end of an anesthesia and during the immediate recovery period. Speed of N_2O movement allows it to retard oxygen uptake during recovery.
- **Effects on closed gas spaces:** Gas-filled spaces—dangerous.

Nitrous oxide can diffuse 20 times faster into closed spaces than it can be removed, resulting in expansion of pneumothorax, bowel gas, or air embolism or in an increase in pressure within noncompliant cavities such as the cranium or middle ear.

- Ventilatory drive is not affected.
- Teratogenic should be avoided in first trimester of pregnancy to avoid its teratogenic effect.

Purpose of Nitrous Oxide Sedation

- Reduce fear, apprehension, or anxiety.
- Raise pain reaction threshold.
- Reduce fatigue.
- In analgesia stage, the patient is conscious, has all vital reflexes intact, can communicate and cooperate with the dentist, and quickly returns to a normal state following a few minutes of oxygenation.
- Aid in the treatment of special patients.
- Increase tolerance for longer appointments.
- Control defiant or uncontrolled behavior.
- Control pain by replacing local anesthesia.
- Replace poor techniques of behavior management.

Advantages

- Noninflammable and nonirritant.
- Rapid induction and recovery.
- Very potent analgesic (low concentration).
- No nausea and vomiting.
- Nontoxic to liver, kidney and brain.

Disadvantages

- Not potent alone (supplementation).
- Hypoxia
- Inhibits methionine synthetase (precursor to DNA synthesis).
- Inhibits vitamin B_{12} metabolism.
- Dentists, OR personnel, abusers at risk: "*Long-term (chronic) exposure to nitrous oxide in sufficient concentrations can produce irreversible, toxic changes, and should be a concern for dental personnel working in environments in which nitrous oxide is administered to patients.*"

Controlling N_2O in the Operatory

- Ventilation
- Fresh air inlets—ceiling
- Return air vents—floor level
- Location of ventilation system exhaust
- Air exchange rate (>10/h)
- Work practices
- Inspect equipment every day.
- Use scavenging system.
- Instruct patient to refrain from mouth breathing and talking.
- Bag should collapse and expand as the patient breathes.
- After administration, flush the system 100% O_2.
- Maintenance
- Inspect and test for leaks (soap).
- Document results of tests and actions taken.
- All repairs done by authorized dealers.
- **Premixed N_2O and O_2:** Pressurized nitrous oxide and oxygen (50:50%) at a maximum cylinder pressure of 2000 lbs/sq. inch is available for analgesic purposes. The apparatus is known as Entonox or Nitronox apparatus. It is used in dental anesthesia, obstetric analgesia and relief of pain during dressing of surgical wound. It is delivered through a demand valve inhaler over the nose.
- **Zones of N_2O:** Four zones of N_2O anesthesia have been described:

1. **Moderate analgesia (6–25%):** Nitrous oxide inhaled. Twenty-five percent of nitrous oxide is more potent than 10 mg morphine.
2. **Dissociative analgesia (26–45%):** Thirty percent gives rise to psychological symptoms and lack of ability to concentrate. This is more severe at 45% concentration.
3. **Analgesic anesthesia (46–65%):** Near complete analgesia. Patient may respond to commands.
4. **Light anesthesia (66–80%):** Complete analgesia and amnesia, not possible to communicate with the patient.

INTRAVENOUS INDUCTION AGENTS

General anesthesia is not limited only to the use of inhalational agents. Induction of adult patients usually involves the use of intravenous induction agents and with proper premedication, these agents can also be used successfully in pediatric patients. The advantages of an intravenous induction are smooth and rapid induction, and avoidance of theater pollution. These agents can also be used for maintenance of anesthesia by infusion technique, i.e. *total intravenous anesthesia* (TIVA). A comparative analysis of commonly used intravenous induction agents is given in **Table 14.4.** Lower induction doses are required in the premedicated patients, severe anemia, malnourished patient, liver and kidney diseases. Side effects of these drugs get exaggerated in these patients. *Contraindications* for intravenous induction agent are airway obstruction, temporomandibular joint ankylosis, submucous fibrosis and predicted difficult intubation (In cases where oral opening is not adequate for laryngoscopy).

MUSCLE RELAXANTS

A muscle relaxant is used to facilitate tracheal intubation at the start of anesthesia and to provide surgical relaxation intraoperatively. Harold Griffith, in 1942, for the first time used the refined extract of Curare (a South American arrow poison) to produce muscle paralysis. However, it must be remembered always that muscle relaxants produce only muscle paralysis and do not provide anesthesia, which comprises of unconsciousness, amnesia and analgesia.

Table 14.4: Comparison of intravenous induction agents

	Thiopentone	*Ketamine*	*Propofol*	*Etomidate*
Class	*Thiobarbiturate*	*Phencyclidine*	*Alkyl phenol*	*Imidazole*
Cardiovascular system Heart rate Mean BP (MAP)	 ↑↑ ↓↓	 ↑↑ ↑↑	 N/C ↓↓↓	 N/C N/C;↓
Respiratory system Ventilation Bronchodilation	 ↓↓↓ ↓	 N/C;↓ ↑↑↑	 ↓↓↓ N/C;↑	 ↓ N/C
CNS Cerebral blood flow Cerebral O_2 requirement Intracranial pressure	 ↓↓↓ ↓↓↓ ↓↓↓ ↓↓ ↓	 ↑↑↑ ↑ ↑↑↑ N/C ↑↑	 ↓↓↓ ↓↓↓ ↓↓↓ ↓↓↓ ↓	 ↓↓↓ ↓↓↓ ↓↓↓ ↓↓↓ ↓
Laryngeal reflexes	Activated	Preserved in lighter plane	Depression	
Salivation	Less	High	Less	
Recovery	Slow, somnolence	Emergence delirium, PONV	Rapid and clear	Rapid and clear
Contraindications/side effects	Porphyrias, uncorrected hypovolemia	Raised (Intracranial tension) ICT, hypertension, heart disease	Pain on injection, contraindicated in egg allergy	Pain on injection, adrenocortical suppression
Dose	3–5 mg/kg	1–2 mg/kg	1–2.5 mg/kg	0.2–0.5 mg/kg

Abbreviations: *N/C, no change; BP, blood pressure; MAP, mean arterial pressure; CNS, central nervous system; PONV, postoperative nausea and vomiting; ICT, intracranial tension.*

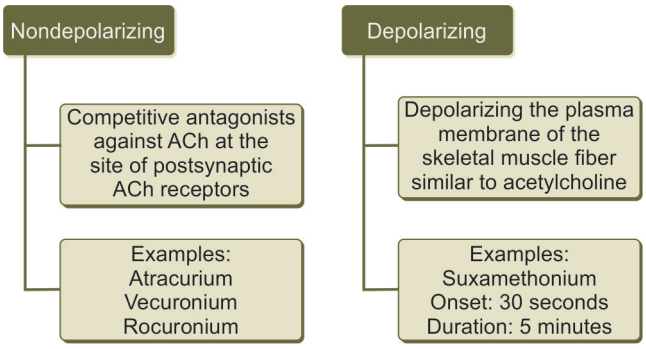
Neuromuscular Blocking Drugs

- Block neuromuscular transmission at the neuromuscular junction.
- Used as an adjunct to anesthesia to induce paralysis.

Mechanical ventilation should be available to maintain adequate respiration. Neuromuscular blocking agents are divided into two classes **(Flowchart 14.4):**

1. **Depolarizing neuromuscular agents:** Depolarizing muscle relaxants very closely resemble naturally occurring neurotransmitter acetylcholine and therefore readily bind to acetylcholine receptors, generating a muscle action potential. However, unlike acetylcholine they are not metabolized by acetyl cholinesterase enzyme present at the site and their concentration in the synaptic cleft in the neuromuscular junction does not fall rapidly. This results in its persistent action on the receptor and muscle relaxation. After it gets metabolized by pseudocholinesterase enzyme in the blood, its effects wear off. It is rapidly acting and has short duration of action. Suxamethonium (Scoline) is a depolarizing muscle relaxant. Depolarizing muscle relaxant does not require reversal agent.
2. **Nondepolarizing neuromuscular agents:** Nondepolarizing neuromuscular blocking agents produce competitive antagonism at neuromuscular junction, and prevent acetylcholine from binding to its receptors **(Table 14.5).** Thus, no muscle end plate potential is developed and normal neuromuscular activity is blocked. These blockers need to be reversed by anticholinesterase drugs (reversal agents), which increase acetylcholine concentration,

Flowchart 14.4: Types of neuromuscular blocking drugs



Abbreviation: *ACh, acetylcholine*

e.g. pancuronium, vecuronium, atracurium and rocuronium.

Action of nondepolarizers is prolonged in acidosis, hypokalemia, hypocarbia, hypothermia, patients on aminoglycoside, antibiotics and myasthenia gravis.

Balance Anesthesia

- Monitoring
- Position—supine, lateral, prone, sitting **(Table 14.6)**.

Fluid Management

- Crystalloid versus colloid
- **NPO fluid replacement:** 1st 10 kg wt, 4 mL/kg/hr; 2nd 10 kg wt, 2 mL/kg/hr and 1 mL/kg/hr thereafter.
- **Intraoperative fluid replacement:** *minor procedures* 1–3 mL/kg/hr, *major procedures* 4–6 mL/kg/hr, *major abdominal procedures* 7–10 kg/mL.

Table 14.5: Muscle relaxants, doses and duration of action

Muscle relaxants	*Intubating dose (mg/kg)*	*Maintenance dose (mg/kg)*	*Duration of action (min)*	*Remarks*
Depolarizing				
Suxamethonium	1.5–2		5–10	Hyperkalemia, muscle pains, raised ICT, prolonged blockade
Nondepolarizing				
Pancuronium	0.1–0.12	0.01	60–120	Tachycardia, hypertension, avoid in renal failure
Vecuronium	0.1–0.12	0.01	45–90	Bradycardia, avoid in renal and liver disease
Atracurium	0.5	0.1	30–45	Histamine release, metabolism by Hoffmann's elimination. Safe in liver and kidney disease
Rocuronium	0.8–1.2	0.15	35–75	Rapid onset of action, faster intubation

Reversal of Anesthesia

The only component of anesthesia that is truly reversible at the conclusion of general anesthesia is the effect of the nondepolarizing muscle relaxant.

The timing of the last dose of muscle relaxant is important and if it is too near to the conclusion of surgery, adequate time must be allowed before reversal is attempted.

Nondepolarizing muscle relaxant is reversed by anticholinesterase drugs, e.g. Neostigmine sulfate (0.05–0.07 mg/kg). These drugs inhibit acetylcholine breakdown and raise its levels leading to reversal of muscle relaxant. Acetylcholine has undesirable muscarinic effects like bradycardia, profuse salivation and bronchospasm. The atropine sulfate (anticholinergic) is administered along with them to block these effects. The status of the neuromuscular block can be checked by the use of peripheral nerve stimulator.

Emergence

- Turn off the agent (inhalation or intravenous agents).
- Reverse the muscle relaxants.
- Return to spontaneous ventilation with adequate ventilation and oxygenation. Suction upper airway.
- Wait for patient to wake-up and follow command.
- Maintain hemodynamically stable patient.

Postoperative Management

- Post-anesthesia care unit (PACU)
  - Oxygen supplement
  - Pain control
  - Nausea and vomiting
  - Hypertension and hypotension
  - Agitation

Table 14.6: Initial doses of drugs used for sedation and analgesia

Initital doses of drugs for procedural sedation and analgesia	
Minimal sedation	
Nitrous oxide	50 : 50 mixture with oxygen
Midazolam	0.1 milligram/kg IV
Fentanyl	1.5 micrograms/kg IV
Alfentanil	3–8 micrograms kg IV
Pentobarbital	2.5 milligrams/kg IV
Brief moderate or deep sedation	
Methohexital	1 milligram/kg IV
Propofol	1 milligram/kg IV
Etomidate	0.15 milligram/kg IV
Ketamine	1 milligram/kg IV
Extended moderate or deep sedation	
Propofol	1 milligram/kg IV followed by 0.5 milligram/kg every 3 min, as needed; give half-doses for the elderly
Ketamine	1 milligram/kg IV (± midazolam, 0.05 milligram/kg IV)

- Surgical intensive care unit (SICU)
  - Mechanical ventilation
  - Hemodynamic monitoring.

Points to Remember

- Properties of an ideal anaesthetic agent
- Inhalational induction agents
- Intravenous induction agents
- Muscle relaxants
- Postoperative management.

CHAPTER 15 Sedation Techniques for Dentistry

INTRODUCTION

Traditionally, dentistry has been carried out under local anesthesia. However, sedation is required for uncooperative children, adult patients with simply genuine fear and phobia of dental treatment and for medically compromised patients (cardiovascular disease, asthma, chronic epilepsy, spasticity, Parkinsonism) and also for those having persisting fainting attacks or gagging. As for general anesthesia, only patients who satisfy The American Society of Anesthesiologists (ASA) I and II criteria should be considered for sedation.

Since the early work of Langa with nitrous oxide and Jorgenson using intravenous (IV) agents, a variety of sedative techniques for dentistry have been described. Patients can remain fully conscious or can almost become anesthetized when different techniques of deep sedation or ultralight anesthesia are used.

LEVELS OF SEDATION

Conscious Sedation

It basically consists of a minimally depressed level of consciousness that retains the patient's ability to independently and continuously maintain an airway and respond appropriately to physical stimulation or verbal command and that is produced by a pharmacological or non-pharmacological method or a combination of both.

Minimal Sedation

It comprises of a minimally depressed level of consciousness produced by a pharmacological method that retains the patient's ability to independently and continuously maintain an airway and respond normally to tactile stimulation and verbal command. Although cognitive function and coordination may be modestly impaired, ventilatory and cardiovascular functions are unaffected.

Moderate Sedation

It is a drug-induced depression of consciousness during which patients respond purposefully to verbal commands either alone or accompanied by light tactile stimulation. No interventions are required to maintain a patent airway, and spontaneous ventilation is adequate. Hemodynamic stability is usually maintained.

Deep Sedation

Deep sedation is a drug-induced depression of consciousness during which patients cannot be easily aroused but respond purposefully following repeated or painful stimulation. The ability to independently maintain ventilatory function may be impaired. Patients may require assistance in maintaining a patent airway, and spontaneous ventilation may be inadequate. Hemodynamic stability is usually maintained.

General Anesthesia

General anesthesia is a drug-induced loss of consciousness during which patients are not arousable even by painful stimulation. The ability to independently maintain ventilator function is often impaired. Patients require assistance in maintaining a patent airway, and positive pressure ventilation may be required because of depressed spontaneous ventilation or drug-induced depression of neuromuscular function. Cardiovascular function may be impaired.

TECHNIQUES OF SEDATION

Intravenous Sedation

The first generally accepted IV sedation regime was devised by professor Jorgensen of California, who advocated the use of diluted solution of pentobarbitone, pethidine and hyoscine by slow IV injection in the management of

mentally handicapped patients. This technique while effective often produced quite deep levels of sedation with prolonged recovery. This was followed by the use of small incremental doses of methohexitone (Brevital), after an initial loading dose of the same drug to produce ultralight anesthesia. With this technique, patient's comfort was obtained at the expense of the integrity of the respiratory and cardiovascular systems—a potentially dangerous situation.

For many years diazepam was the IV agent of choice, but concerns about active metabolites and recirculation leading to prolonged recovery and pain on injection with venous sequelae have led to it being superseded by midazolam, which is more potent and short-acting.

Midazolam has an excellent anxiolytic with a powerful anterograde amnesic effect. It must be titrated very carefully and slowly until the patient reaches a sedation "endpoint", characterized by a delayed response to questions and commands and some slurring of speech. Verbal contact must be maintained. For most patients, this will require 0.03–0.05 mg/kg which will provide useful sedation for about 45 minutes. Midazolam has no analgesic properties, and local anesthetic injections will be required for painful procedures. In sedative doses, midazolam causes minimal cardiovascular depression, but respiratory depression can be marked. Patients must be monitored carefully, and use of pulse oximetry to monitor oxygen saturation is highly recommended. Oxygen should be administered via nasal cannulae at 1–2 liters per minute (LPM) to prevent hypoxia. Patients must fulfill set criteria for recovery before being discharged. Patients must be accompanied home by a responsible adult. Ideally, the sedative agent should be given in the morning and the patient may resume normal activities on the following day. Flumazenil is a specific benzodiazepine antagonist available to treat any inadvertent overdose of benzodiazepines.

Advantages

- Highly effective technique—smooth induction
- Rapid onset of action
- Titration is possible
- Patent vein is a safety factor
- Control of salivary secretions possible
- Nausea and vomiting less common
- Gag reflex diminished
- Motor disturbances (epilepsy, cerebral palsy) diminished.

Disadvantages

- Venipuncture is necessary
- Venipuncture complications (infiltration, hematoma and thrombophlebitis) may occur
- More intensive monitoring required
- Chances of delayed recovery
- Escort needed.

Since IV sedation techniques may produce major depression of cardiorespiratory parameters, it is not to be administered to the patient by any person except those who have had training in anesthesiology.

Drugs Commonly Available

- Sedative, hypnotics and antianxiety drugs
  - Benzodiazepines—diazepam, midazolam
  - Barbiturates—thiopentone, methohexitone
- Nonbarbiturate hypnotics
  - Propofol
  - Ketamine
  - Etomidate
- Antihistaminics—promethazine
- Narcotic agonists—pethidine, pentazocine, fentanyl.

Other Commonly Used Sedative Agents

Propofol: It is the most recent IV anesthetic agent, which is introduced into the clinical practice. Propofol has been used for induction and maintenance of anesthesia as well as for sedation for short dental procedures done under local anesthesia. Propofol by continuous infusion provides a readily titratable level of sedation and a rapid recovery, once infusion is terminated, irrespective of the duration of the infusion. Generally, at propofol infusion rate, greater than 30 μg/kg/min, patients are amnesic. In comparison with midazolam used to maintain sedation, propofol provides equal or better control and more rapid onset and offset. Sedative dose of propofol is 1–2 mg/kg/min. Intravenous propofol is well-suited for day care set-up as it possesses significant antiemetic activity at low doses and recovery from anesthesia is rapid without hangover effect. Full orientation generally returns within 5–10 minutes after stopping the infusion.

Ketamine Hydrochloride

Ketamine is a phencyclidine derivative. It is a nonbarbiturate hypnotic, which produces dissociative type of anesthesia. It produces sedation, amnesia and

intense analgesia. It has a very high margin of safety. It has good tissue compatibility (no irritation of veins). Since the intraoral muscles, particularly those of the tongue, do not become relaxed under the effect of ketamine, the airway remains unobstructed. This unique characteristic is ideal for dentistry. Airway obstruction, if occurs, is usually due to mechanical causes such as excessive salivation due to the use of ketamine or pressure on the lower jaw by the operator. Despite alleged retention of the protective pharyngeal and laryngeal reflexes, tracheal soiling and aspiration has been reported following induction of anesthesia with ketamine. The addition of sedative premedication increases the incidence of aspiration, especially when ketamine is used in anesthetic doses (1–2 mg/kg IV or 8–10 mg/kg IM).

Dramatic increases in heart rate and blood pressure are produced by IV ketamine, which can be modified by premedication with benzodiazepines, especially midazolam in the titrated dose of 0.05–0.07 mg/kg IV.

Ketamine should be avoided in patients with hypertension and ischemic heart disease. Ketamine causes clinically insignificant transient dose related respiratory depression. Main disadvantage of ketamine is that it increases intracranial and intraocular pressure. There is increased incidence of nausea and vomiting with the use of ketamine. During the operative procedure, purposeless muscle movements of the extremities, myoclonic movements and athetoid or fibrillary like motion of the mouth and tongue are frequently seen. Patient shows some rigidity of the jaw muscles, and mouth may have to be forcefully opened with Fergusson's mouth gag. This side effect of ketamine may interfere with the operative procedure and may be objectionable to the dental surgeon.

Ketamine is known to produce emergence phenomenon in the form of vivid dreams, hallucinations and illusions. The frequency of emergence reactions in children is only 0–5%, considerably less than that in adults. Intravenous benzodiazepines decrease the incidence of dreams when administered prior to induction of ketamine anesthesia. Since the elimination half-life of ketamine is 2–3 hours, recovery from anesthesia is delayed.

In an attempt to reduce the side effects and the recovery times, ketamine should be used in low doses to produce sedation and analgesia (0.1–0.5 mg/kg IV or 2–4 mg/kg IM). The current practice of administering intermittent bolus doses of ketamine may be improved through the use of continuous infusion techniques (10–20 μg/kg/min).

Propofol and Ketamine Combination

Addition of small dose of ketamine (10–30 μg/kg/h) to propofol (0.5–1.5 mg/kg/h) might provide the ideal sedative combination in dentistry, producing titratable sedation, intense analgesia, increased hemodynamic stability, less respiratory depression and a low incidence of psychomimetic side effects.

Fentanyl—sedative or Hypnotic Combination

Fentanyl is an ideal narcotic for use in dental practice. Its duration of action is short (30–45 min). It is suitable for outpatient dental practice. It does not cause hypotension. Bradycardia, respiratory depression, nausea, vomiting and muscle rigidity can occur when it is used in higher doses. For sedation, it can be given IV in the dose of 1–2 μg/kg along with any sedative or hypnotic drug like midazolam, methohexitone or propofol.

Neurolept Analgesia

The term describes a state of indifference and immobilization where patient becomes pain free (analgesic), deeply sedated and partially or wholly amnesic, but yet remains capable of obeying commands and answering simple questions. This state is produced by the agent innovar, a combination of droperidol and fentanyl. Droperidol, a tranquilizer and a powerful antiemetic will be effective for up to 6 hours, whereas the narcotic component fentanyl has a limited activity of a maximum of 45 minutes. This sedative technique is unsuitable for outpatient dental practice because of its prolonged activity and is discouraged in the practice of modern anesthesia.

Pethidine and Promethazine Combination

This is yet another technique of historical interest. Pethidine (narcotic) in 50 mg doses and promethazine (Phenergan) in 25 mg doses are drawn into the same syringe and diluted to a concentration of 5 mg/mL of pethidine and 2.5 mg/mL of promethazine. 1–2 mL of this mixture is administered IV at one time till adequate level of sedation is achieved. Duration of sedation is normally for 60–90 minutes and the patient is drowsy for several hours and recovery is delayed. This technique is also abandoned with the advent of much easily titrable and shorter acting drugs.

Inhalational Sedation

In 1966, Langa popularized the descriptive term relative analgesia for painful dental surgery.

It is an inhalation sedation technique consisting of three elements—first, administration of low to moderate concentration of nitrous oxide in oxygen (0–70%); second, as nitrous oxide begins to exert its pharmacological effects, the patient is subjected to reassuring and semi-hypnotic suggestions; and thirdly, the use of fail-safe equipment with a range of safety features, especially preventing accidental administration of 100% nitrous oxide. Sevoflurane, 0.1–0.3% and 40% nitrous oxide in oxygen, has been used for inhalational conscious sedation in children undergoing dental treatment.

The term relative analgesia, however, is misleading because for complete dental work, relative analgesia is not necessary. Langa believed that the nitrous oxide concentration (20–30%) should be sufficient in most patients to carry out treatment without local anesthesia, but the more recent view is that control of pain should be obtained essentially by local anesthesia and any analgesic effect of the nitrous oxide serves only to remedy minor deficiencies in the local block. Accordingly, a better descriptive term is "inhalational sedation" if nitrous oxide is used in this way.

Indications

- Uncooperative children of reasoning age
- Mildly apprehensive adult patients
- Medically compromised patients
- Patients with gagging problem.

Contraindications

- Patients with extreme anxiety
- Nasal obstruction, sinus problem, common cold, habitual mouth breathing
- Upper respiratory tract infections
- Patients with serious psychiatric disorders
- Chronic obstructive pulmonary disease (COPD).

These patients have chronically elevated carbon dioxide blood levels, and the stimulus for breathing in these patients is lowered blood oxygen content. Oxygen enriched mixture of gases with inhalational sedation technique raises the oxygen saturation of the blood and removes the stimulus for involuntary breathing leading to respiratory apnea in the patients.

- First trimester of pregnancy.

Advantages

- Onset of action is rapid.
- Nitrous oxide has bland, pleasant, nonirritating odor.
- Rapid uptake and elimination of nitrous oxide ensures that no hangover effect is experienced.
- Recovery is fast.
- Breath to breath titration is possible.
- Wide margin of safety
- Cardiorespiratory stability is maintained.
- Spontaneous ventilation can be maintained.

Disadvantages

- Specialized equipment (e.g. vaporizers, etc.) is required, which is expensive.
- In the absence of scavenging system, exposure to nitrous oxide may cause occupational hazards to dental and nursing staff. The abortion rate is higher in practicing female dental assistants when this technique is used.
- Methods that aid in minimizing exposure of the office personnel to nitrous oxide levels are as follows:
  - Testing the equipment for leaks
  - Venting of waste gases outside the building
  - Use of scavenging nasal hoods
  - Use of airsweep (portable electric fan)
  - Minimizing conversation with patient (avoid mouth breathing)
  - Monitoring of air with infrared (IR) nitrous oxide analyzer to prove the effectiveness of the control measures, at least 2–3 times in a year. Reasonable concentration of nitrous oxide appears to be approximately 50 parts per million (ppm)
- Use of nitrous oxide is potentially risky in pregnant patients, especially in their first trimester.

Techniques of Administration

- Nitrous oxide-oxygen sedation will always begin and end with the patient receiving 100% oxygen.
  - The patient should be advised to follow fasting guidelines prior to the use of nitrous oxide-oxygen sedation. The patient is requested to void if necessary prior to treatment.
- If the patient is wearing contact lenses, they should be removed, as gas leak around the bridge of the nose may produce drying of the eyes. So also any artificial dentures, they need to be removed before the procedure.

- Review baseline vital signs prior to sedation. During sedation keep verbal communication with the patient and monitor vital signs and oxygen saturation using pulse oximeter and electrocardiogram (ECG).
- Position the patient in comfortable, reclining position in dental chair. Start the flow of oxygen at 5.0 LPM and place the nasal mask over the patient's nose. Remind the patient to breathe through the nose. Nasal masks are available in a variety of sizes. The size is checked and the one being used should fit the patient's nose. With a well fitting nasal mask and an oxygen flow of 5 LPM—most of the patients are comfortable and the reservoir bag remains partially inflated and it deflates and inflates to a degree with each breath. Once an adequate minute volume of gas flow has been determined for the patient, the titration of nitrous oxide may begin. Initially nitrous oxide is given in the concentration of 10% for a few breaths then increased slowly till patient experiences some sensory disturbance such as tingling sensation in fingers, toes, lips or tongue and tinnitus. At this point, the concentration of nitrous oxide is decreased slightly as this is probably just beyond the desirable point and proceed with local anesthetic injection. The administration of 35–40% (or less) nitrous oxide in oxygen normally produces the euphoria and the tranquilization necessary to allow dental procedure, provided that supplementary local anesthetic is used.
- At the completion of treatment, nitrous oxide flow will be terminated and patient is permitted to breathe 100% oxygen for not less than 3–5 minutes to minimize the possibility of developing diffusion hypoxia.
    - No patient should be left unescorted from the dental OPD, after the procedure even with the lightest of sedation provided. Fine motor activities, like driving, operating machinery, should be avoided for next 24 hours.

Sedation Techniques in Special Situations

Cardiovascular Diseases

In patients with angina pectoris, congestive cardiac failure, severe cardiac dysrhythmias, myocardial infarction and high blood pressure, inhalational sedation has been employed with great success because nitrous oxide has analgesic, amnesic and sedative properties helping the patient to relax and thus reducing the work load of the myocardium and providing the patient and myocardium with the oxygen enriched gas mixture. Intravenous sedation can also be provided, however drugs have to be administered slowly in diluted concentrations and titrated to the clinical effect to avoid sudden cardiovascular compromise.

Asthma

Any type of stress in these patients is a potential cause of an acute exacerbation of asthma, particularly manipulations in lighter plane of anesthesia. Inhalational agents, like halothane and sevoflurane, have pleasant odor as well as bronchodilator properties and are recommended to be used, whereas isoflurane can prove irritant to the airway and should be avoided in these patients with increased airway hyper reactivity. Intravenous induction agents, like propofol and ketamine, are ideal to be used in patients with known hypersensitivity of the airway. Ketamine also exhibits bronchodilator properties and is therefore ideal. Propofol also obtunds airway reflexes and thereby minimizes airway irritability due to inadequate depth of anesthesia. Thiopentone is usually avoided as it is known to exaggerate airway irritability and produce bronchospasm.

Epilepsy

Benzodiazepines, like midazolam, are preferred along with thiopentone or propofol in patients with known history of epilepsy, as these drugs exhibit antiepileptogenic properties. Longer acting benzodiazepines, like diazepam or lorazepam, are also effective to control seizure activity but are avoided as most of these cases are office based and these drugs can cause delayed recovery and postoperative respiratory depression. Nitrous oxide is not an epileptogenic agent and therefore, may be employed in patients with a history of chronic seizure activity as long as hypoxia is avoided.

Hepatic Dysfunction

Nitrous oxide does not undergo biotransformation and therefore can be used without additional risk and with a high probability of success in a patient with hepatic dysfunction. Halothane should be avoided in patients with known hepatic dysfunction and it can worsen the condition further. Intravenous drugs should be used in titrated doses as most of the drugs are metabolized in the liver.

Clinical Indicators of Oversedation

- Patient either too deeply sedated or agitated
- Obstructed airway and breathing

Table 15.1: Modified Aldrette score

Discharge criteria	*Score*
• **Activity:** Able to move voluntarily or on command:	
▪ Four extremities	2
▪ Two extremities	1
▪ Zero extremities	0
• **Respiration:**	
▪ Able to deep breathe and cough freely	2
▪ Dyspnea, shallow or limited breathing	1
▪ Apneic	0
• **Circulation:**	
▪ Blood pressure ± 20 mm of preanesthetic level	2
▪ Blood pressure ± 20–50 mm of preanesthetic level	1
▪ Blood pressure ≥50 mm of preanesthetic level	0
• **Consciousness:**	
▪ Fully awake	2
▪ Arousable on calling	1
▪ Not responding	0
• **O_2 saturation:**	
▪ Able to maintain O_2 saturation ≥ 92% on room air	2
▪ Needs O_2 supplementation to maintain O_2 saturation >90%	1
▪ O_2 saturation <90% even with O_2 supplementation	0

A total score of more than or equal to 9 is required for discharge.

Table 15.2: Post-anesthesia discharge scoring system (PADSS)

Criteria	*Description*	*Score*
Vitals (pulse rate and blood pressure)	Within 20% of preoperative value Within 20–40% of preoperative value >40% range of preoperative value	2 1 0
Ambulation	Steady gait/no dizziness With assistance No ambulation/dizziness	2 1 0
Nausea and vomiting	Minimal Moderate Severe	2 1 0
Pain	Minimal Moderate Severe	2 1 0
Surgical bleeding	Minimal Moderate Severe	2 1 0

Score of more than or equal 9 is acceptable.

- Patient responds sluggishly to command
- Patient becomes uncooperative
- Patient laughs, cries or feels giddy
- Patient has uncoordinated movements
- Patient talks incoherently.

Postoperative Discharge Scores

To avoid cases of oversedation being missed and thereby landing in postoperative morbidity, various scoring systems have been devised. The modified Aldrette score and the post-anesthesia discharge scoring system (PADSS) are most commonly used to determine whether patient is fit to be discharged **(Tables 15.1 and 15.2).**

Points to Remember

- Sedation techniques with different agents
- Clinical indicators of oversedation
- Postoperative discharge scores.

CHAPTER 16 Short Anesthesia in a Dental Chair

INTRODUCTION

The term "dental anesthesia" usually encompasses the administration of a local anesthetic (LA) agents or sedation techniques or general anesthesia (GA), to individuals for the extraction of teeth, minor oral surgical procedures or conservative dentistry either in dental surgeries, clinics, or dental hospital outpatient departments (OPDs). Extensive oral and maxillofacial surgery is carried out normally by oral and maxillofacial surgeons on hospital inpatients.

Local anesthetic blocks are safer than general anesthetic techniques and patients should be encouraged to have dental work performed under local anesthesia. Some patients, however, find cooperation difficult or impossible, because of fear and anxiety. A sympathetic approach coupled with behavioral management techniques, hypnosis or simple sedation can be very successful in helping some of these patients. GA should only be used, if there are very strong indications.

The estimated mortality rate of dental anesthesia is 1 : 260,000, which compares favorably with the extrapolated mortality rate of GA of 1 : 10,000. Much of this difference results from the fact that dental anesthesia is of very short duration and the patients are usually fit and healthy. However, the fact that the deaths have also occurred mostly in young, fit patients undergoing a brief, comparatively trivial procedure, has been a major cause of concern. The majority of outpatient dental anesthetics have been given by nonspecialist anesthesiologists, either medically or dentally qualified and in surgeries which are often poorly equipped for the purpose, particularly with regards to electrical monitoring devices. The only way to prevent this occurrence is to reduce the necessity for GA to as low a level as possible by public education and preventive dentistry and the service to be provided by trained anesthesiologists in a properly equipped environment and with skilled assistance in order to reduce the risk to the patient to the absolute minimum. *The dental surgeon should never act as both operator and anesthetist at the same time.*

The central role of the anesthesiologist is to protect the patient from the pain and stress of surgical intervention and to preserve physiological homeostasis during the perioperative period.

INDICATIONS FOR GENERAL ANESTHESIA IN DENTAL CHAIR

- *Young children*, especially when multiple extractions in different quadrants of the mouth, are planned. Extensive conservative dentistry work in young children, combined with the extractions in one sitting
- *Uncooperative patients*, either those who are mentally subnormal or who have physical infirmity, enough to become uncontrollable under local analgesia, e.g. spastics
- Patients, who are too *apprehensive to cooperate* with local anesthesia methods
- *Acute infective conditions*, except where there is edema of the floor of the mouth or Ludwig's angina, and in whom acute sepsis has not led to trismus with limitation of the opening of the mouth. Due to the low pH of infected tissues, local anesthesia will not relieve pain. Also there is a chance of spreading the infection to surrounding tissues, while injecting LA. Where severe infection is present treatment is best carried out as an inpatient
- *Allergy to LAs*—true allergy to LAs is very rare. The preservative methylparaben present in some LA solutions can provoke allergic reactions. Patients who claim to be allergic, should be questioned carefully, since it is much more common for patients to describe vasovagal fainting reactions, or flushing and palpitation as a result of absorption of adrenaline from the anesthetic solution

- Failure of action of LA agent
- Failure of sedation.

GENERAL PRINCIPLES OF MANAGEMENT

Patient Assessment

The initial screening of patients for GA should be performed as for any other procedures. The anesthesiologists should always discuss with dental colleague's policies for GA, and their implications for an individual patient, to allow efficient patient management.

MONITORS AND RESUSCITATION EQUIPMENT

For safe practice of dental anesthesia, minimum monitoring standards during anesthesia should be followed. Peripheral arterial oxygen saturation, electrocardiogram (ECG), noninvasive blood pressure and capnography (when tracheal intubation is performed) should always be done. A precordial stethoscope can be very helpful. The anesthesiologist should be clinically vigilant and continuously monitor color of lips and mucosa, and movements of chest and reservoir bag. The alarms of monitors should never be switched off. A defibrillator must be available in any situation, where GA is to be administered.

A full range of tracheal tubes with all the accessories for tracheal intubation, plus two working laryngoscopes must be immediately available. A full range of emergency drugs with needles and syringes must be available in the surgery, along with all the equipment required for setting up an intravenous (IV) infusion. All anesthesiologists must be familiar with the recommended resuscitation equipment and drugs and should be able to perform tracheal intubation. They must check the availability of recommended resuscitation equipment and drugs and their location in the dental OPD before inducing the case to avoid emergency hassles. Facilities for the supply and storage of medical gases must meet the relevant regulations.

DAY-STAY SURGERY

Multiple extractions, conservative dental treatment, extraction of impacted 3rd molar teeth, enucleation of simple cyst and other small operations, which are of short duration, taking only 20–40 minutes, are suitable to be carried out on a day-stay basis. The main advantage of day-stay surgery for the patient, is a rapid return home, avoiding admission to hospital, while the advantage to the hospital or health authority is considerable saving in cost. In selecting patients for treatment on a day-stay basis, certain strict criteria must be met:

- Patients must be fit and healthy and free from cardiopulmonary disease satisfying American Society of Anesthesiologists (ASA) categories I and II
- Surgery must not be expected to last more than 1 hour
- There should be no significant risk of complications, like excessive bleeding or vomiting, which would require admission to hospital
- Recovery from anesthesia should be rapid and proper recovery facilities should be available
- Patients must be accompanied home by responsible adults and home circumstances should be suitable for continuing postoperative care.

Most hospitals have inpatient facilities for dental emergencies and patients with recognized risk factors must be admitted for treatment.

Preanesthetic Considerations

A routine should be established that prevents any oversight in the preparation of the patient for the surgery. Advice, preferably written, to be given beforehand to ensure:

- The patient has to follow fasting guidelines and has to avoid even light meals to at least 6 hours prior to surgery. However, sips of clear liquid may be allowed up to 2 hours prior to surgery (especially in children)
- The patient should be instructed to wear clothing that is not tight around the neck or waist and have sleeves that are easily drawn up above the elbow in case IV agents are used
- Cosmetics and jewelry are not to be used
- A responsible escort attends with the patient all the time
- Arrangements for transport home with a responsible escort have been made
- A written informed consent regarding the surgical and anesthetic procedures to be obtained before beginning the procedure
- Instruct the patient to empty his bladder and bowels before coming to the procedure
- Confirm the identity of the patient and the type and site of surgery before starting the procedure
- When the patient is positioned in a dental chair, a waterproof apron should be placed around the patient's neck to protect his clothing

- Anesthetist should make note of presence of crowns, bridges, loose teeth, dentures or soft-tissue lesions. Any removable appliances should be removed, as they may cause airway obstruction when the patient becomes unconscious.

Premedication

Since most of the cases are on ambulatory basis, i.e. the patient is discharged to home within a few hours of surgery; sedative premedication is usually avoided in these patients. But it may be used in children and uncooperative patients. Chloral hydrate (50–100 mg/kg), trimeprazine (2 mg/kg) or midazolam (0.5–0.75 mg/kg) may be given orally mixed with a small quantity of juice to disguise the taste, or intranasally midazolam (0.2–0.3 mg/kg).

POSITION IN DENTAL CHAIR: HORIZONTAL/SITTING

Dental Chair

Whichever position is adopted for anesthesia, it must be possible to put the chair into a horizontal or even head low position immediately in an emergency. If the chair is electrically powered, there should be a manual release to achieve this in the event of a power failure. The chair should have an adjustable headrest to allow the head to be correctly positioned and the arm-rests should be easily removable. In the hospital outpatient or day-stay unit, if the supine position is to be used, an operating table can be used.

There has been considerable controversy regarding the most appropriate position for patients during dental anesthesia. Traditionally, outpatient dental treatment under GA was performed with the patient seated upright in the dental chair. Until Bourne, in 1957, drew attention to the dangers of the unrecognized fainting attack occurring immediately prior to or during induction of anesthesia. He postulated, that many of the cases of cerebral damage or deaths related to dental anesthesia could be explained by hypotension, bradycardia or cardiac arrest associated with a fainting and recommended a routine adoption of supine position.

In the supine position, there is a greater risk of airway obstruction due to the tongue and soft palate falling backward. There is greater risk of pharyngeal soiling with the blood and regurgitation of stomach contents and there is reduction in expiratory reserve volume.

Cardiovascular changes during dental anesthesia do not appear to be influenced by posture. Tachycardia and hypotension occur with both intravenous and inhalational techniques and there are no significant differences between sitting and supine positions.

In order to achieve the best balance of respiratory and cardiovascular conditions, the position commonly adopted for outpatient dental anesthesia is the semisupine. Patient's head should be slightly extended and the mandible should be horizontal and parallel to the floor, when the mouth is open.

Mouth Pack

The mouth pack is inserted with the object of constructing a diaphragm/partition between the site of operation and the lower airway. Dental packing material may be either Gamjee-cotton wool inside a Stockinette sleeve or ribbon gauze (8 cm × 120 cm) or a synthetic sponge material.

Correct placement is essential: The pack should not push the tongue back against the posterior pharyngeal wall and should prevent any debris from passing into the lower pharynx or larynx. The anesthetist must observe the reservoir bag and ensure that the airway is not compromised during placement of the pack. It should prevent mouth breathing. A small tail from the pack must always protrude out of the mouth to alert staff of its presence. It may need to be changed during the course of anesthesia, if it becomes fully soaked. At the end of the procedure, the pack is removed.

INDUCTION OF ANESTHESIA

The biggest challenge of dental anesthesia is the sharing of airway between the dentist and the anesthesiologist. Most of the patients anesthetized are between 3 years and 8 years of age. One of the only indications in the adults for GA is the acutely abscessed tooth. Other adults requiring GA are mentally handicapped, challenged people.

Anesthesia can be induced using an inhalation or intravenous technique. Inhalation induction is commonly used for younger children, especially, if as access is likely to be difficult. Older children and adults will usually accept an intravenous needle.

Inhalational induction is usually commenced by holding the nasal mask close to the patient's face and eventually forming a tight seal of the mask around the nose and lips of the patient to direct the gas mixture towards the mouth and nose. In small children, gaseous induction

using sevoflurane (with parental presence) is often easiest. Since its introduction, sevoflurane has largely replaced halothane as agent of choice, because inhalation is quick and smooth and there are limited cardiovascular and respiratory effects and recovery is faster. Sevoflurane may either be introduced in 2% increments every 2–3 breaths to a maximum of 8%, along with high flows of oxygen (6–8 liters/min) and nitrous oxide (60 : 40) with maintenance of anesthesia at or around 2%, with oxygen and nitrous (2–4 liters/min). Induction using 8% sevoflurane does not appear to cause any adverse effects. However, if sevoflurane is not available, halothane is preferred over isoflurane, that is irritant and can lead to coughing and laryngospasm. A pulse oximeter and ECG should be placed before the child goes to sleep. A cannula must be inserted once the child is asleep for all but the briefest general anesthetic, e.g. even extraction of one tooth that takes a couple of seconds.

Older children may be offered a choice of gaseous or intravenous as induction, and letting them decide, is a good way of achieving cooperation, because the child feels less threatened. Propofol, although a bit costlier, is the agent of choice for intravenous induction (2–3 mg/kg) and it ensures clear headed recovery and good anti-emesis, however, thiopentone (3–5 mg/kg) can also be used. Ketamine has delayed recovery characteristics and induces dysphoria, hence better avoided. Application of local anesthetic cream [eutectic mixture of local anesthetics (EMLA)] to the skin will ensure that insertion of the cannula is painless. However, it has to be applied one hour prior to procedure, which can be difficult in outpatient setting.

MAINTENANCE OF ANESTHESIA

Once the mouth prop and pack have been inserted, surgery can commence. If the procedure is to take a little longer, then the anesthesia is maintained using the nasal mask delivering oxygen (minimum 30%), nitrous oxide and a low concentration of the volatile agent. The anesthesiologist's prime responsibility is to maintain a clear airway by holding the mandible forward and upward to prevent the tongue falling backwards. There is a significant incidence of hypoxia, and to a lesser extent, hypercarbia during pediatric dental extractions, using the conventional nasal mask technique. Children with large adenoids and/or tonsils or a large soft palate may obstruct their nasal airway, as soon as they become unconscious, especially when lying flat (supine). It is difficult to sustain an adequate depth of anesthesia, if the patient is a persistent mouth breather. A nasopharyngeal airway may be essential in some of these patients.

Laryngeal mask airway (LMA) has been recommended after both inhalational and IV induction, because episodes of hypoxia are less frequent. However, surgical access may be limited using an LMA. The LMA is particularly useful for minor oral surgical procedures, such as raising a small flap, extraction of unerupted teeth, which is likely to take little longer time. Care must be taken regarding the positioning and fixation of the laryngeal mask as it tends to get displaced easily. Endotracheal intubation must be used to provide reliable oxygenation in certain indicated patients or whenever the surgery is expected to last longer or intraoral persistent bleeding is expected throughout the procedure.

The anesthesiologist must monitor the patient's condition by observing the color of the lips and mucosal surfaces and watching the movement of the reservoir bag in the circuit. It may be possible to feel the carotid pulse in a child using the little finger on the facial artery underneath the mandible. In an adult because of the potential for cardiorespiratory complications, the electrocardiogram, noninvasive blood pressure and oxygen saturation must also be monitored.

ENDOTRACHEAL ANESTHESIA

Formal endotracheal intubation, is now undertaken much more commonly than in the past. Mentally challenged patients, extended surgery (beyond 15–20 min), obstruction of nasal airways or difficulty in maintaining an airway are indications for endotracheal intubation. Endotracheal intubation may be achieved during inhalation anesthesia or by the use of an IV induction agent, followed by intermediate acting, non-depolarizing muscle relaxant, such as atracurium or vecuronium. Suxamethonium should be avoided in ambulant outpatients, because of postoperative muscle pains. A nasotracheal tube is always to be preferred, as it allows access to both sides of the mouth without movement of the tube and the throat can be packed more securely.

The flipside, however, is especially in younger children, where they have high chances of adenoids being disrupted by nasal tube, which may cause troublesome bleeding. Therefore, in patients with known history of adenoids, nasal intubation should be avoided. Anticholinesterase, i.e. neostigmine along with anticholinergic, like atropine is administered at the end of the procedure to reverse the neuromuscular blockade. The use of opioid is accompanied

by an increased incidence of nausea and vomiting and respiratory depression postoperatively, hence should be titrated properly. Before shifting the child to the recovery area, thorough suctioning of the oral cavity needs to be done. Make sure that the throat pack has been removed and the child should have unobstructed breathing.

RECOVERY

At the end of the surgery, the mouth prop is removed, but the new packs secured with long threads are left in place over the bleeding sockets. Patient should be laid in the lateral position during recovery. Even after very short procedures, fall in oxygen saturation can occur in the recovery period, as a result of residual respiratory depression, inadequate reversal, airway obstruction or the diffusion of nitrous oxide into the alveoli. The airway and breathing must be monitored continuously and suction used to keep the mouth clear of blood, if necessary. Oxygen should be given, until the patient has opened the eyes and expelled the mouth packs.

Patients should remain in the recovery area for at least 2 hours before being discharged into the care of a responsible adult, who must accompany them. The patient should be fully conscious, alert, fully oriented in time and space with no hangover effect at the time of discharge. Vital parameters must be stable. Patient should be able to stand and walk unsupportedly. There should not be any bleeding from the operated site. Postoperative nausea, vomiting and pain should be minimal. Patient should be evaluated using any of the postoperative discharge scores devised to determine the fitness of the patient before he is discharged home **(Refer to Chapter 15 for postoperative discharge scores).**

Postoperative analgesia can be in the form of mild oral analgesics, such as liquid paracetamol, rectal paracetamol (10–15 mg/kg) at the end of surgery before awakening or oral liquid analgesics, when the child has recovered from anesthesia. Intramuscular injections of non-steroidal anti-inflammatory drugs (NSAIDs) are painful and opiates are probably unnecessarily powerful, especially in a day-care set up and should be avoided.

Written postoperative instructions must be given, which emphasize that the patient must not drive or operate machinery for the rest of the day and alcohol must be avoided.

COMPLICATIONS OF DENTAL ANESTHESIA

Hypoxia

Even when 30% oxygen is given during dental anesthesia, arterial hypoxia is likely to occur, unless a perfect airway is maintained. This can be difficult, when the surgeon exerts pressure during extractions on the lower jaw and the mandible will need repositioning constantly. Airway obstruction can also occur as a result of malposition of mouth pack, tongue falling back, and enlarged tonsils and adenoids. If it is difficult to obtain a clear nasal airway, then insertion of a soft, well-lubricated nasopharyngeal airway will usually solve the problem. Increasing the oxygen concentration [fraction of inspired oxygen (FiO_2)] or in resistant cases, applying a (continuous positive airway pressure (CPAP) of 5 mm Hg of H_2O helps to reduce the severity of arterial hypoxemia.

Laryngospasm

It can occur due to the combination of the surgical stimulus and too light level of anesthesia or as a result of blood or saliva irritating the vocal cords. The surgery must stop and the pharynx should be cleared with suction. Administer 100% oxygen. Plane of anesthesia should be deepened (preferably with IV propofol) and positive pressure ventilation should be initiated. This helps to break the laryngospasm in most of the cases. If the laryngospasm does not resolve, then suxamethonium 0.5 mg/kg should be administered to resolve the laryngospasm and positive pressure ventilation continued with 100% oxygen. Endotracheal intubation may also be required, if the laryngospasm does not correct itself.

Mouth Breathing

Mouth breathing will dilute the anesthetic gases and the patient may become too lightly anesthetized and will start to struggle. The pack should be correctly positioned to seal off the mouth. Nasopharyngeal airway may be required.

Contamination of Trachea

Every effort should be made to protect the airway. Complete obstruction of the larynx or trachea has catastrophic consequences. Teeth, crowns, portion of fillings have all been retrieved in the past. In the semisupine position aspiration may be more likely and in the supine position

regurgitation of stomach contents may occur more readily necessitating use of an artificial airway.

Apnea

Apnea may be due to the following reasons:

- Respiratory obstruction
- Breath holding in light anesthesia
- Deep anesthesia
- Severe hypoxia
- Grave cardiovascular depression requiring resuscitation.
- Fainting—fear, anxiety and occasionally pain in the patients presenting for outpatient dental anesthesia, can cause significant autonomic nervous system overactivity. High circulating catecholamine levels and an increased sympathetic component can give rise to a labile blood pressure and tachycardia. Parasympathetic overactivity can cause bradycardia and sweating and predispose to fainting. Fainting is triggered by emotional factors and as a result of stimulation of the limbic cortex and hypothalamus, produces reflex vasodilatation mainly in muscles.

Bradycardia occurs due to increased parasympathetic activity and decreased venous return due to vasodilatation. The fall in cardiac output and severe hypotension causes a rapid loss of consciousness, which can usually be corrected by putting the patient in a head low position or elevating the legs to restore the venous return. In the dental chair, the patient may be actively prevented from falling and if the fainting is not recognized, soon enough severe brain damage and even death may result. Careful monitoring of the pulse and blood pressure throughout the procedure is therefore vital.

Hypotension

Causes of hypotension may include the following:

- Induction of anesthesia in the dental chair, whether it is by inhalational or as IV route
- Pressure on the carotid sinus area, when supporting the lower jaw
- Bradycardia and hypotension due to surgical stimulation of vagal reflexes
- Severe hypoxia.

Cardiac Dysrhythmias

There is a high incidence of cardiac dysrhythmias during dental and oral surgeries. Nodal rhythm and ectopic beats, both unifocal and multifocal, are common. Tachycardia is very common with heart rates over 120 beats per minute during tooth extraction, especially in children. Parasympathetic responses can also occur. Important factors in the etiology of dysrhythmias include high preoperative catecholamine levels (fear, anxiety and pain), surgical stimulation in a lightly anesthetized patient and the presence of airway obstruction with hypoxia. Halothane sensitizes the myocardium to the action of circulating catecholamines and its use is associated with 30% incidence of dysrhythmias. Enflurane and isoflurane produce dysrhythmias in about 10% patients. Arrhythmias are further worsened by presence of hypoxia and hypercarbia.

An effective method of preventing cardiac disturbances is to infiltrate the tissues around the tooth with LA solution, which does not contain adrenaline. This can be done easily after a brief induction and reduces considerably the depth of anesthesia required for any procedure. Additionally, it provides an element of postoperative pain relief. The arrhythmias usually occur during extraction of teeth, but are transient, seldom require treatment and respond to cessation of pull on the tooth.

Nausea and Vomiting

Incidence of nausea and vomiting is high, after any oral procedure and proper preoperative preparation of the patient, selective use of anesthetic agents (propofol), avoidance of opioids and anticholinesterases, and prophylactic use of antiemetics (metaclopromide, ondansetron) will reduce the incidence.

Operating Room Pollution

Dental surgeries are areas of high contamination with anesthetic gases. Efficient ventilation (12–15 room changes of air per hour) and scavenging are required.

Points to Remember

- Indications for general anesthesia
- Equipment
- Premedication
- Day stay surgery
- Position in dental chair: horizontal/sitting
- Induction of anesthesia
- Maintenance of anesthesia
- Endotracheal anesthesia
- Recovery
- Complications of dental anesthesia.

CHAPTER 17 Tracheal Intubation for a Patient Undergoing Oral and Maxillofacial Surgery

INTRODUCTION

Tracheal intubation, usually referred as intubation, is the placement of a specially fabricated tube into the trachea. (Originally the tubes were made from latex rubber, but latest tubes are made up of polyvinyl chloride or silicone rubber and also wire-reinforced silicone rubber or stainless steel). These tubes are known as endotracheal tubes. The intubation is carried out to serve as a conduit through which primarily patent airway is maintained and various anesthetic drugs/agents or gases can be administered, as well as ventilation is facilitated in anesthetized patient. It also prevents asphyxiation or airway obstruction. (Tracheal intubation is generally considered the best method for airway management under a wide variety of circumstances, as it provides the most reliable means of oxygenation and ventilation and the greatest degree of protection against regurgitation and pulmonary aspiration. However, tracheal intubation requires a great deal of clinical experience to master, and serious complications may result even when properly performed).

Intubation is normally facilitated by using conventional laryngoscope, flexible fiberoptic bronchoscope or video laryngoscope to identify the vocal cords and pass the tube between them into the trachea. After the trachea has been intubated, a balloon cuff is inflated, just above the far end of the tube to help to secure it in place and to prevent leakage of respiratory gases, and also to protect the tracheobronchial tree from receiving undesirable stomach acid contents, blood, secretions and other fluids (pulmonary aspiration).

Once there is no longer a need for ventilator assistance, the tracheal tube is removed. This is referred as extubation.

INDICATIONS FOR TRACHEAL INTUBATION

- Multiple extractions in one sitting
- Multiple minor surgical procedures
- Mentally challenged patients and extremely uncooperative patients
- All extensive maxillofacial surgeries
- Pediatric age group patients.

For a patient undergoing any of the above-mentioned procedures under general anesthesia, intubation of the trachea becomes mandatory, for the management of airway, as well as for the administration of gases. The reasons are as follows:

- Patient's airway is shared by the anesthetist and the surgeon
- Airway needs to be protected from aspiration of blood coming from the operative area, as well as any foreign bodies like broken teeth, fillings, etc.
- There are chances of regurgitation and aspiration of gastric contents
- For surgery, lasting for long hours.

Patient's History and Airway Assessment

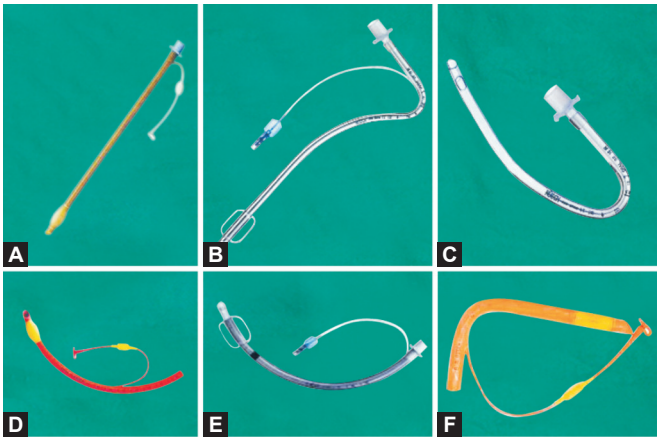
Apart from the airway, the patient's cardiac and respiratory status should be assessed.

History of prior difficulty in intubation needs to be inquired. Also the potential for aspiration of gastric contents into the lung is to be assessed.

ARMAMENTARIUM REQUIRED FOR INTUBATION

Laryngoscope

Laryngoscope is required for visualization of the vocal cords. The laryngoscope blades in common use, for the



Figs 17.1A to F: Endotracheal tubes—(A) Flexo-metallic (armored) tube; (B) Nasal-cuffed North Pole tube; (C) Oral plain South Pole tube; (D) Cuffed oral red rubber tube; (E) Cuffed oral/nasal PVC disposable tube; (F) Oxford red rubber cuff tube

right-handed person are straight or curved. There are four sizes of the blades available. Depending on the size and age of the patient, appropriate sized blade is chosen *(See Figs 13.3 and 13.4, for details Refer to Chapter 13).*

Endotracheal Tubes

For the purpose of securing airway, different types of endotracheal tubes are available in different materials. The size of the tube selected depends again on the age of the patient **(Figs 17.1A to F).** The sizes of the endotracheal tubes are no. 0 to no. 11, ranging from neonate to adult. The tubes are either plane or with cuff. The commonly used tubes are either rubber or Portex® cuffed tubes. Special tubes are also available for nasal intubation *(Refer to Chapter 13).*

After insertion of endotracheal tube, the cuff is inflated for protection of the airway from aspiration of gastric contents or blood from operation site. It also prevents air leak.

Suction

A functioning suction is a must prior to the attempt at laryngoscopy. Suction catheters of various diameters should be available.

Oxygen Source

Anesthesia machine and breathing circuits must be checked for leaks before proceeding for intubation. Adequate oxygen source has to be confirmed before attempting intubation. 100% oxygen is to be administered via a tight fitting mask and reservoir bag prior to any attempt of laryngoscopy or intubation.

Procedure for Endotracheal Intubation

Intubation can be achieved in following ways:

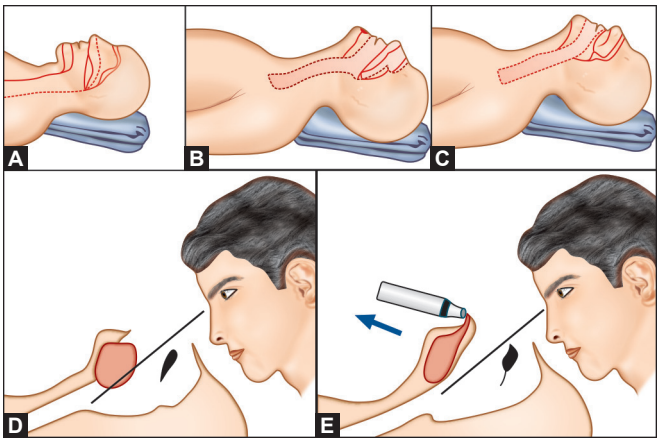
1. After induction of general anesthesia [by intravenous (IV) or inhalation method]
   A. Oral—orotracheal intubation
   B. Nasal—nasotracheal intubation
2. Awake intubation
   A. Blind oral
   B. Blind nasal
   C. Retrograde—rail road technique
   D. By use of fiberoptic scope.

Induction of General Anesthesia

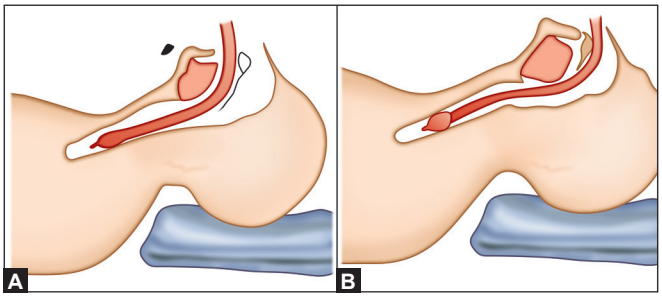
Patient is taken on operation table (who has been fasting, as per the fasting guidelines). After usual check-up of vital parameters, an IV line is started. Patient is preoxygenated for approximately 3 minutes. This fills the alveoli with 100% oxygen and buys time for intubation, when the patient is paralyzed and apneic. Patient is sedated with a sedative hypnotic agent and also analgesic (mostly opioid) is administered to reduce the stress response to laryngoscopy and intubation. Patient is given IV induction agent, till he loses consciousness, after that a muscle relaxant is given through the IV route to facilitate laryngoscopy and intubation. Before insertion of laryngoscope, patient is again preoxygenated using face mask and ventilation with a bag.

Ideal Position for Intubation

The patient's head is kept on a pillow and then head is extended by gentle traction on upper teeth **(Figs 17.2A to E).** This gives flexion at cervical spine (35°) and extension at the atlanto-occipital joint (15°).



Figs 17.2A to E: Position for laryngoscopy: (A) Normal supine; (B) Head extended (HE); (C) HE + neck flexion; (D) Axis of vision; (E) Laryngoscopic vision [(C to E) Extension at atlantoaxial level and flexion of lower cervical spine]



Figs 17.3A and B: Oral and nasal tube in situ

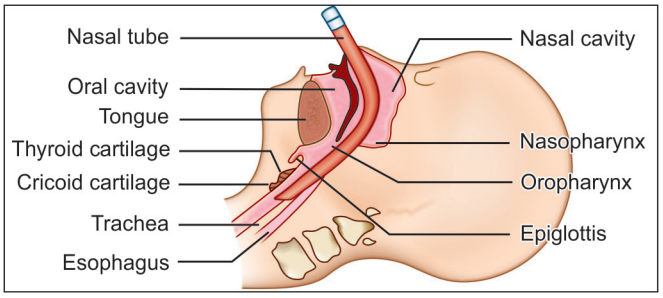


Fig. 17.4A: Nasal tube in situ

Intubation Procedure

The handle of the laryngoscope is held in the right hand and the tip of the curved laryngoscope blade is inserted into the right corner of the mouth and advanced along the side of the tongue toward the right tonsillar fossa, so that the tongue lies in the recess on the left side of the laryngoscope blade. The blade is inserted behind the base of the tongue and the tongue along with mandible is lifted up when tip is lying in the vallecula.

The 7.0 mm internal diameter (ID) endotracheal tube is a reasonable choice for most women and an 8.0 mm ID endotracheal tube is reasonable for most men. When the visualization of the glottis is poor, the tube can be directed anteriorly with the help of a malleable stylet. The end of the stylet should lie at least 1 cm proximal to the end of the endotracheal tube to reduce the chance of airway injury. The proximal end of the endotracheal tube cuff is placed just below the vocal cords. The markings on the tube in relation to the patient's incisors are noted. In adult males, the tube is generally inserted to about 23 cm at the incisors, to position the tip of the tube, at an appropriate 4 cm distance above the carina. For females, the distance is about 21 cm. If the tube is inserted too far, it will cause endobronchial intubation, while tubes that are not inside enough, may be more at risk of accidental extubation. The endotracheal tube cuff is inflated to the point of obtaining a seal, at the vocal cords, so that no audible or palpable air leak is present.

The entire attempt at endotracheal intubation should take no longer than 30 seconds. The tube is connected to breathing circuit by proper connections. The position of the tube in the trachea is confirmed by auscultation of both the sides of chest (lungs) by using stethoscope, when the patient is being ventilated (for checking equal air entry). The tube is then fixed to the corner of the mouth by the use of adhesive tapes, if it is passed orally and to the circumference of the nostril, if it is passed through the nose, and secured over the bridge of the nose.

Thus, intubation can be achieved orally—orotracheal intubation or nasally—nasotracheal intubation **(Figs 17.3 and 17.4A).** (Depending upon the site of surgery, the tube is passed through the nose or mouth. The tip of the tube is passed beyond vocal cords under direct vision, till the cuff lies just beyond the cords).

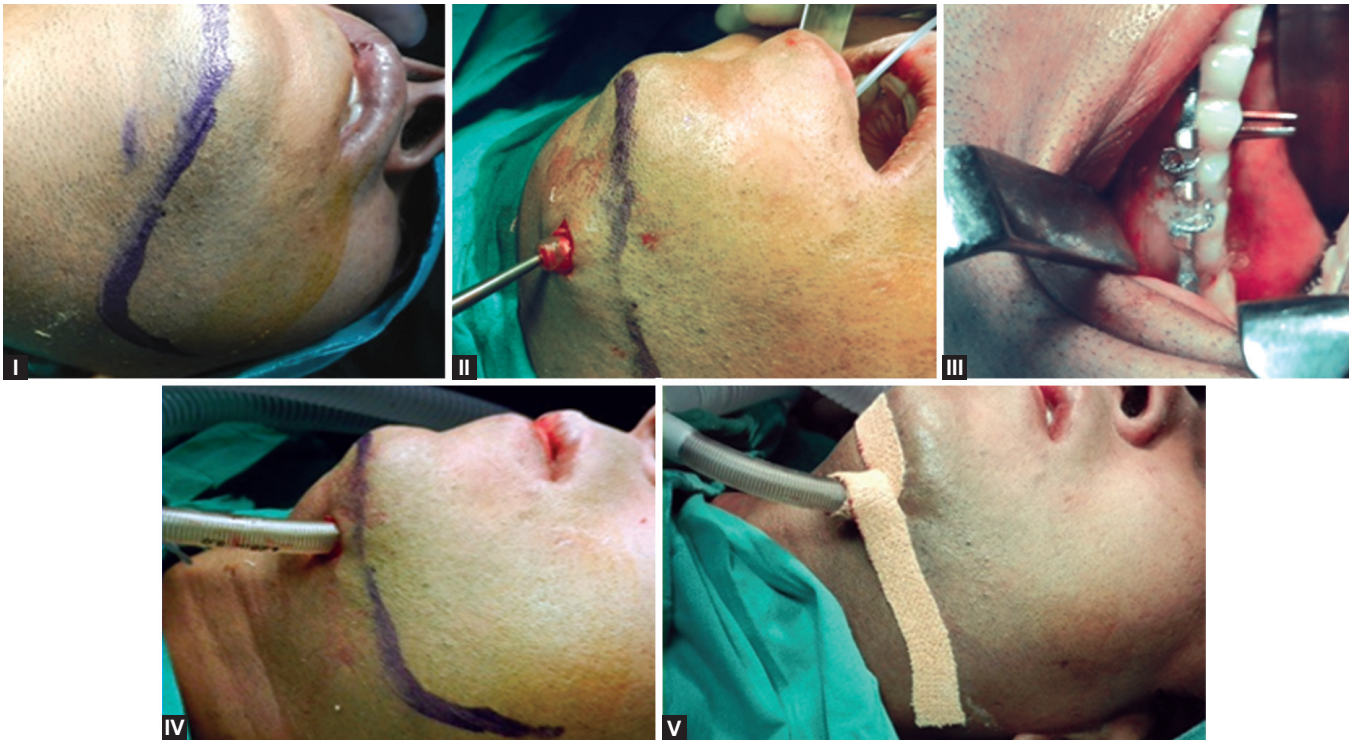
Submental Oroendotracheal Intubation in Maxillofacial Trauma Patients

Submento-oroendotracheal intubation is an alternate technique of airway management in patients with craniofacial maxillary trauma **(Fig. 17.4B)**.

Airway management during surgery in patients with complex craniomaxillofacial trauma has always been a challenge for anesthesiologists, as the surgeon and the anesthesiologist share the same limited space. Intraoperative assessment of occlusion and maxillomandibular fixation is often required for exact reduction of facial fractures. Conventional oral tracheal intubation does not allow intraoperative assessment of the occlusion and maxillomandibular wiring. Most oral surgical procedures are undertaken with the nasotracheal tube in place. In certain circumstances where access to both the nose and oral cavity is required, the endotracheal tube has to be shifted intraoperatively from the nose to the oral cavity or vice versa.

Submental intubation is a procedure in which endotracheal tube is passed through a surgically created opening in submental region.

It allows free intraoperative access to the dental occlusion and the nasal pyramid. Therefore, simultaneous treatment of all the facial fractures, without interference of the tube or the need of switching tube from nasal to oral or vice versa during surgery.



Courtesy: Dr Kumar Nilesh

Fig.17.4B: (I) Submental incision, (II) Hemostat inserted intraorally to create a tunnel; (III) The pilot balloon, followed by the tracheal tube is gently pulled out through the submental tunnel; (IV) Endotracheal tube is connected to the anesthesia breathing circuit; (V) Final connection and draping

Usually, there are no additional problems in passing the tube through the floor of the mouth. Complications of submental intubation could include damage to the cuff, balloon, infection of submental wound, abscess formation in the floor of the mouth, salivary fistula, development of mucocele, and hypertrophic scarring. All these complications are relatively rare and avoidable with meticulous technique.

Technique

Orotracheal intubation with reinforced (flexometallic) endotracheal tube is done, using standard general anesthesia technique. At the start of the procedure, patient is administered 100% oxygen to buy time for submental tunneling. A 1.5 to 2 cm incision is made extraorally, in the submental region parallel and medial to the inferior border of the mandible **(Fig. 17.4B-I)**. The incision is lateral to the anterior belly of digastric muscle. Whenever possible, the right side is preferred, because it allows better visualization of the intraoral position of tracheal tube, with direct laryngoscopy. The incision is extended intraorally by blunt dissection with artery forceps, through the subcutaneous layers, mylohyoid muscle, submucosa and mucosa **(Fig. 17.4B-II and III)**. The intraoral opening is lateral to the submandibular and sublingual ducts. Thus, a "submental tunnel" is created.

The tracheal tube is briefly disconnected from the breathing circuit and the tube connector is removed from the tube. The pilot balloon, followed by the tracheal tube is gently pulled out through the submental tunnel **(Fig. 17.4B-IV)**. During this step, the endotracheal tube is stabilized intraorally manually or by Maggil's forceps. The tube connector is reattached and endotracheal tube is connected to the anesthesia breathing circuit **(Fig. 17.4B-V)**. Bilateral air entry is checked. The distance marking on the endotracheal tube at the submental skin exit point is noted.

This helps in checking the tube position intra-operatively. The tube is fixed in position with the suture. Intraorally, the tracheal tube lies in the sublingual sulcus, between the tongue and mandible. It is away from the surgical field and allows intraoperative maxillomandibular fixation. The entire procedure usually takes 5 to 10 minutes and the blood loss is minimal.



Courtesy: Dr Vidya Rattan)

Fig. 17.4C: Retromolar intubation technique. Endotracheal tube is brought out through the retromolar space. Occlusion can be achieved without any hindrance

At the end of surgical procedure, submento-endotracheal intubation is converted back to orotracheal intubation or the reinforced tube can be pulled out, through the submental tunnel also. The submental incision is closed not so tightly with interrupted skin sutures.

The intraoral incision heals secondarily, however, it is advisable to close it with 3-0 or 4-0 interrupted coated vicryl sutures.

Retromolar Intubation Technique

To avoid invasive nature and complications associated with submental intubation, the technique of retromolar intubation can be used in selected cases. It is the modified way of stabilizing the orotracheal tube, when nasoendotracheal intubation is contraindicated and there is a need to bring the teeth in occlusion to carry out temporary intermaxillary fixation with ires, perioperatively. In this technique, the flexometallic endotracheal tube is placed in the retromolar space behind the last erupted teeth **(Fig. 17.4C)**. Arora and Vidya Rattan, for the first time demonstrated that there is sufficient space in retromolar region for successful placement of the endotracheal tube in children and certain adults. (The retromolar space is the space behind the last erupted upper and lower molar teeth). The retromolar tube is stabilized in position by fixation to first or second molar tooth in "figure of eight" fashion.

In some adults, this space can be created by extracting nonfunctional third molars. Intermaxillary fixation of teeth is possible with endotracheal tube exiting through retromolar space. This technique has the potential of replacing more invasive techniques such as tracheostomy and submental intubation in some cases.

Awake Intubation

Awake intubation is indicated in certain cases, where oral opening is restricted or due to anatomical deformity, the larynx cannot be visualized, e.g. temporomandibular joint (TMJ) ankylosis, large oral cysts or tumors, marked hypoplasia of the mandible, facial deformity after burns or trauma. Patient should be explained regarding the process of awake intubation and its necessity before commencing the procedure, to gain maximum cooperation.

Drugs used for sedation during awake intubation: Agents commonly used for this purpose are those belonging to the benzodiazepine group (diazepam, midazolam), short-acting narcotics—fentanyl or the infusion of propofol. Too much deep sedation is avoided, as patient's cooperation is mandatory in awake intubation. So also, since airway difficulty is anticipated, it is necessary to maintain spontaneous breathing of the patient, till the airway is secured and the tube position is confirmed.

Airway Preparation

Optimum airway preparation is the key to a successful awake intubation. Control of secretions is therefore, of utmost importance. This will not only provide a clear field for the anesthesiologist, but also help to achieve patient cooperation.

Antisialagogue Administration

The reduction in secretions increases effectiveness of topical local anesthetic agent. The drugs used are atropine or glycopyrrolate.

Local Anesthetic Techniques

It is necessary to use topical anesthesia for the airway.

- Lignocaine 4–10% (spray or viscous gel) is used.
- Surface anesthesia to nasal mucosa is achieved by packing the ribbon gauze soaked in local anesthetic solution or with lignocaine lubricant jelly.
- Surface anesthesia of oropharyngeal and laryngeal region is achieved by gargles, spray, lozenges and ultrasonic nebulizer.
- Cricothyroid puncture is used to anesthetize the tracheal mucosa
- Regional nerve blocks used are maxillary nerve block, glossopharyngeal nerve block and superior laryngeal nerve block.

Airway preparation remains the same for all types of awake intubation.

Blind Nasotracheal Intubation

It should be performed gently, preferably with the patient breathing spontaneously. Patient should be explained the entire procedure, so that maximum cooperation can be obtained.

Blind intubation is easier to describe than to perform. Patient may be intubated either awake or asleep, without visualizing the larynx. Once the endotracheal tube is passed into the nasopharynx, the monitoring of breath sounds becomes the key for successful intubation. At each inspiratory effort, the tube should be advanced while constantly monitoring breath sounds. If advancing the tube results in loss of/or reduction in breath sounds, then the tube should be withdrawn to the point at which, the breath sounds are maximally heard. The endotracheal tube then can be turned slightly and readvanced with each inspiratory effort. Successful tracheal intubation will be detected by continuous auscultation of distant breath sounds, some resistance is encountered, as the tube passes through the vocal cords, the patient coughing.

One of the major problems with a blind nasotracheal intubation is the incidence of nasal bleeding, it can also create a false route in the posterior pharyngeal wall.

Retrograde Method (Rail-road Technique)

Provided there is access to cricothyroid membrane, retrograde method in the conscious or sedated patient, using catheters or wires may provide a simple solution, whenever there is intubation difficulty **(Figs 17.5 and 17.6)**.

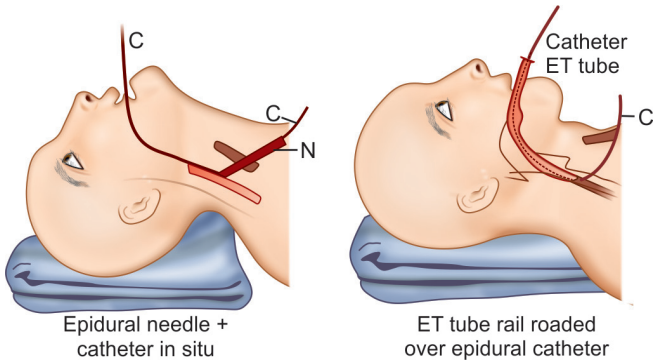


Fig. 17.5: Retrograde oral intubation technique
Abbreviations: C, catheter; N, needle; ET tube-endotracheal tube.

Fiberoptic Intubation

This is the new gold standard technique of awake intubation. Latest state of the art, fiberoptic instruments are being used with increasing frequency in anesthesia. In this technique, either a conventional rail-roading over fiberoptic scope is used or a guidewire is passed through suction channel to rail-road the tracheal tube. The greatest advantage of this method is that, it is the only method of awake intubation, where the endotracheal tube is inserted directly under vision **(Fig. 17.7A and B)**.

Basic Steps of Fiberoptic Intubation

- Keep the insertion cord straight and taut and do not form a loop
- Oxygenate through any possible route
- Push fiberoptic scope very slowly and gently to enter the oropharynx through oral or nasal route
- Identify the first landmark "the epiglottis" **(Fig. 17.4A)**
- Advance the fiberoptic scope to the laryngeal opening
- Identify the second landmark "the trachea". It is characterized by the tracheal rings of cartilage **(Fig. 17.4A)**
- Advance it down slowly till you see the third landmark, "the tracheal bifurcation" or "carina"
- Advance the endotracheal tube with a gentle rotation motion
- Remove the fiberopicscope

Verify the position and fix the endotracheal tube and connect the breathing circuit **(Table 17.1)**.

Complications Associated with Endotracheal Intubation

- Malpositioning of the tube
  - Accidental intubation of esophagus.
  - Endobronchial intubation
  - Displacement of tracheal cuff
  - Misplacement of the tube
  - Bronchial intubation
  - Laryngeal cuff position
  - Unintentional extubation/displacement of tube
- Tube malfunction

  Cuff perforation, while tube in situ
  - Obstruction of tube
  - Outside the tube-by the tube itself.

  Within the tube
  - Fire/explosion
  - Aspiration of stomach contents



Figs 17.6A to I: Steps of retrograde nasal intubation (rail-road method). (A) Inspection of the patency of the nostril; (B) Packing the nostril with roller gauze strip soaked in local anesthetic (LA) solution with adrenaline; (C) LA viscous solution pushed to achieve surface anesthesia of the pharynx; (D) Transtracheal LA injection through cricothyroid puncture; (E) Infant feeding tube being introduced through the nostril; (F) Infant feeding tube is brought out from the oral cavity, by encouraging the patient to push out the tube by tongue movements; (G) Small incision over cricothyroid membrane; (H and I) Introduction of 16 gauge Touchy's needle with sytlet in situ, in trachea

- At extubation:
  - Difficulty of impossible extubation
  - Tracheal collapse
  - Airway obstruction
  - Aspiration of stomach contents.
- Following endotracheal intubation anesthesia—early recovery phase (0–24 hours)
  - Laryngospasm
  - Negative pressure pulmonary edema
  - Sore throat
  - Damage to nerves
  - Edema/stenosis—glottic, supraglottic/subglottic/tracheal
  - Retro-arytenoids edema
  - Hoarseness and voice changes-vocal cord granuloma/paralysis
  - Vocal cord paralysis.
- Intermediate recovery phase (24 to 72 hours):
  - Infection

contd.

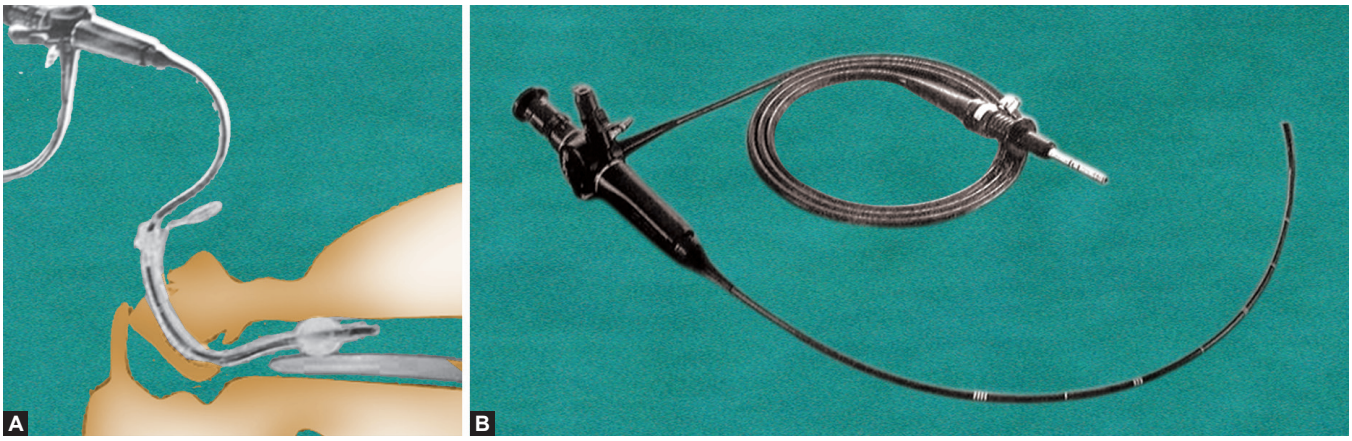


Fig.17.6 J to R: (J) Epidural catheter is being introduced through Touhy's needle, while securing the needle at the entry point; (K) Epidural catheter emerging from mouth through cricoid membrane, trachea and laryngeal aperture; (L) Epidural catheter is being threaded through the eye into the lumen of infant tube; (M) Epidural catheter is brought out through nostril from the oral cavity with the help of infant feeding tube from nostril to oral cavity; (N and O) Rail-roading of endotracheal tube over epidural catheter. Epidural catheter held taut till endotracheal tube reaches the level of cricothyroid membrane. After that, the epidural catheter has to be held loosely; (P) Successful retrograde intubation (Rail roading), and Confirmation of endotracheal tube placement, along with Monitoring the patient; (Q) Patient in the recovery room; (R) Patient extubated, but epidural catheter kept in situ (For any emergency in immediate recovery period)

- F-Late (72 hours +) recovery phase:
  - Laryngeal ulcer, granuloma and polyp
  - Synechia of vocal cords, laryngotracheal membranes and webs
  - Laryngeal fibrosis
  - Tracheal stenosis
  - Stricture of nostrils
  - Mouth and pharyngeal damage
  - Associated non-airway damage.

Complications at Endotracheal Intubation

Direct trauma: These injuries include bruised or lacerated lips and tongue, chipping of teeth or inadvertent extraction, luxation of teeth, lacerations of the pharynx, submucosal hemorrhage and tears of vocal cords. With nasal intubation, there can be trauma to the turbinates followed by epistaxis. Careful suction and packing of the nostrils, if required should be done.



Figs 17.7A and B: (A) Intubation using fiberoptic laryngoscope; (B) Fiberoptic laryngoscope

Table 17.1: Complications associated with laryngoscopy and tracheal intubation

Minor complications of short duration
• Sore throat • Lacerations of the lips or gums ,tongue,oral mucosa • Laceration of other structures within the upper airway • Chipped, fractured or dislodged teeth, • Trauma to the eyes due to laryngoscope • Nasal injury
Other potentially more serious complications
• Accelerated or irregular heartbeat, • High blood pressure,tachycardia • Hypoxia,hypercarbia • Elevated intracranial and introcular pressure, • Bronchospasm
More serious complications
• Laryngospasm • Perforation of the trachea or esophagus • Pharyngeal damage
More serious complications
• Retropharyngeal dissection • Pulmonary aspiration of gastric contents or other foreign bodies • Fracture or dislocation of the cervical spine, temporomandibular joint or arytenoid cartilages • Decreased oxygen content, elevated arterial carbon dioxide • Vocal cord weakness • Surgical emphysema of the neck and mediastinum
Nasotracheal intubation complication
• A risk of dislodgement of adenoids and potentially severe nasal bleeding
Contd...

Contd...

Unintentional and unrecognized intubation of the esophagus
• Death will ensue from cerebral and cardiac anoxia
Immediately life-threatening,
• Laryngospasm and negative pressure pulmonary edema (fluid in the lungs) • Aspiration, unrecognized esophageal intubation • Accidental disconnection or dislodgement of the tracheal tube
Severe and long-lasting or permanent complications
• Vocal cord damage • Nerve injury • Esophageal perforation • Retropharyngeal abscess

The incidence of dental complications of tracheal intubation has been quoted as 1 in 1000. Careless movement of the head may produce serious lesions such as fracture, luxation of the cervical spine with spinal cord compression or section.

Hemorrhage occurs following intubation by nasal route. Extensive hemorrhage requiring blood trans fusion may occur, if there is damage to the middle turbinate. Gentle and patient maneuver of the tube will prevent this complication. Trauma to the eye may occur by inadvertently rubbing the cornea with operator's hand or the handle of laryngoscope (ointment and cover with tape). Tearing of the mucosa lining the pyriform fossae, may lead to surgical emphysema of the neck and mediastinum, it can lead to the development of tension pneumothorax, when patient is ventilated under mask.

Nasal intubation can cause trauma to the nasopharynx and may lead to retropharyngeal abscess or mediastinitis (infection).

The risk of aspiration of stomach contents is particularly high in patients with full stomach, poorly functioning cardiac sphincter or loss of protective reflexes.

Esophageal intubation is potentially hazardous complication, if it remains undetected. The tube may be also misplaced in one of the main bronchus, preventing air exchange on the other side.

Complications During Intubation

Obstruction of the tube: Biting on the tube, if patient is in lighter planes or just before extubation. In case of recycled tubes, kinking of the tube is very common. Complete or partial blockage (inside the lumen of the tube) can result from blood clot, tissue, dried secretions, dried tube lubricants, foreign bodies, etc.

Rupture of trachea or bronchus can occur due to sharply beveled tubes or sharp tipped stylets, overinflation of the cuff, use of excessive force or repeated attempts at intubation. Ignition of the tube is a complication of laser surgery.

Complications Following Intubation

1. Sore throat is a common and benign sequelae of tracheal intubation. Damage to the hypoglossal nerve may occur due to pressure from laryngoscope blade.
2. Glottic edema may occur in supraglottic, retroarytenoid and subglottic regions. It is more common in children.
3. Hoarseness is quite common, but vocal cord paralysis is not a common sequelae.
4. Infection may occur at any point, along the route of the tube. Nasotracheal intubation can be followed by sinusitis. Treatment may require local mouthwashes to parenteral antibiotics, depending on the severity of the infection.
5. Laryngeal polyp formation due to growth of granulation tissue has a low incidence and it is not related to the type of tube, route of intubation or duration of intubation.
6. Synechia of cords, laryngotracheal membranes and webs, laryngeal fibrosis, tracheal stenosis, stricture of nostril are other complications.

Points to Remember

- Indications for tracheal intubation
- Armamentarium required for intubations
- Various types of intubation techniques-their indications
- Possible complications during and after laryngoscopy and intubation.

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Section 4

Exodontia and Minor Oral Surgical Procedures

18. Exodontia
19. Principles of Minor Oral Surgical Procedures and Transalveolar Extractions
20. Surgical Management of Impacted Teeth
21. Surgical Endodontics

CHAPTER 18 Exodontia

INTRODUCTION

Exodontia is a branch of dentistry that deals with the extraction/removal of teeth. Howe had described an ideal extraction as "the painless removal of the whole tooth/root with minimum trauma to the investing tissues (hard and soft), so that the wound heals uneventfully". Removal of a tooth does not require large amount of force, but fine and controlled force, so that the tooth is gently lifted from alveolar process and not pulled out.

TECHNIQUES OF DENTAL EXTRACTIONS

- **Intra-alveolar extraction/traditional/conventional extraction:** Removal of a tooth/root by using specially designed dental forceps and elevators. It is also known as closed method of extraction. This method cannot be used in root deformities, hypercementosis, grossly decayed crown/root, brittle tooth/root, endodontically treated tooth/root. The procedure is also termed as simple extraction.
- **Transalveolar extraction:** Carried out by planning surgical flap technique with alveolar bone removal and tooth sectioning of a tooth/root. It is known as open method for extraction or complex/complicated extraction procedure.
- **Stobie technique:** Extractions of multiple mandibular anterior teeth using dental elevator for teeth extractions.

CHALLENGING FACTORS

- Restriction by the lips and cheeks; access issue
- Movement of the tongue
- Movement of the mandible
- **Oral opening:** Adequate/inadequate
- **Communication of the oral cavity with pharynx and larynx and esophagus:** Fear of slippage and aspiration or swallowing of a tooth/root/fractured pieces
- Microorganisms present in the oral cavity, saliva flooded oral cavity
- The related structures: Floor of the mouth, tongue, hard and soft palate: possibility of injury to them
- The location and position of the tooth to be extracted.

INDICATIONS

Extraction of a tooth is one of the most common procedures carried out in a dental office. Due to the advances in endodontic and periodontic treatment modalities, the current trend is to preserve the teeth as far as possible. The extraction of teeth is usually carried out as a last resort for the therapeutic or prophylactic purpose.

Unrestorable teeth (due to anatomical or economical factors), which may be affected, due to following reasons:

- **Severe caries (49% of cases):** Endodontic treatment not possible either due to technical or economic reasons
- **Severe periodontal disease (41% of cases):** Not salvageable by periodontal therapy
- Severe attrition, abrasion, erosion
- Acute/chronic pulpitis/pulpal necrosis due to trauma/infection
- Teeth with necrosed pulp and periapical lesion not treatable by endodontic treatment
- **Over-retained deciduous teeth blocking the eruption of permanent tooth:** In case of missing permanent tooth, many times deciduous tooth is retained in a dental arch
- Supernumerary teeth
- **Malposed teeth:** Cause constant trauma to soft tissues, prone to caries due to noncleansing issue
- Impacted teeth
- **Tooth in the fracture line:** Current concept of extraction is done, only if the fractured tooth is a source of infection or root fracture or there is interference in fracture reduction or healing due to retaining such a tooth.

- **Tooth directly involved in pathology:** Cyst, tumor
- Teeth with poor prognosis in the line of therapeutic radiation, (prior to radiation course given in case of oral malignancy) to prevent osteoradionecrosis or radiation caries. Due to newer methods of radiation, the problem is less common.
- Teeth with vertical fracture or cracked tooth syndrome, which is very painful condition
- **Prophylactic extraction (tooth acting as septic focus):** endocarditis, rheumatic fever, prior to cataract surgery
- **For orthodontic treatment consideration:** Therapeutic extractions, malposed teeth, crowding, serial extractions
- **For prosthetic purpose:** Teeth interfering with stability/construction/design of full or partial denture
- **Supraerupted tooth:** Vertical extrusion of a tooth due to missing counterpart in the opposite arch
- **Teeth causing chronic trauma to the soft tissues of the oral cavity:** Constant cheek bite, ulceration on the lateral border of the tongue, etc.
- **For orthognathic surgical procedures:** Upper third molars are extracted in LeFort I osteotomy, lower third molars are extracted in sagittal split osteotomy procedure, premolars are extracted in anterior subapical osteotomy procedures.

CONTRAINDICATIONS

It is usually classified as due to systemic and local reasons: further divided as relative and absolute contraindications.

Relative contraindications suggest that the systemic or local conditions of the patient can be modified/improved by proper medication and following certain treatment protocols suggested by the physician, so that uneventful extraction procedure with proper healing is achieved.

Absolute contraindications if ignored, then simple extraction may turn into fatal or life-threatening event for the patient. Proper medical/dental history prior to extraction is a must to avoid unforeseen complications. Instructions and advice from the treating physician also helps to understand patient's emotional background along with medical condition. List of the drugs to be avoided also can be obtained from the physician by request. In high-risk patients, the relative contraindication can be considered as absolute contraindication, till the time adequate measures are taken to control the systemic or local problems. Many a times, it is found that patients with chronic systemic conditions do not undergo routine check-ups/follow-ups and carry on with self-medication for years together. (Follow the medication, which is prescribed to them many years back). This is the time to motivate them to visit the medical consultant to suggest them current medication after carrying out necessary investigations.

Systemic Contraindications

Relative Contraindications

- **Cardiovascular system (cardiac patient):** Rheumatic heart disease, coronary heart disease, unstable angina pectoris, myocardial infarction, congestive cardiac failure (CCF)
- **Blood dyscrasias:** Anemia, leukemia, agranulocytosis
- Uncontrolled diabetes
- Uncontrolled hypertension
- **Nephritis:** End-stage renal disease with severe uremia
- Toxic goiter
- Jaundice, cirrhosis of liver
- **Bleeding disorders:** Hemophilia
- Acquired coagulopathies due to anticoagulants/antiplatelet drugs
- Adrenal insufficiency
- **Neurological disorders:** Epilepsy, stroke
- **Respiratory system:** Asthma, pulmonary tuberculosis, chronic obstructive pulmonary disease (COPD), acute chest infection
- Patient on long-term corticosteroids, immunosuppressive or chemotherapeutic medications.

Physiologic Contraindications

- **Pregnancy:** First and last trimester are more crucial period. During the first 3 months of pregnancy, process of organogenesis/fetal development takes place. 3rd week to 8th week during differentiation, all the drugs should be avoided for the potential risk. All dental invasive procedures should be avoided, unless severe infection warrants the emergency treatment. 3rd trimester patient may develop supine hypotension syndrome during dental treatment in a flat position. Left lateral position will allow the venous return.
- **Extraction during menstruation period:** Painful and stressful condition along with mood swings for many women. High circulating estrogen levels may cause excessive bleeding. Not the best time to undertake extraction unless it is a must.
- **Extreme old age:** Compromised body physiology as well as fragile physical and mental conditions should be handled with utmost care.

Absolute Contraindications

- **Teeth in recent irradiated area:** Within 6 months to 1 year
- Within 6 months of myocardial infarction (after bypass surgery or stents)
- Teeth in the area of central hemangioma, arteriovenous (AV) malformation, aneurysm
- **Pregnancy:** 1st and last trimester
- **Site of malignant tumor:** Hastens metastasis.

Relative Local Contraindications

- Acute generalized periodontitis, acute necrotizing ulcerative gingivitis (ANUG)
- Acute dentoalveolar abscess, acute cellulitis
- Acute pericoronitis.

ARMAMENTARIUM USED FOR EXODONTIA

Extraction Forceps

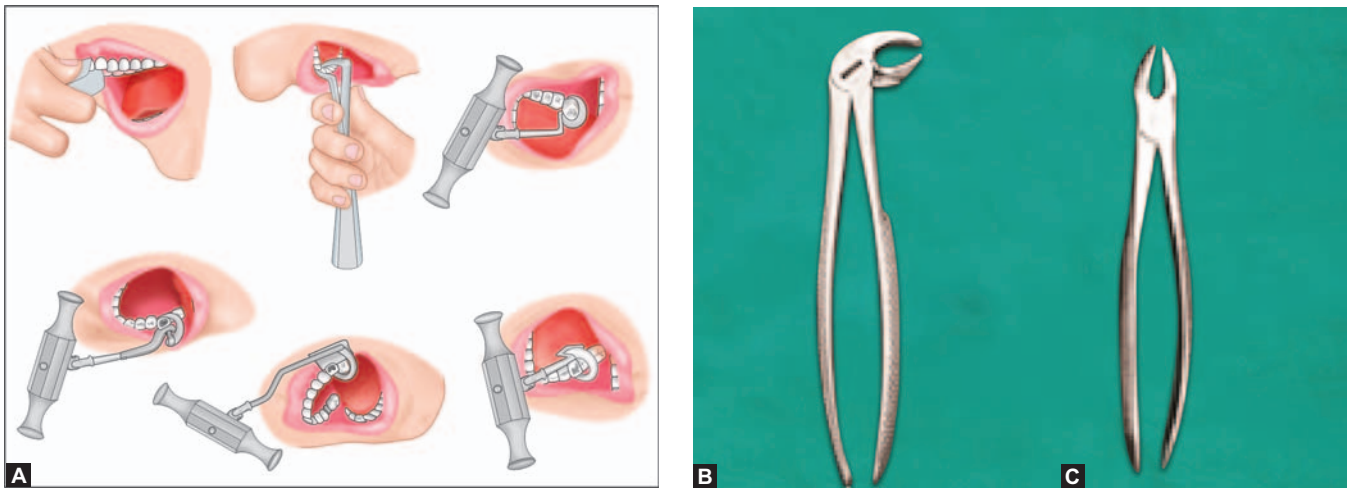
The history of dental extraction forceps goes back to 322–384 BC, at that time Aristotle introduced the dental forceps. In the 14th century, dental pelican was invented by Guy de Chauliac. Cyrus Fay, in 1426, used the dental forceps to fit the neck of the tooth. The anatomical design for the dental forceps was given by Sir John Toms in1841 and in the 20th century, the current design of forceps and elevators was developed and it is still in use till today **(Figs 18.1A to C)**.

The extraction forceps are designed to grasp and deliver the teeth from the sockets. The forceps design is based on crown shape, root shape, tooth size and location in the mouth. *Each forceps has two handles:* a hinge joint and two beaks. All the forceps have crosshatching on the handles to allow a firm grip. The handles must be of a suitable size to rest properly in the operator's palm and should be long enough for strong and steady movements of extraction. The handles may be straight or curved. The handles act as a lever, which gives mechanical advantage. If the handles are held far from the beaks, less effort is required to apply the force during extraction. The beaks of the forceps are concave or hollowed on their inner surface to fit the roots and have serrations on the inner side of the beaks to allow a better grip on the tooth. The beaks are applied along the long axis of the tooth, below the cementoenamel junction (CEJ) in mandibular teeth, and above the CEJ in the maxillary teeth. The beaks have sharp edges to cut the periodontal fibers, therefore, can be introduced easily under the free gum margin below the CEJ. The angulation for the beaks facilitates gripping the tooth at CEJ first and then below it. The beaks are also wedge-shaped to expand the alveolar crestal bone. A firm grip on the tooth is established prior to giving any forceps movements. The hinge joint allows the beaks to open, close and grasp the root. It also transfers and concentrates the forces applied to the beaks. The joint should have free movement for easy manipulation without any rolling movement.

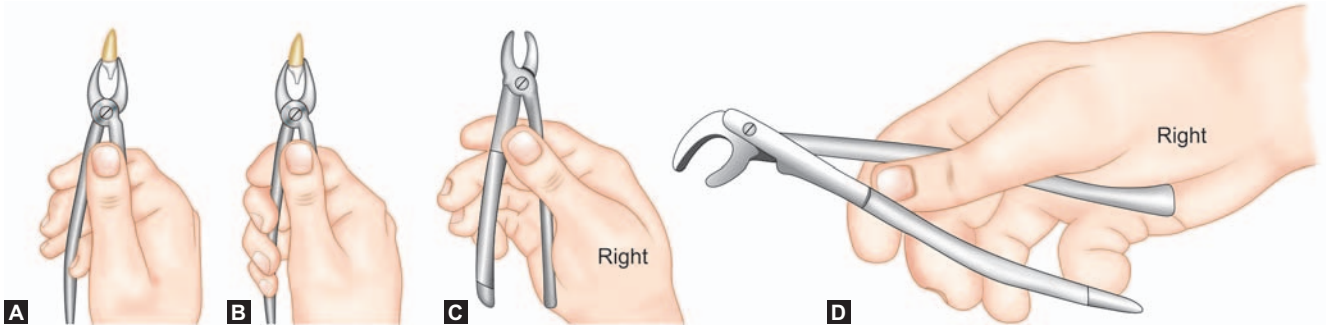
Forceps Design Styles

- **American pattern:** Hinge is directed horizontally with the handles of the forceps.
- **English pattern:** Hinge is directed vertically to the handles of the forceps.

The forceps used for maxillary and mandibular teeth differ in design.



Figs 18.1A to C: (A) Olden type of dental forceps; (B) Modern design of Lower; and (C) Upper forceps



Figs 18.2A to D: Proper holding of a forceps: (A) Initial grip on the forceps; (B) The correct grip on the forceps, after proper positioning the beaks below CE junction; (C) Right way to grip the maxillary forceps; and (D) Right way to grip the mandibular forceps

Proper Holding of the Forceps

The handles of the forceps are held differently depending on the position of the tooth to be removed. The forceps are picked up in the operator's right hand with the thumb supporting it at its joint or just below it and the forceps handles in the palm of the hand. The little finger should be inside the handle during application to the tooth and during extraction, it should be on the handle. For maxillary extractions, beaks are pointed towards superior direction, and for mandibular extractions, the beaks are pointed downwards **(Figs 18.2A to D)**.

Maxillary Extraction Forceps

In all the maxillary extraction forceps, handles and beaks are at 180° to each other, i.e. in a straight line **(Fig. 18.3)**.

- **Maxillary anterior forceps:** They have identical beaks that are closed, straight, flat and broad. The handles are straight, not curved. They are used for extraction of the maxillary incisors and the canines.
- **Basic forces:**
  - **Maxillary central incisors:** Labial movement, mesial rotation
  - **Maxillary lateral incisors:** Labiopalatal movements, removal in the labial direction
  - **Maxillary canine:** Labiopalatal movements, removal in the labial direction.
- **Maxillary premolar forceps:** They have identical beaks that are concave on the side facing the operator. The beaks are broad and open. They are used for extraction of the maxillary premolars. The curvature of the blade is to give access to the premolars placed posteriorly in the arch. Rotational and buccal movements are given for the maxillary second premolar, while only buccopalatal movements are given for the first premolar.
- **Basic forces:**
  - **First premolar:** Buccopalatal movements and removal in the buccal direction
  - **Second premolar:** Buccopalatal movements and removal in the buccal or palatal direction.

Maxillary Molars (Right and Left)

The beaks of these forceps are not identical. One beak is rounded and the other one is pointed. The pointed beak engages the groove between the buccal roots and the other beak engages the palatal surface above the CEJ. The beaks also have a curvature towards the operator, like the premolar forceps. When viewed, if the pointed beak is to the left of the operator, it is a right-sided forceps and

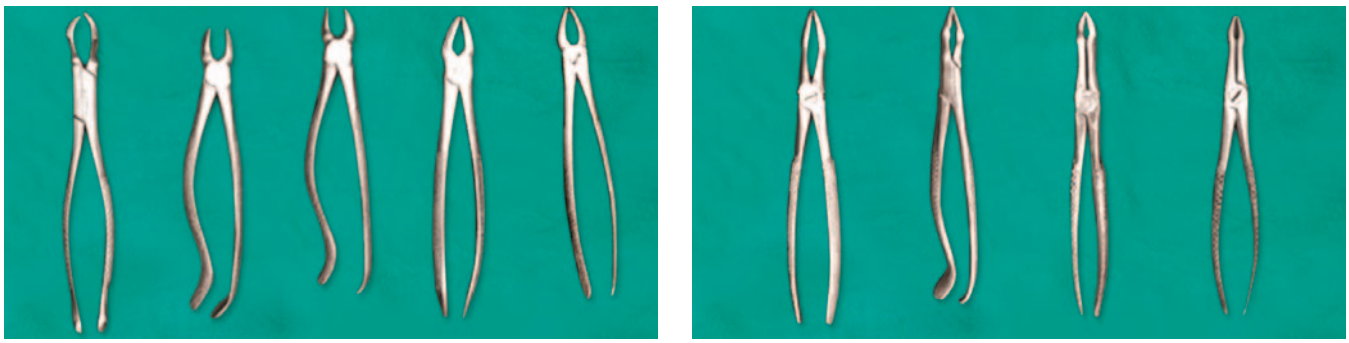


Fig. 18.3: Maxillary extraction forceps

vice-versa. The handles have concavity on the inner side and convexity on the outer side.

- **Basic forces:**
  - The first and the second molars are extracted by giving buccopalatal movements and removal in the buccal direction
  - The third molar is extracted by giving buccal movements and distal rotation.
- **Maxillary cowhorn forceps:** These forceps have unidentical beaks, one of which has a single pointed tip and the other, a bifid pointed tip (resembling horns of a cow). The single pointed tip engages the furcation between the two buccal roots and the other tip engages the palatal root. It is a paired forceps. The beaks are curved towards the operator. While viewing the concave surface of the beaks, the bifid beak will be on the right for the maxillary right-sided forceps and vice-versa. They are used for maxillary teeth, where there is extensive destruction of the crown, but the trifurcation of the roots is intact.
- **Maxillary anterior root forceps:** They have identical, straight, slender and closed beaks. They are used primarily for the extraction of the root stumps of the maxillary anterior teeth.
- **Maxillary posterior root forceps:** They are similar to the anterior root forceps, but like the premolar forceps, they have a curvature towards the operator for access posteriorly. They are used for removing single molar root pieces and premolar root stumps.
- **Bayonet forceps:** They have identical, pointed, angulated and closed beaks. The length of the beaks varies from long to short. According to the thickness of the beaks, they can be classified into thick beak and thin beak bayonet forceps. The thick beak bayonet forceps are used to remove maxillary posterior root stumps that are not separated, while the thin beak forceps are used to remove single roots.
- **Maxillary third molar forceps:** The handles are extra long and the beaks are angulated shaped, when viewed from sides.

Mandibular Forceps

They are designed such that handles and beaks are at right angle to each other to facilitate easy access to the mandibular teeth **(Fig. 18.4).**

- **Mandibular anterior forceps:** They have identical broad, short and closed beaks. The joint is a rivet joint unlike most forceps that have a box joint. They are used for extracting mandibular anterior teeth.



Fig. 18.4: Mandibular extraction forceps

- **Basic forces:**
  - **Central and lateral incisors:** Labiolingual and mesiodistal movements and removal in the labial direction
  - **Cuspid:** Labiolingual movement and removal in the labial direction.
- **Mandibular premolar forceps:** They have identical broad open beaks that are longer than the beaks of the anterior forceps. They are used for extraction of the mandibular premolar teeth.
- **Basic forces:**
  - Both the premolars are extracted with buccolingual and mesiodistal movements.
- **Mandibular molar forceps:** They have identical, broad, stout open beaks with a pointed tip. The sharp pointed tips can engage the bifurcation both at buccal and lingual surfaces. They are used for the extraction of mandibular molar teeth.
- **Basic forces:** All the molars are extracted by buccolingual movements and removal in the buccal direction.
- **Mandibular cowhorn forceps:** They have identical, open, short and pointed beaks that resemble the horns of a cow. The beaks are round and taper to a point. The forceps grips the tooth at the bifurcation between the mesial and distal roots. When pressure is applied and the beaks are closed using the buccal and the lingual plates as the fulcrum, the tooth is luxated or literally squeezed out of the socket, provided the root morphology is favorable. They are used to remove grossly carious mandibular molars with extensive destruction of the crown.

- **Mandibular root forceps:** These forceps have identical, slender beaks that are closed. The beaks are longer than that of the premolar forceps to enable the forceps to take a deep grip on the root stump. It is used for removal of root stumps of all the mandibular teeth.

INSTRUMENTS USED TO LUXATE THE TOOTH

Elevators

The dental elevators are used to luxate/elevate the teeth from the socket prior to application of the forceps. In addition to luxation of the teeth, the elevators also expand the bony socket facilitating tooth extraction. They are also used to remove root remnants from the extraction socket.

The elevator has three components: (1) handle, (2) shank and (3) blade.

1. **Handle:** This is usually large in size to facilitate a good grip on the instrument while working. It may be 180° to the shank or at right angles to the shank. The latter is known as crossbar elevators. The crossbar elevators can generate tremendous amount of force.
2. **Shank:** It connects the handle to the blade. The shank should be strong enough to withstand and transmit the forces applied to the handle.
3. **Blade:** The blade of the elevator is the working tip of the elevator, which is used to transmit forces to the tooth, root and bone.

Characteristics of Elevator

- Elevator has no joint, needs a fulcrum to work, has to be wedged between the interdental bone and the tooth. They are available in different sizes and shapes.
- Blades can vary in size and shape and depending on that the elevators are classified as:
  - Depending on the working tip shape:
    - The straight or the gouge type
    - The triangular type
    - The pick type
  - According to the use of the elevator designed to remove:
    - The entire tooth: Straight elevator hospital pattern, coupland elevator
    - The roots broken at gingival margin: Apexo elevator, coupland elevator
    - The roots broken off halfway to the apex: Curved hospital pattern, winter elevators
    - Apical third of the root
  - According to form:
  - **Straight or gouge type:** All types, wedge type, Miller, Pott elevator
  - **Curved** right and left Cryer's Apexo elevator
  - **Angulated or triangular:** Right and left Cryer or pennant type
  - **Cross bar:** Handle at right angle to the shank; winter elevators
  - **Pick type:** Crane pick, root tip pick.

Choice of Elevator

Choice of elevator will depend on the condition of the tooth to be removed and its mobility, how much tooth structure is remaining, availability and position of solid fulcrum, direction of the movement required and space available for elevation **(Fig. 18.5A to C)**.

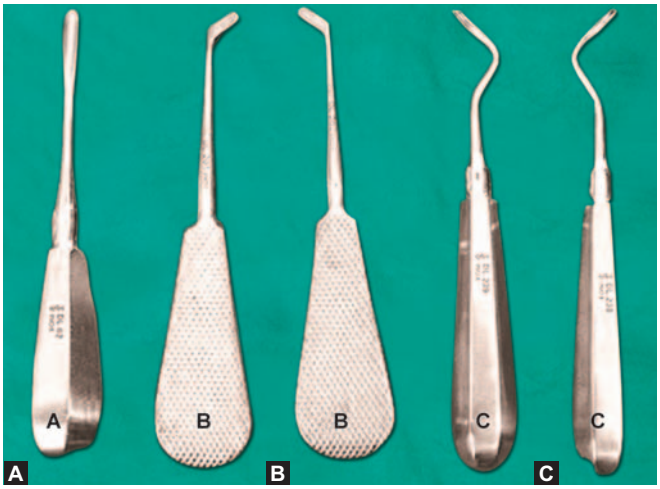
Commonly Used Elevators

Straight Elevators (Coupland, London Hospital Pattern)

They are the most common types used for the luxation of teeth. The blade has a concave surface on one side that faces the tooth to be elevated. Sometimes the blade can be at an angle to the shank, allowing the instrument to reach the posterior areas of the oral cavity easily. Common examples of these elevators are: the Miller and the Pott's elevator **(Fig. 18.5A)**.

Hockey Stick or London Hospital Elevator

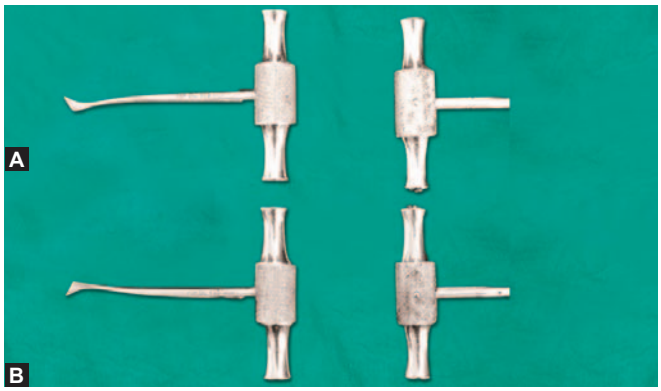
This elevator is similar to the Cryer's elevator, with the working blade at an angulation to the shank, but the blade



Figs 18.5A to C: (A) Straight elevator; (B) London hospital hockey stick pattern elevators; (C) Apexo elevators



Figs 18.6A and B: (A) Cryer's straight elevator, (B) Different tips available in Cryer's elevators



Figs 18.7A and B: (A) Winter Cryer's elevators and (B) Winter's crossbar elevators

is straight, rather than triangular, and has a convex and a flat surface. The flat surface is the working surface and has transverse serrations on it for better contact with the root stump. When viewed, the instrument looks like a Hockey stick and hence the name. The principles and functions are similar to the Cryer's elevator **(Fig. 18.5B)**.

Apexo Elevators

These are straight elevators that resemble the Cryer's elevators, but have a biangulated and sharp, straight working tip. They are paired elevators for the mesial and the distal roots. Their uses and work principles are same as for the Cryer's elevators. They can also be used to remove the maxillary root stumps **(Fig. 18.5C)**.

Cryer's Elevator

Cryer's elevator is a straight elevator with a triangular blade. The working tip is angulated, with one convex and another flat surface. The flat surface is the working side. It is based on the lever and the wedge principle **(Figs 18.6A and B)**.

Uses

- For extraction of root stump of mandibular molars when one root is removed and the other is to be removed.
- For extraction of mandibular molar root stumps when both the roots are present but one is fractured at a lower level than the other or when the bifurcation is intact.

Two separate elevators are available for the mesial and distal roots. The working blade is introduced into the empty socket and moved towards the remaining root piece. In this technique, the interradicular bone is fractured prior to removal of the root stump.

Winter's Elevator

Winter's elevator is a crossbar elevator. The shank is at right angles to the handle. The working tip is at an angle to the shank. The blade has a convex and a flat surface. The flat surface is the working surface and placed facing the tooth to be elevated. It works on the wheel and axle principle.

Uses

To luxate the mandibular molar teeth.

Winter Cryer's Elevator

As the name suggests, the elevator is a crossbar elevator with a triangular blade. The uses and the applications of this instrument are similar to the Cryer's elevator. It works on the wheel and axle and wedge principles **(Figs 18.7A and B)**.

MECHANICAL WORK PRINCIPLES OF FORCEPS AND ELEVATION

There are three work principles applicable to the dental elevators. They are:
(1) Lever principle, (2) Wedge principle, (3) Wheel and axle principle.

Lever Principle

This is the most commonly used principle. Lever is the simple machine used to lift heavy objects by exerting small amount of force. The elevator is a lever of the first order. In this, the fulcrum is located between the input effort and the output load/resistance. In order to gain mechanical advantage, the effort arm must be longer than the resistance arm **(Fig. 18.8)**.

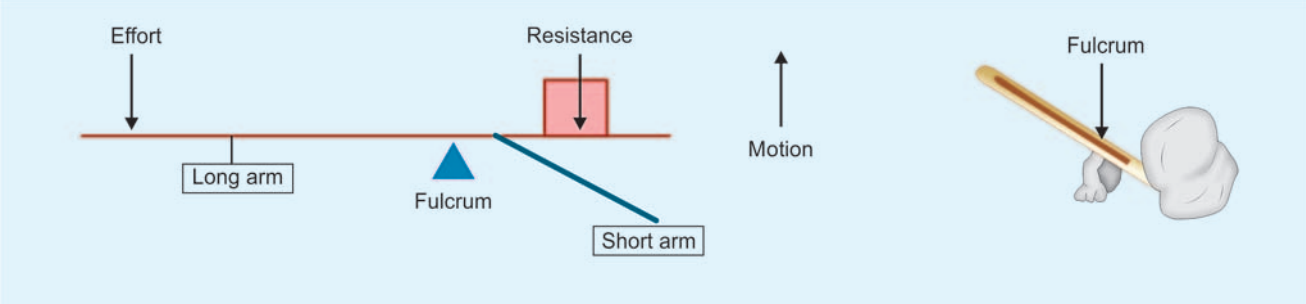


Fig. 18.8: Lever principle of elevation

- **Use of lever principle while using forceps:** While extracting a tooth, controlled force is delivered in a predetermined direction. The effort or power is represented by handles of the forceps, and the resistance or weight is represented by the beaks. Fulcrum is at the hinge joint.
- **Use of lever principle while using elevators:** This principle is also used when elevators are used, where modest force is transmitted at long power arm or the handle, so that the mechanical advantage is derived at the short-weight arm, i.e. the working end/blade, which engages the tooth, e.g. coupland elevator. Maximum mechanical advantage is gained in using elevator is by keeping the effort arm longer than the resistant arm.

Wedge Principle

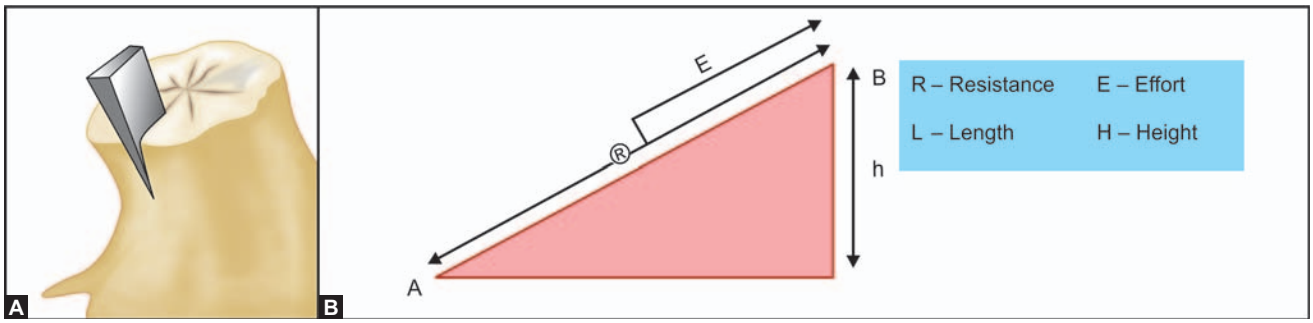
It consists of two movable inclined planes, which meet and form a sharp angle. The wedge is a movable inclined plane which overcomes a large resistance at right angles to the applied effort. The effort is applied to the base of the plane and the resistance has its effect on the slant side. It is usually used in conjunction with the lever principle. It is an established physics principle that a wedge can be used to split, expand or displace the portion of a substance that receives force. The sharper the angle of the wedge, the less effort is required to overcome the resistance. Mechanical advantage of wedge is 2.5. The mechanical advantage is calculated by dividing the length of the slope by the wedge's width **(Figs 18.9A and B)**.

The wedge elevator is forced between the root and the bone, parallel to the long-axis of the tooth. A small Apexo or Warwick James elevator can displace the roots towards the occlusal plane out of socket, similarly a straight elevator is applied between the tooth and interdental bone to separate the periodontal ligament attachment **(Figs 18.10A and B)**.

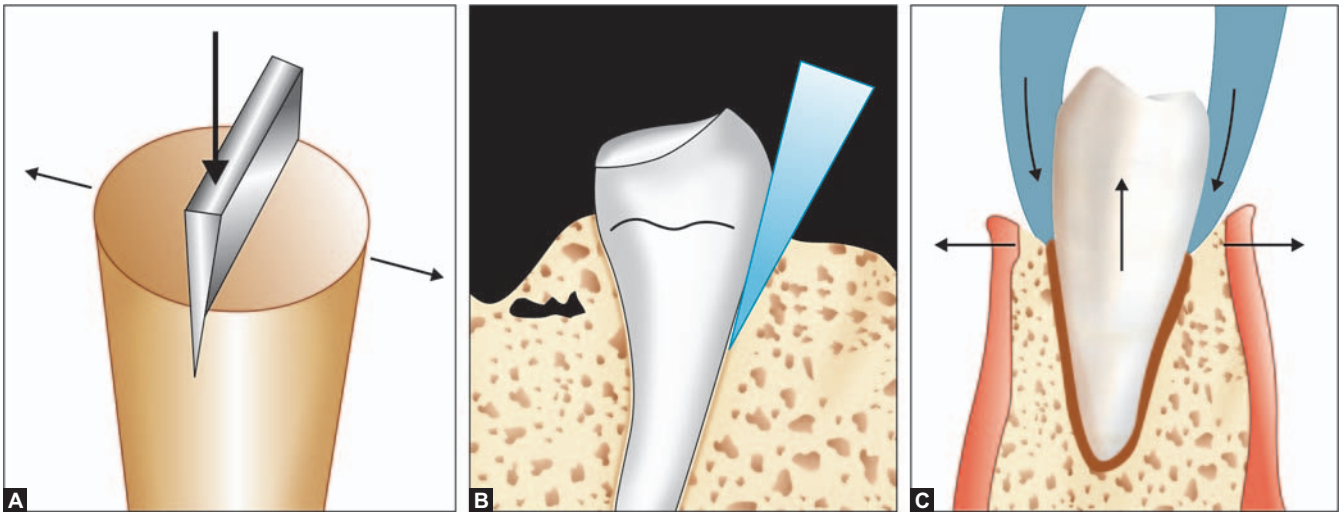
The dental forceps also take the advantage of this principle. The narrow tip is first introduced below CEJ and the broader portion of the beak is gradually inserted further by expanding the bone **(Fig. 18.10C)**.

Wheel and Axle Principle

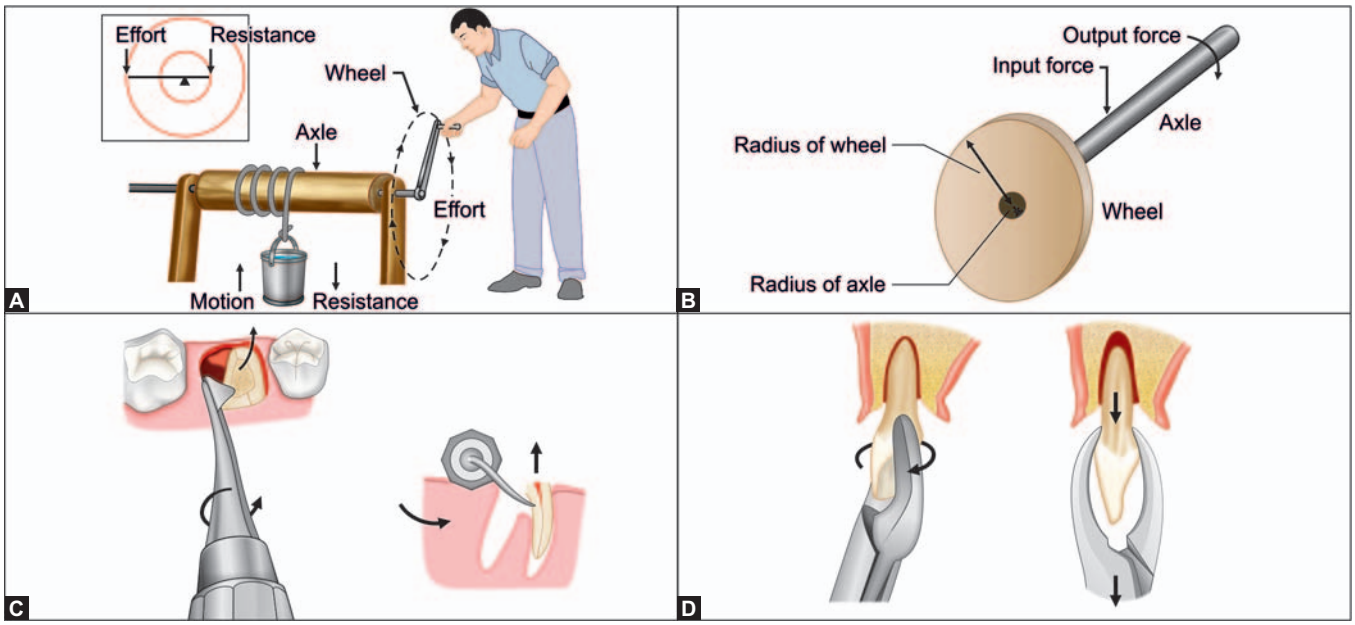
The mechanical device consists of a wheel attached to an axle or central pole, where torque is applied to the wheel winds a rope or chain onto the axle. The wheel and axle principle is actually a modified form of lever principle, but it can move a load farther than a lever can. A light force applied to a crank handle onto the side of a wheel creates a torque about the axle centerline (the fulcrum) to lift a heavy load. The effort is applied to



Figs 18.9A and B: Mechanical advantage using wedge principle to split, expand or displace the substance



Figs 18.10A to C: Wedge principle applied during use of: (A and B) Elevator; (C) Forceps beaks to expand the crestal alveolar bone

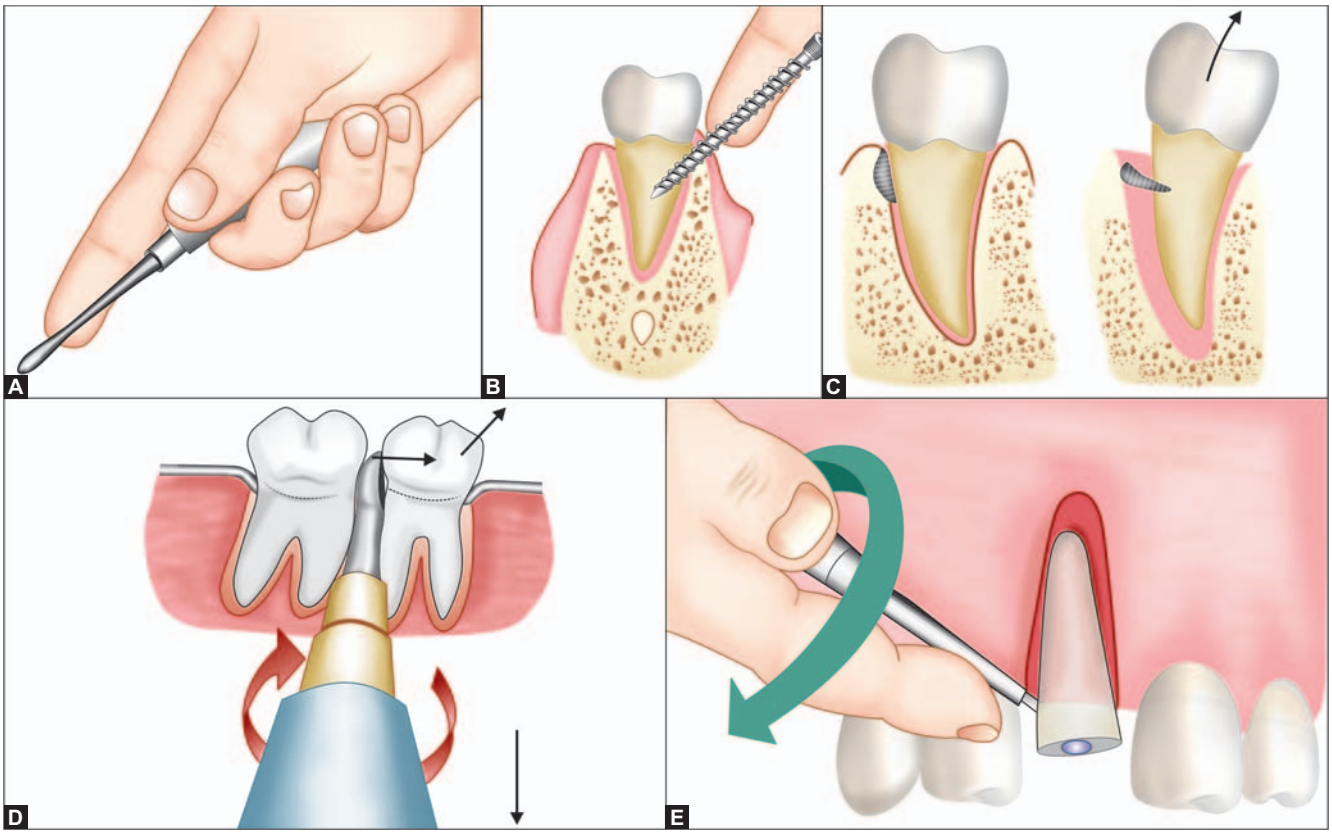


Figs 18.11A to D: (A and B) Mechanical principle of wheel and axle to gain advantage and (C and D) Clinical application of wheel and axle principle by using: (C) Cryer elevator; (D) Maxillary forceps

circumference of a wheel, which turns the axle so as to raise a weight. Greater the diameter of the wheel, more is the mechanical advantage. This principle is used with wedge and sometimes with the lever principle **(Figs 18.11A and B)**.

The principle is applicable to the crossbar and Cryer's elevators, where mechanical advantage is 4.6. The working tip of the crossbar is introduced deep into the space between the bone and the root and handle is rotated in an arc (wheel) to remove the root. When the handle is rotated, the force created on the blade is multiplied creating greater mechanical advantage to elevate the root out of socket **(Fig. 18.11C)**.

To remove the tooth using forceps, it engages labial/buccal and lingual/palatal aspects of a tooth and then force is applied in the form of an arc to the handles, which results in the rotation of a tooth in the socket, making it loose **(Fig. 18.11D)**.



Figs 18.12A to E: Handling application of elevator: (A and B) Proper grip of the elevator; (C to E) Rotation of elevator around its long-axis

Indications for the Use of Elevators

- To luxate multirooted teeth prior to the forceps application.
- To luxate, remove teeth that cannot be engaged by the beaks of the forceps, e.g. impacted teeth, malposed teeth, badly carious teeth, firm teeth.
- To remove fractured root stumps, apical tips.

Rules to be Followed While Using the Elevators

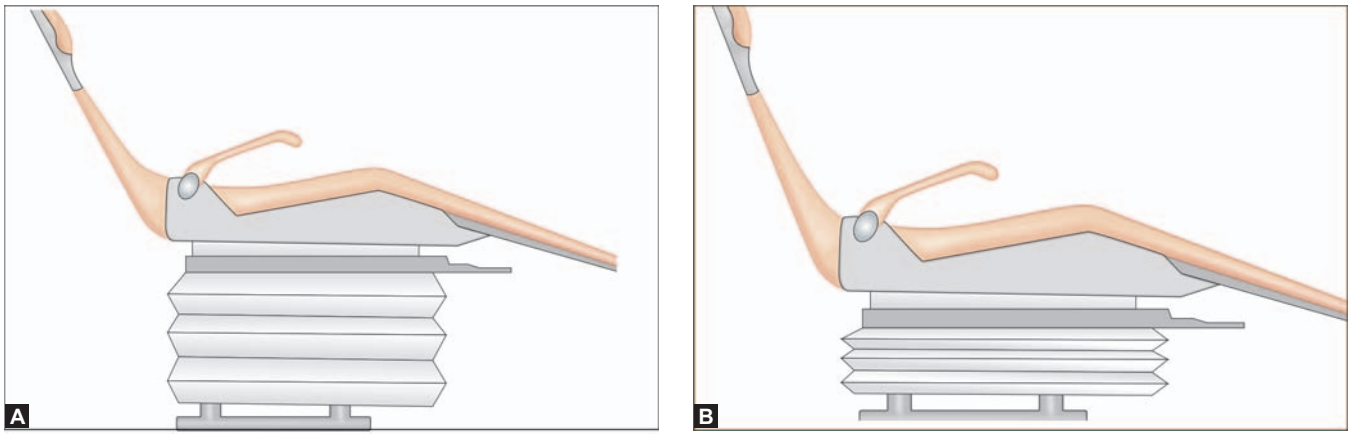
- Hold the elevator with palm grip **(Figs 18.12A to E)**.
- Never use the adjacent tooth as the fulcrum, unless that the adjacent tooth is also to be extracted.
- Never use the buccal or lingual plate as the fulcrum.
- Always use finger guards to protect the soft tissues if the elevator slips.
- Support the shank of the elevator with the index finger to control the forces applied to the elevator.
- Always elevate from the mesial side of the tooth.
- The concave or flat surface of the elevator faces the tooth/root to be elevated, follow the root curvature.

Danger of Elevators

- Loosening/extracting adjacent tooth
- Fracture of alveolar process or mandible
- Penetrating into maxillary sinus or pushing the root into it
- Damage to the soft tissue elsewhere due to slipping of elevator tip
- Forcing the root in lingual pouch after breaking the lingual plate.

Preparation of the Patient Prior to Extraction

- Proper medical and dental history of the patient
- **Medication prior to extraction:** Antibiotics, analgesics/anti-inflammatory
- **Clinical evaluation:** Intraoral thorough examination; for access, mobility, crown condition
- **Radiological examination:** Relation to vital structures, configuration of roots, condition of the investing bone.



Figs 18.13A and B: Adjusting the height of a dental chair for extraction of a tooth: Height adjusted for (A) Maxillary teeth extraction and (B) Mandibular teeth extraction

Basic Requirements for Carrying Out Dental Extraction

- A good radiograph
- Adequate anesthesia: Local, local with sedation or general anesthesia
- Proper instruments
- Adequate illumination
- Efficient assistance
- Good suction apparatus
- Proper position of dental chair, specific to the tooth, which is to be extracted
- Proper position of a patient
- Proper position of the operator
- Selection of proper dental forceps/elevators
- Proper different extraction movements.

Proper position of dental chair, specific to the tooth, which is to be extracted

Best chair position is the position, which is the most comfortable for the patient as well as for the operators and assistant.

Angulation of the Dental Chair

- **For maxillary teeth:** Chair is tilted backwards and maxillary occlusal plane is adjusted to 45–60° to the floor, when the mouth is fully opened.
- **For mandibular teeth:** Chair is made straight and mandibular occlusal plane with mouth open, is adjusted parallel to the floor or 10° to the floor.

Height of the Dental Chair

- **For maxillary teeth extraction:** Occlusal level should be 8 cm/3-inches below the shoulder level of the operator
- **For mandibular teeth:** 16 cm/6-inches below the elbow of the operator **(Figs 18.13A and B).**

Height of the patient's mouth is at or slightly below the operator's elbow and operator's arms are inclined downward at an angle of 120° at elbow.

Position of the Patient

Patient should be seated comfortably in a dental chair with proper adjustment of the head rest. Patient's head, neck and trunk should be in one line.

For the extraction in the maxillary and mandibular right and left quadrants, patient's head is turned towards the operator. For maxillary and mandibular anterior extractions, patient should be looking straight.

Position of the Operator

Operator will generally stand on right side of the patient. He has to stand erect with equal distribution of body weight on both the feet. He should keep the arms close to the body, which gives support and stability and this posture allows the straight wrist position. Force delivery during extraction should be given with arm and shoulder and not with the wrist or hand pressure.

Operator should stand in front and slightly on the right side for all teeth extractions, except right mandibular molar teeth. He should stand behind at 11 o'clock position for right mandibular molar extraction. This arrangement is for right-handed operators, and the reverse for left-handed operators. Mandibular anterior extractions can be done with operator standing in front of the patient at 8 o'clock position. Some operators prefer to approach the mandible from behind the patient; in that case the left hand goes around the patient's head and supports the lower jaw.

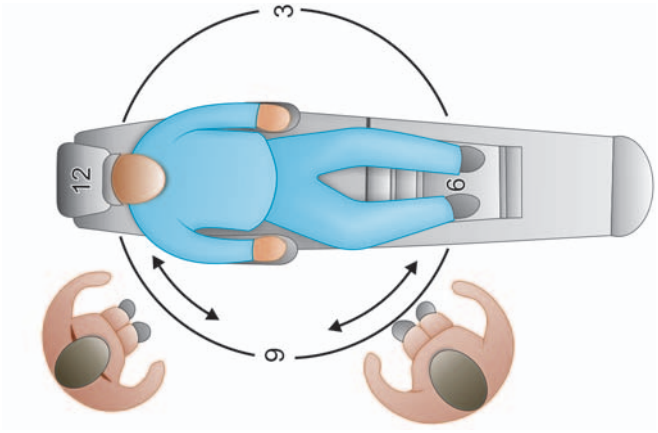


Fig. 18.14: Position of the operator for various extraction rocedures

If the operator chooses to sit and work, then the patient is at more lower level than standing position and other positions will remain similar **(Fig. 18.14 and Table 18.1).**

Role of Nondominant (Left) Hand

- Reflection/retraction of cheek, lip, tongue
- Protection of other teeth and soft tissue
- Stabilization of patient's head, supporting/stabilizing mandible, alveolar bone
- Gaining the tactile sensation/information during the procedure
- Deliver the whole tooth/root/dislodged filling, etc.
- Reposition the uncooperative patient
- Compress the extraction socket.

For the extraction of left maxillary teeth, the left thumb supports the palatal alveolar bone and index finger retracts the buccal tissues, while for right upper teeth, left hand thumb retracts the buccal tissues and index finger supports the palatal alveolar bone. In left-handed person, there will be reverse order. For lower left teeth extractions, the left thumb supports the mandible and index finger retracts the buccal soft tissues, middle finger controls the tongue. For lower right teeth extractions, left hand index finger retracts the buccal tissues, left thumb controls the tongue and other fingers support the mandible. Reverse positions of the fingers and thumb for left-handed person.

Table 18.1: Position of the operator for various extraction procedures

Extraction procedures	*Position of the operator*
For all maxillary teeth, anterior mandibular teeth and teeth of the 3rd quadrant	The operator is to the front and right of the patient
For left-handed operator to the left	
For the teeth in the 4th quadrant	The operator stands behind and to the right of the patient
For left-handed operator, to the left	

Role of Assistant

- Helps operator to gain access and visualize the field by retracting lip, cheek, tongue, etc.
- Suctions the excess blood, saliva, irrigation fluid to keep the field clean
- Supports/stabilizes head/mandible.

Requirements for Closed Extractions

- Adequate access and visibility: Good illumination via light source
- Unimpeded pathway of removal of a tooth
- Use of controlled force to luxate and extract the tooth.

Operator's Preparation

Operator should take universal precautions for prevention of transmission of infection.

Patient's Preparation

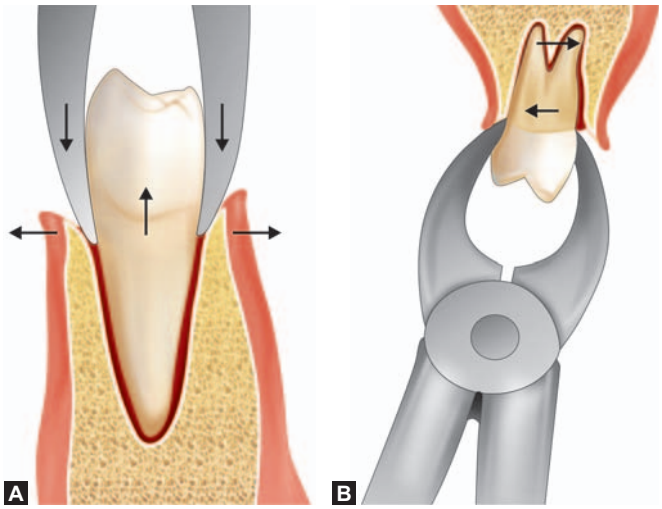
- Sterile disposable drape should be used
- Proper oral hygiene instructions should be followed by the patient
- Gross scaling should be carried out prior to extraction, if indicated
- Oral antiseptic mouthwash rinses are advised.

Clinical Procedure for Intra-alveolar/Simple Extraction of a Tooth

- Positioning of the patient
- Administration of local anesthesia
- Separation of soft-tissue attachments from the tooth
- Adaptation of forceps to the tooth
- Luxation of the tooth by elevator or forceps
- Removal or extraction of a tooth.

Common Technique Carried Out by Using Dental Forceps and Elevators

- Applying displacing force to a tooth:
  - Direct application of a forceps: Alveolar purchase
  - Indirect via a fulcrum: Use of elevators
- Expansion of socket: Wedging by forceps beaks
- Forceps beaks should be held parallel to the long-axis of the root, below the CEJ



Figs 18.15A and B: Severing the soft-tissue attachment around the tooth to be extracted prior to introducing the beaks of forceps

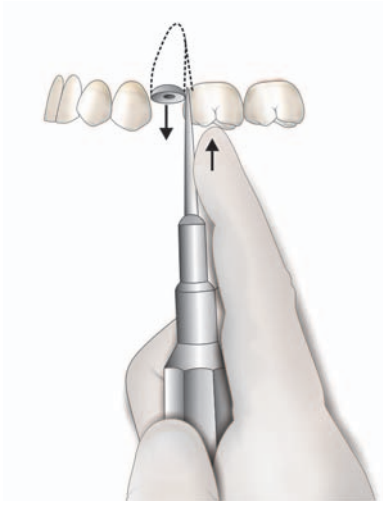
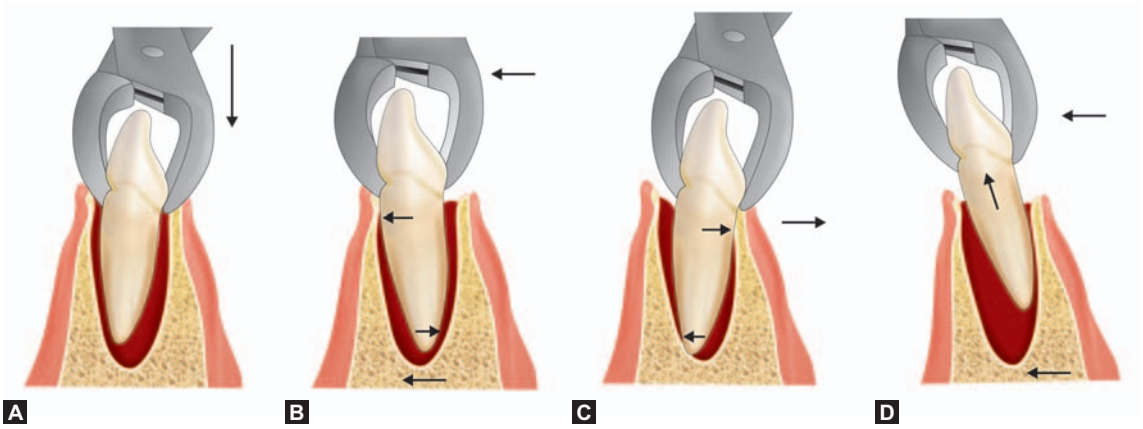


Fig. 18.16: Luxation of a tooth using elevator

- Traction should be given towards the least resistance: Consider the thickness of buccal/lingual cortical plates.

STEPS TO CARRY OUT SIMPLE EXTRACTION

- **Step 1 (severing/loosening the soft-tissue attachment around the tooth):** Separating the tooth from the alveolar bone along with crestal and principal periodontal fibers, and gingival papilla is carried out by using moon's probe or specially designed straight or curved desmotome or periosteal elevator. It also helps to assess the depth of local anesthesia. It also allows the extraction forceps to be placed more apically without impingement on the gingiva. The pointed end of the instrument is used in a prying motion to elevate dental papillae between the teeth or attached gingiva around the tooth **(Figs 18.15A and B).**
- **Step 2 [luxation of tooth with a dental elevator (optional step)]:** Usually straight elevator is used, which is inserted perpendicular to the tooth into the interdental space after reflection of interdental papilla. Slow strong, forceful turning of the elevator is carried out with inferior portion of the blade resting on alveolar bone and superior portion of the blade is turned towards the tooth to be extracted. This will result in some amount of alveolar expansion and tearing of the periodontal ligament and tooth will move in the posterior direction **(Fig. 18.16)**.
- **Step 3 (adaptation/application of the forceps to the tooth):**
  - **Expansion of bony socket:** Bone is relatively elastic, so it is possible to expand the bony socket by inserting the beaks of the forceps below CEJ over the root. The beaks act as wedges to dilate the crestal bone on the buccal and lingual side.
  - **Rules to be followed:** Proper selection of a dental forceps is a must. After placing the left hand in position, the clear view of the tooth is obtained. Tips of the forceps beaks are inserted parallel to the long-axis. Lingual beak is inserted first and then buccal beak. Forceps beaks must be placed on root surface as far apically as possible and not on the crown. The root is grasped with firm, steady grip. The handles of the forceps are grasped at the ends to gain maximum mechanical advantage. A controlled force is applied with the wrist locked and arm held against the body, the operator is ready to apply force with the shoulder and upper arm without any wrist pressure.
- **Step 4 [major movements of forceps for luxation of a tooth (Figs 18.17A to D)]:**
  - **Apical pressure/force during introduction of dental forceps:** This is the first force generated, by giving a firm vertical pressure up and down the long-axis of the tooth. The beaks of the forceps are forced into periodontal ligament space, the center of rotation is moved apically, which results in greater movement of forces at the crest of the ridge



Figs 18.17A to D: Major movement of a forceps for luxation of a tooth: (A) Apical force application; (B) Buccal or labial movement; (C) Lingual movement; and (D) Fully luxated tooth in the socket

and less force is directed towards the apex. This decreases the chance of apical root fracture.

- **Labial/buccal pressure:** It produces expansion of the buccal cortical plate at crest and offers simultaneous lingual apical pressure.
- **Lingual/palatal pressure:** It expands the lingual cortical plate and offers buccal apical pressure with expansion.
- **Tips:** The major portion of the force is directed towards the thinnest/weakest bone. Thus in maxilla and all teeth in the mandible, except lower molars, the major movement is labial/buccal. First the pressure is always applied on less accessible side of the tooth, in case of cervical caries, first movement is directed towards carious portion. The next movement is then towards the opposite direction with slow, deliberate, strong pressure. Buccal and lingual pressure will continue to expand the alveolar socket. Considerable force is used in upper jaw, while in lower jaw, this must be limited to that the operator can counteract by supporting the mandible with left hand.
- **Rotational pressure:** Figure of 8 is used by using wheel and axle principle for the teeth with single/conical root. Internal expansion of the socket is achieved by rotational force **(Figs 18.18A and B)**.

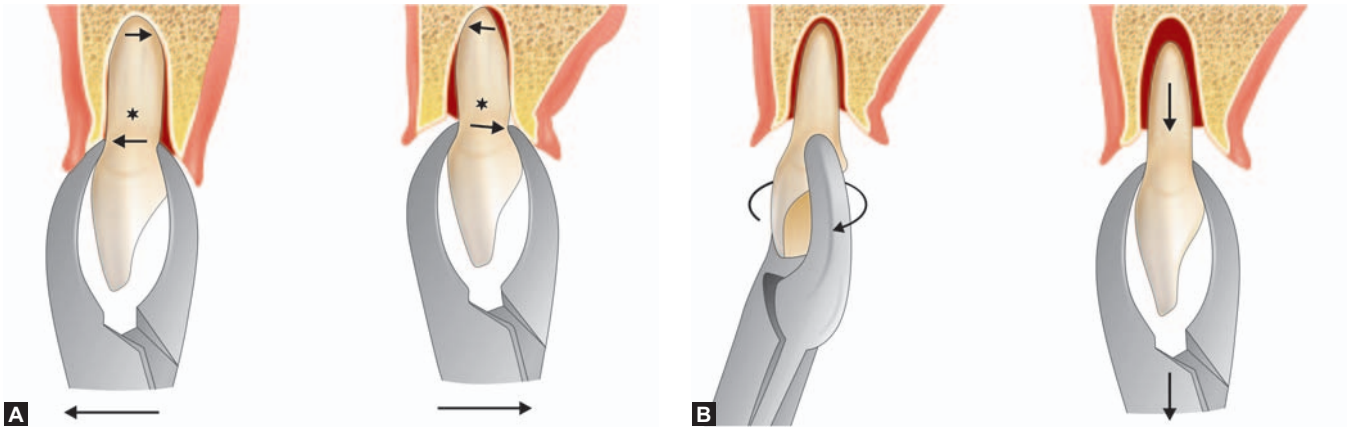
- **Step 5 (removal of a tooth from the socket):**
  - Tractional force is used for final delivery of the tooth out of socket, so it should be as gentle as possible **(Figs 18.18A and B)**.
  - The operator should use different movements for different teeth extractions as described earlier in dental forceps write up. When the tooth is luxated enough, the major portion of the force should be directed towards the thinnest cortex and tooth is lifted up gently from the alveolar socket.
  - Tractional force is the last movement after the sufficient expansion.
- **Step 6:** Compression of the socket is carried out.

REASONS FOR BREAKAGE OF A TOOTH/ INCOMPLETE REMOVAL OF A TOOTH

- Wrong selection of a forceps
- Faulty grip of the forceps/elevator
- Excessive jerky or inadequate extraction movements
- Gripping of a crown instead of root
- Uncooperative patient.

COMPLICATIONS OF TOOTH EXTRACTION

- **Intraoperative complications (immediate):**
  - Failure to luxate/remove the tooth
  - Fracture of a tooth, alveolus, mandible, maxillary tuberosity
  - Mucosal laceration/puncture wounds on gums, lips, tongue, floor of the mouth
  - Luxation/removal of adjacent tooth
  - Displacement of root/tooth in facial space, maxillary sinus, lingual pouch
  - Aspiration of a tooth/root
  - Nerve injury
  - Hemorrhage-primary
  - Temporomandibular joint (TMJ) dislocation/subluxation



Figs 18.18A and B: Sequence of movements of forceps ending in rotational movements and finally removal of a tooth from the socket by tractional force

- **Postoperative (delayed complications):**
  - Hemorrhage: Reactionary, secondary
  - Pain
  - Dry socket: Alveolar osteitis
  - Postoperative edema/swelling
  - Hematoma/ecchymosis
  - Infection
  - Trismus
- **Late complications:**
  - Chronic osteomyelitis/osteoradionecrosis
  - Nerve damage: Anesthesia/paresthesia
  - Chronic pain
- **Systemic complications:**
  - Syncope, fits, respiratory obstruction, hyperventilation, myocardial infarction, etc.
  - Management of complications is given in appendix 1 at the end of the book.

POST-EXTRACTION CARE

- Inspect the socket: Remove the debris/bone/tooth fragments
- Irrigate the site with saline
- Compress the alveolar bone with firm finger pressure
- Curette out the granulation tissue from the socket and excess granulation tissue around gingival cuff
- Trim/smoothen any sharp edges from alveolar margin with bone file
- Ensure hemostasis
- Suture, if required
- Medication: Antibiotics/analgesics.

Instructions to the Patient

- Moist pressure pack to be held with gentle pressure for at least 30 minutes
- No spitting/gargling/smoking
- Avoid hot food/alcohol for at least 24 hours
- Liquid/semisolid/soft diet.

Points to Remember

- Techniques of dental extractions
- Indications and contraindications for dental extractions
- Armamentarium used for exodontias
- Mechanical work principles for the use of forceps and elevators
- Procedure for dental extracton
- Complications.

CHAPTER 19 Principles of Minor Oral Surgical Procedures and Transalveolar Extractions

INTRODUCTION

The first dictum of medicine and surgery is "Primum Non Nocere: first do no harm". Minor oral surgery comprises of those surgical procedures, which can be comfortably completed by a dentist in not more than 30 minutes. Minor surgical procedures will include carrying out complicated surgical extractions (combination of tooth sectioning, mucoperiosteal flap reflection, bone removal prior to the use of a forceps or elevators), elimination of small lesions in the oral cavity, which are in the hard or soft tissues.

BASIC PURPOSE OF SURGERY

The basic purpose of any surgery is as follows:

- Elimination of disease
- Prevention of disease
- Removal of damaged or redundant tissue
- Improvement of function and esthetics.

PRINCIPLES OF ORAL SURGERY

- Developing a surgical diagnosis
- Basic necessities for surgery
- Aseptic technique
- Incision planning
- Flap design
- Tissue handling
- Hemostasis
- Dead space management
- Decontamination and debridement
- Suturing
- Edema control
- Postoperative infection control
- Patient's general health and nutrition
- Follow-up.

Developing a Surgical Diagnosis

The decision to perform a surgery depends upon the several diagnostic steps. Before undertaking the surgery, the clinician should perform following steps:

- First identify the clinical problem
- Carry out thorough logical reasoning and use the available data
- Establish the relationship between the individual problems
- Obtain the presurgical evaluation data:
  - Patient's physical, laboratory and imaging examination data
  - Possible etiological factors for the lesion development
  - The thorough history of lesion.

Clinical Characteristics of Lesion

- Location
- Shape
- Sharpness of boundaries
- Color
- Consistency
- Texture
- Mobility or fixation
- Local induration or inflammation
- Erosion or ulceration
- Pulsation
- Fluctuation
- Regional lymphadenopathy
- Radiological changes.

The oral cavity is an excellent barometer of general systemic health. Oral abnormalities can be extensions or manifestations of underlying systemic disease. Therefore, the surgical decision should be undertaken after ruling out systemic problems.

History of Lesion

- Chief complaint—pain, edema, swelling, regional lymphadenopathy, decreased sensation (hypoesthesia) and altered sensation (paresthesia)
- Duration of the lesion
- Change in any senses—taste, smell, hearing, vision
- Change in size, degree of fluctuation, erythema, erosion, etc.

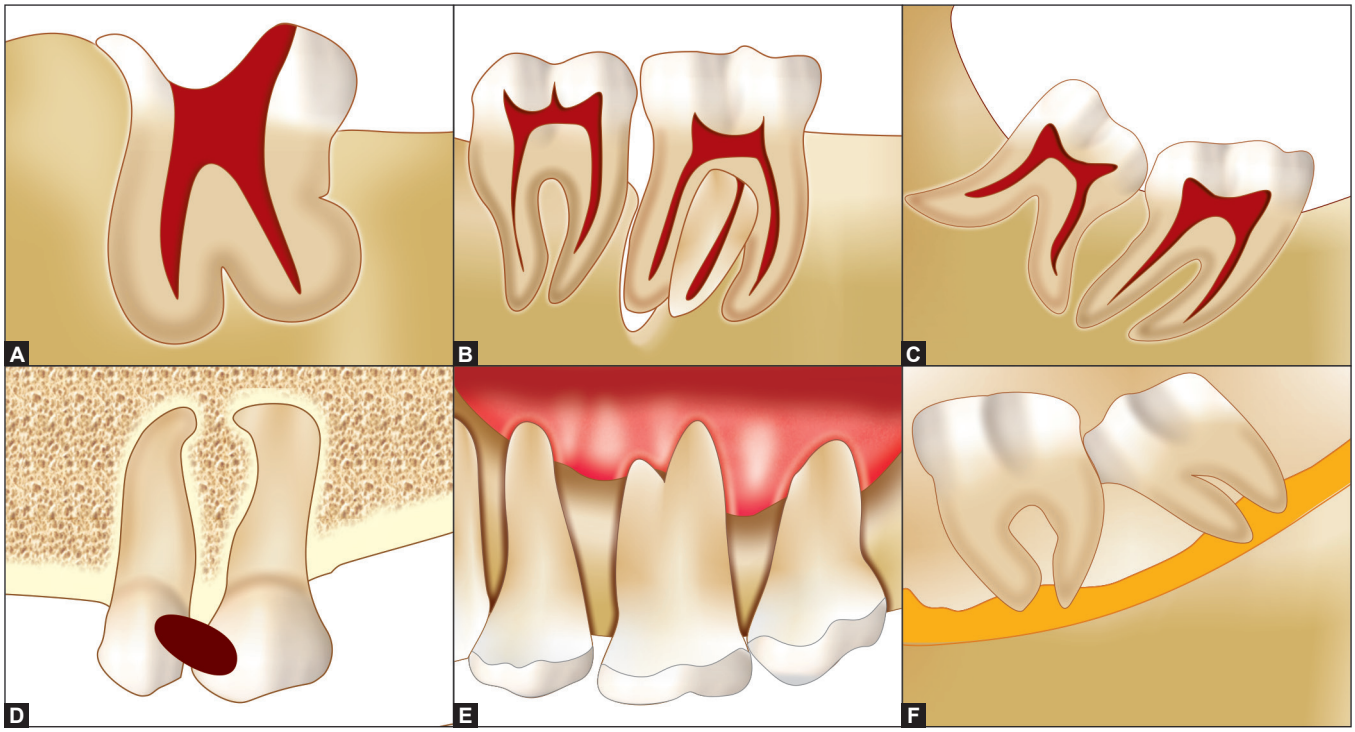
Transalveolar Extraction (Open or Surgical Extraction)

Transalveolar extraction is the method used for recovering the roots that are fractured during routine extraction of teeth (routine closed extraction method) for a variety of reasons. It consists of removal of some amount of the bone investing the roots, if required, and using the forceps or elevators to deliver a tooth/root.

- **Indications for transalveolar surgical extraction:**
  - Any tooth, which offers a lot of resistance for elevation technique
  - Retained roots, which cannot be grasped by the forceps or delivered with an elevation technique
  - Previous history of difficult or attempted and failed extraction technique
  - Any large restoration with root canal therapy—brittle teeth
  - Hypercementosis/ankylosis of a tooth
  - Geminated/dilacerated tooth
  - Radiographic evidence of complicated/difficult root pattern or roots with unfavorable or conflicting lines of withdrawal
  - Sclerosis of the bone
  - Teeth associated with pathology—periapical granuloma, cyst, tumor, etc.
  - Impacted teeth, embedded teeth.
- **Pre-extraction clinical assessment:**
  - Presence of infection
  - Access to the tooth:
    - Oral opening of the patient—adequate
    - Restricted—due to trismus, temporomandibular joint (TMJ) disorders, muscle fibrosis, oral submucous fibrosis, etc.
  - Hypomobility of the tooth—hypercementosis, ankylosis
  - **Condition of the crown:**
    - Marked attrition—usually with calcified pulp chamber, brittle tooth
    - Presence of extensive caries, large restorations of the tooth to be extracted and adjacent tooth.
    - Previous history of endodontic treatment
  - **Tooth alignment in the arch:**
  - **Presence of fixed or removable** prosthesis
  - **Age of the patient**—old age—sclerosis of bone
  - Embedded roots.
- **Indications for preoperative radiographs:**
  - History of difficult or attempted, failed extraction
  - A tooth which is abnormally resistant to elevation or forceps extraction (hypercementosis, ankylosis, dilacerated roots, extra long roots, curved roots)
  - Any teeth or roots in close relationship to either the maxillary sinus or inferior dental canal or mental nerve
  - Any teeth with history of trauma (fractured crown or roots or alveolar bone)
  - Any partially erupted, unerupted tooth, missing tooth, supernumerary tooth, retained root, lingually placed tooth, impacted tooth
  - Heavily restored tooth or pulpless tooth—brittle, possible presence of periapical pathology
  - Any condition, which predisposes to dental or alveolar abnormalities, like: osteitis deformans (hypercementosis of the roots), osteoradionecrosis, osteopetrosis, etc.

Pre-extraction Radiological Evaluation

- Relationship with associated vital structures:
  - Maxillary sinus **(Figs. 19.1A to F)**
  - Inferior alveolar canal
  - Mental nerve
  - Adjacent teeth roots.
- Configuration of roots:
  - Number of roots
  - Width—greater below cementoenamel junction (CEJ) than at the CEJ
  - Size of roots
  - Curvature of roots, divergence of roots
  - Length—thin, tapered roots
  - Resorption of roots
  - Shape of the individual root
  - Hypercementosis, ankylosis, root caries/root resorption
  - Previous endodontic therapy.
- Condition of surrounding bone:
  - Density of bone surrounding the tooth
  - Dense bone—condensing osteitis, sclerosis will increase the difficulty.



Figs 19.1A to F: Preoperative radiograph is helpful to detect these conditions: (A) Hypercementosis; (B) Extra-roots; (C) Dilacerated roots; (D) Curved, long root; (E) Roots in the maxillary sinus and (F) Approximity to the inferior alveolar nerve

Multiple Extractions

Single sitting procedure for multiple adjacent teeth with slight modification of routine extraction pattern facilitates a smooth transition from a dentulous to an edentulous state:

- Soft tissue reflection is extended slightly to form a small envelop flap, exposing a crestal bone prior to extractions
- After extractions, the ridge is checked for any sharp bony spicules or undercuts
- Alveolectomy/plasty—suturing.

Order of Multiple Teeth Extractions

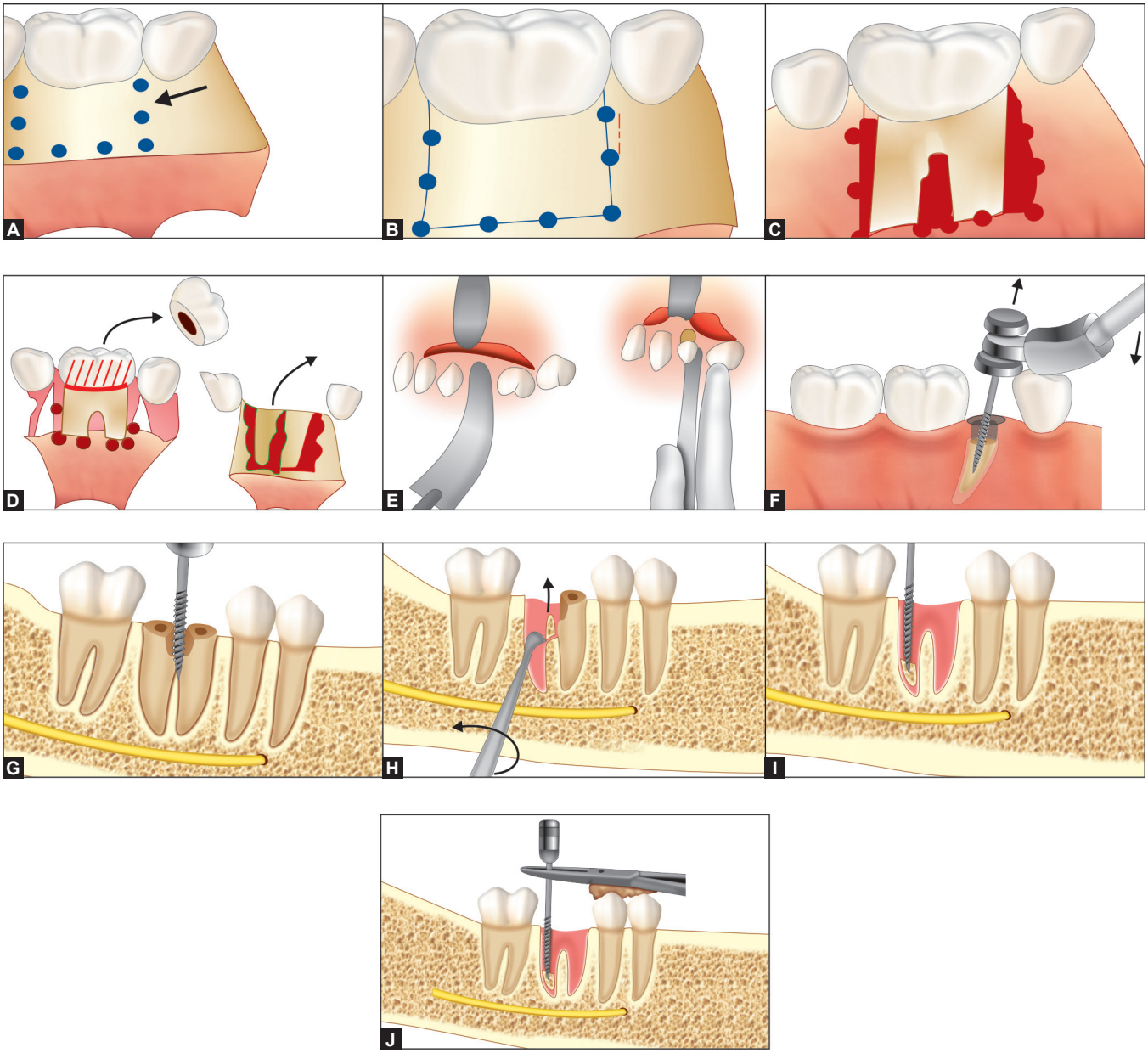
- Maxillary posterior teeth except first molar
- Maxillary anterior teeth except the canines
- Maxillary first molar
- Maxillary canine
- Mandibular posterior teeth except the first molar
- Mandibular anterior teeth except the canines
- Mandibular first molar
- Mandibular canine.

Difficult Extraction/Breakage of the Root

- Reposition the patient
- Visualize the root directly or with the help of a mouth mirror
- Irrigate the socket forcibly
- Suction the area
- Probe with an explorer, endo file or an apexo elevator
- Sometimes it is prudent to leave very small root tip behind, but the risk/benefit ratio should be in patient's favor and patient should be informed about it.

Surgical Extractions (Complicated Extractions)

- Unplanned extractions—an event that can convert an uncomplicated extraction into a complicated one
- Proper pre-extraction assessment of a difficult case
- Any premonition or suspicion that the tooth/bone will break—think and plan
- Properly planned surgical extraction is always less traumatic (people attack the tooth—the hardest structure in the body, but hesitate, when it comes to soft tissue incision)
- Do not shy away from complicated extraction
- Proceed as predicted with fewer surprises.



Figs 19.2A to J: Postage stamp technique of transalveolar extraction: (A) Reflection of mucoperiosteal flap and bur holes are made; (B) Connected bur holes to create a window; (C) Exposing the roots; (D) Sectioning the crown and roots for easy removal; (E) Transalveolar extraction of a root piece by planning small envelop flap; (F) Removal of root using endodontic file; (G) Dividing the roots by bur; (H) Removal of remaining root by apexo or Cryer elevator; (I) and (J) Removal of apical third by endodontic reamer. Additional support can be taken by holding the reamer with needle holder

Postage Stamp Technique for Transalveolar Extraction

- Helps in controlled removal of bone, preventing uncontrolled fracture of the alveolar process **(Figs 19.2A to J)**
- Allows judicious use of elevators and forceps
- Allows tooth sectioning in a controlled manner, facilitating predictable result instead of an apical root fracture.

Three Basic Principles

1. Obtain adequate access which makes difference between success and failure.

2. Create an unimpeded path of removal
3. Use controlled force.

Basic Necessities for Surgery

The main requirements for any surgery are adequate visibility and assistance. Adequate visibility will depend on the following:

- Adequate access/good visibility
- Adequate light source
- A clean surgical field (free from excessive bleeding).

Adequate Access

Adequate access will require:

- Comfortable patient
- Adequate oral opening
- Adequate flap design to expose the field of surgery
- Proper retraction of the tissues by assistant
- High-volume suction, hemostasis of the operating field.

Patient

- Comfortable, mentally and physically
- Alleviation of fear, anxiety, avoidance of pain/discomfort, assurance
- Informed consent
- Minimum amount of draping
- Rinsing with antiseptic mouth wash.

Equipment

- The proper adequate instrument kit should be prepared and sterilized
- Effective light source and suction.

Assistant

Four handed surgery with the help of a skilled assistant. The assistant should be familiar with the procedure being performed to anticipate the surgeon's needs.

Surgeon's and Assistant's Preparation: Follow Universal Precautions

- Wearing of protective eye glasses
- Wearing mask
- Wearing surgical cap
- Wearing gloves.

Aseptic Technique

Aseptic technique has been explained in detail in Chapter 6 on Asepsis and Sterilization.

Planning of an Incision

Planning of an incision is a basic step in any surgery. The incision is defined as "a cut or a wound deliberately made by an operator in the skin or mucosa using a sharp instrument, such as a surgical blade, cautery, etc. so that the underlying structures can be exposed adequately for surgical access". Thorough anatomical knowledge is essential. Incision is placed parallel to the structures without causing damage to the vital structures. Extraoral incisions should be planned along the "Langer's lines" of the normal skin tension or creases, so that minimum scar formation will be seen. Intraoral incision should be planned to prevent subsequent scar contraction or fibrosis, which will prevent normal functioning of the oral soft tissues.

The sharp blade of a proper size and shape should be selected; essential for clean, single stroke incision without much tissue damage.

- Incision should be placed on the sound bone, or away from the surgical area to ensure the prevention of wound dehiscence
- Either pen (intraoral incision) **(Fig. 19.3)** or table knife (extraoral incision) grasp is used with proper support and pressure to produce uniform atraumatic clean incision, with predictable depth
- The skin or the mucosa to be incised, should be stabilized with finger pressure to guide the passage of the blade
- A firm continuous stroke should be used. Repeated strokes increase both the amount of tissue damage and the bleeding, thereby impairing the wound healing. Long continuous strokes are preferable to short interrupted ones



Fig. 19.3: Pen grasp for intraoral incisions

- No sharp angles; the change in direction is accomplished by a gradual curve. Sharp angles tend to produce slough due to poor circulation and may lead to extensive scarring.

Incisions in the Oral Cavity

- It is desirable to incise through attached gingiva and over a healthy bone. The suture line should have adequate bone support underneath for uneventful healing
- Incisions placed near the teeth for extractions should be made in the gingival sulcus
- Incisions involving the reflection of the mucoperiosteal flap are direct, straight line or curvilinear taking the shortest distance vertically through the tissues
- Indirect incisions are used to access the areas like soft palate, tongue, cheeks, lips, floor of the mouth, etc.
- Integrity of the interdental papillae should be maintained as far as possible
- Blood supply to the incision should be adequate
- Incisions should be at right angles to mucosa to prevent shelfing edges that might cause necrosis of the undermined part.

Contraindications for Placement of Incision Lines

Avoid Placing Incisions

- Over the bony/canine prominence—soft tissue defect will be created due to bony fenestration
- Vertical incision in the mental nerve region
- On the palate—near the greater palatine vessels
- Through incisive papillae/over buccal aspect of midcrown
- Over bony lesions/pathologic defects—dehiscence
- Over freni
- Vertical incisions on the lingual side of the mandibular arch.

Types of Incisions

- **Horizontal:** It is seldom used because of natural contour of maxilla and mandible. These types of incisions are directed along the gingival margin either mesially or distally:
  - **Internal bevel incision:** It starts at distal area from the margin and is aimed at bony crest. This is also known as first incision.
  - **Crevicular incision:** It starts at the bottom of the pocket and is directed to the bony margin. This is known as second incision. These incisions are mainly used in periodontal flap surgeries.
- **Vertical:** Vertical or oblique incisions are most desirable and are also called as releasing incisions, on one or both the sides of the flap. It may be single resulting in triangular type of flap:
  - Double vertical incisions on both sides of the flap will result in trapezoidal flap
  - The incisions should extend beyond mucogingival line reaching the alveolar mucosa to allow the release of a flap for reflection
  - Vertical incisions should be placed at obtuse angle to the horizontal incision and should leave interdental papillae intact. Usually extend one tooth anteriorly and one tooth posteriorly.
- **Semilunar (curved, elliptical):** This type of incision is used, when it is desirable to maintain the attached gingiva intact around the teeth and for endodontic surgery. The horizontal component of this flap rests on the alveolar bone. The gap of 5 mm must be present from the base of the gingival sulcus to the incision.

Flap Design

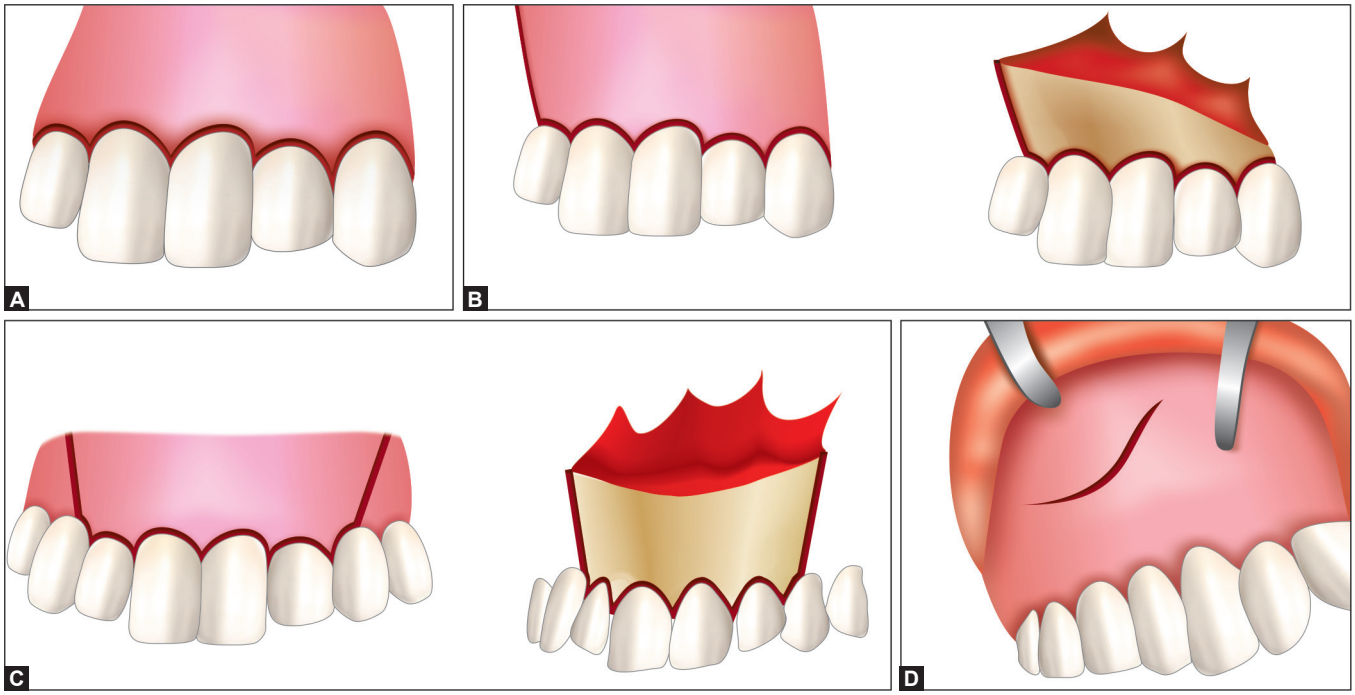
The preparation of adequate mucoperiosteal flap is of paramount importance. Standard surgical protocols should be followed while designing a flap or reflecting it to preserve the integrity and function of the soft tissues. The properly designed flap may bring about minimum morbidity like pain, swelling, etc. postoperatively, but it will definitely prevent the potential morbidity (including complications) associated with damage due to inadequate exposure.

While taking intraoral incision for flap designing, convenience, access, avoidance of injury to the vital structures, maintaining the integrity of the interdental papilla, etc. should be thought about.

Main Complications of Flap Surgery

- Flap tearing
- Flap necrosis
- Flap dehiscence.

Flap tearing: The incision should be clean, sharp and should penetrate the entire mucoperiosteum, if the flap is being reflected over the bone. The flap should be reflected as one unit. The flap should be large enough to prevent tearing or for avoiding the need to modify during surgery. Adequate size of the flap is a must for proper instrumentation and visual access. The length of the flap should be no more than twice the width of the base.



Figs 19.4A to D: Types of flaps: (A) Gingival margin crevicular incision; (B) Two-sided triangular flap; (C) Three-sided rhomboid flap. Note that the base should be wider than height and (D) Semilunar flap

Flap necrosis: Ideally, the base of the flap should be wider than the reflected free margins to allow for the adequate blood supply to the reflected tissues. Flap should have margins that either run parallel to each other or preferably converge from the base to the apex of the flap. Whenever possible, the axial blood supply should be included in the base of the flap. For example, palatal flap can be based on greater palatine artery (pedicled flap).

Flap dehiscence: This is seen in the immediate postoperative phase after suturing is done. This means separation of the flap margins or gaping of a wound. This is prevented by designing a flap in such a way that the sutures will be placed over the solid healthy bone. Poor tissue handling, too tight suturing, hematoma formation, infection, suturing under tension may lead to dehiscence.

Principles of Flap Designing

Intraoral surgical flaps are made to gain surgical access to the area to be operated or to move tissues from one place to another.

Indications

For basic oral surgical procedures to allow complete visualization of the operative field and to access osseous tissues, whenever required.

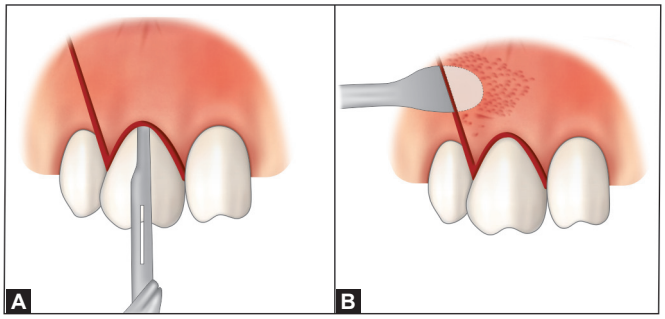
Types of Flaps

A. Full thickness—mucoperiosteal flap **(Figs 19.4A to D)**
   - Partial thickness
B. Envelope flap
   - Two-sided triangular flap
   - Three-sided rhomboid flap
   - Semilunar flap.
C. Labial, buccal flaps
   - Palatal, lingual flaps

Envelope Flap

- The most common type of flap.
- The incision is made to any length (depending on the amount of exposure needed) intraorally around the necks of the teeth along the free gingival margin on the buccal or lingual aspect including the interdental papillae
- The entire mucoperiosteal flap is raised by using periosteal elevator to a point to the apical one-third of the tooth
- This is mainly used for the surgical extraction of a tooth or roots.

Two-sided triangular flap: In addition to the envelope flap, a vertical releasing incision is used in order to have



Figs 19.5A and B: (A) Incision and (B) Reflection of the mucoperiosteal flap with periosteal elevator

better access to the area. This vertical releasing incision is made on one side of the envelope flap (at the proximal or distal end) going divergent towards the buccal vestibule forming an obtuse angle at the free gingival margin. The vertical incision should be made in the interproximal area, as the tissues here are thick. To avoid periodontal defect, the incision should never lie directly on the facial aspect of the tooth. Once the incision is taken, then the two sided triangular flap is reflected towards the base of the flap by using periosteal elevator **(Figs 19.5A and B).**

Three-sided rhomboid flap: This is the modification of the earlier flap to improve the visibility and access. An additional vertical incision is added in the opposite direction from the earlier release. Here, care should be taken that the base of the flap must be wider than the apex to ensure good blood supply.

Semilunar flap: Whenever the periapical area is required to be exposed to carry out periapical surgery, this flap is designed. Again the base of the flap should be broader than the apex and the suture line should not lie on the bony defect.

The incision is taken at least 5 mm away from the free gingival margin. This flap is useful to avoid damage to interdental papilla and to prevent periodontal postsurgical defects. In case of crowding of the teeth, the suturing is not a problem with this flap. The only disadvantage of this flap is that it often lies on the bony defect.

Tissue Handling

Respect the tissue and the tissue will respect you (remember this adage).

Gentle handling, no excessive pulling or crushing, proper retraction with judicious force, avoidance of extreme temperature, minimum use of electrocautery, avoidance of the use of chemical agents are the key factors for satisfactory wound healing. During cutting of the bone by using electrical engine and handpiece and bur, continuous saline irrigation should be done to avoid generation of heat. Selection of the proper instruments is also important to minimize the tissue trauma.

Hemostasis

Hemostasis should be achieved during surgery for the following reasons:

- To minimize the intraoperative total blood loss
- Increase visibility
- To increase the speed of the surgery and to cut down the total operating time
- To minimize the postsurgical hematoma.

Hematoma decreases the vascularity, increases the wound tension, acts as a culture media and makes it susceptible for the development of postoperative wound infection.

Various Procedures to Achieve Hemostasis

- **Intermittent pressure:** With cotton/gauze sponges or with hemostat clamping. Pressure is usually applied for 20–30 seconds, for smaller tiny vessels, while large vessels require about 5–10 minutes of continuous pressure.
- **Use of electrocautery:** For this judicious thermal coagulation, the area around the vessel should be dried thoroughly. Avoid unnecessary burning the tissue.
- **Suture ligation:** Whenever large vessel is severed, the ends are grasped with a hemostat. Nonabsorbable suture (linen) is used to ligate the ends of the vessels.
- **Placement of compression dressing over the wound:** Many times there is oozing over a large area and hemostasis is difficult. A cotton pad or folded ribbon gauze is stabilized over the wound and secured with tie over sutures and left in place for 2–3 days.
- **Use of vasoconstrictor agents:** Such as epinephrine, commercial thrombin or collagen gelfoam, surgical oxidized cellulose, etc.

Dead Space Elimination

Dead space is the area that remains devoid of tissue after closure of the wound. It is created as a result of removal of tissue in the depths of a wound or by not suturing in multiple layers (single layer approximation). Dead space is usually filled with hematoma.

How to Avoid a Dead Space?

- Multiple layer suturing from the depth to the surface
- Use of pressure dressing over the wound in the postoperative period for 12–18 hours
- Use of surgical packing of the defect. Whenever proper approximation of the margins is not possible the strip or the ribbon gauze impregnated with an antibacterial medication can be used
- Use of drains alone or along with the pressure dressings
- Nonsuction drains or suction drains can be used.

Decontamination and Debridement

- Irrigation during surgery
- Irrigation at the end of surgery
- Careful debridement of necrotic tissue, foreign bodies, severely injured tissues
- Antibiotic prophylaxis.

In intraoral wounds, patients should be instructed to use frequent medicated mouthwashes after every food intake.

In extensive oral surgical wounds, the patient should be fed through Ryle's tube till the wound heals to avoid oral contamination.

Suturing

Suturing has been described in detail in Chapter 5 on Suturing Materials and Techniques.

Points to Remember

- Basic purpose of surgery
- Principles of oral surgery
- Indications for transalveolar extraction
- Various intraoral incisions and flap designing.

CHAPTER 20 Surgical Management of Impacted Teeth

INTRODUCTION

The term "impaction" originates from a Latin word "impactus" (wedged).

Prevalence of tooth impaction is a common dental anomaly. The prevalence of impacted and supernumerary teeth in different populations and ethnic groups has been studied extensively. The third molar is the most frequently impacted tooth, with a frequency of occurrence generally reported to be from 16.7% to 68.6% (Queck et al. 2003). The incidence of impacted teeth, excluding third molars, has been reported to vary between 5.6% and 18.8% (Grover et al. 1985). Impacted teeth do not fully erupt in the oral cavity. They are retained for the patient's lifetime, unless surgically removed or exposed and brought into alignment by orthodontics. The early detection of tooth impaction is very important from a therapeutic point of view, as the presence of impacted tooth may cause many complications.

DEFINITION OF IMPACTED TEETH

According to World Health Organization (WHO), an impacted tooth is the one that is unable to fully erupt in its normal functional occlusion/location by its expected age of eruption, because it is blocked by overlying soft tissue or bone or another tooth.

Durbeck WE (1943) defined impaction of a tooth as a cessation of its eruption caused by a physical barrier (detectable by a clinical or radiological examination) in the eruption path or by an ectopic position of a tooth. A physical barrier can be neighboring tooth, dense bone, fibrous tissue or any other pathology or lack of space, or abnormal eruption path.

Archer (1975) proposed that an impacted tooth or an embedded tooth is the tooth that has failed to erupt completely to its correct normal position in the dental arch, and its eruption potential has been lost.

Fully impacted tooth is completely encased in the jaw bone.

Partially impacted tooth is the one, which is not completely encased in the jaw bone and has communication in the oral cavity.

The eruption of permanent teeth represents a complex series of events, mostly genetically based, whereby eruptive movements of the tooth germ taking place at a predetermined time and route, enable the tooth to find its antagonist at a predetermined occlusal plane. Apart from the eruption process, the successful development of permanent dentition involves the synchronized forward and lateral growth of both the maxilla and mandible, which compensates for the difference in size of the dentition in both bones. As the eruption process is so complex, it is not surprising that problems may arise, which lead to complications, including tooth retardation or failure of eruption.

Failure of the eruption of permanent teeth is a common dental anomaly. When there is a clinical absence of one or several teeth, and the history indicates that they have not been extracted, then partial anodontia or tooth impaction should be considered. Radiographic examination may reveal impacted or supernumerary teeth. Developmental disturbances can be due to genetic or environmental factors, including physical and biological factors.

COMMONLY USED TERMINOLOGIES

- **An unerupted tooth:** It is a tooth that is in the process of eruption and is likely to erupt, based on clinical and radiographic findings.
- **Malposed tooth:** A tooth unerupted or erupted, which is in an abnormal position in the maxillary or in the mandibular dental arch.
- **An ankylosed tooth:** Normal periodontal ligament between cementum and alveolar bone is absent and the tooth is fused to alveolar bone (associated with genetics and systemic factors) **(Fig. 20.1)**.

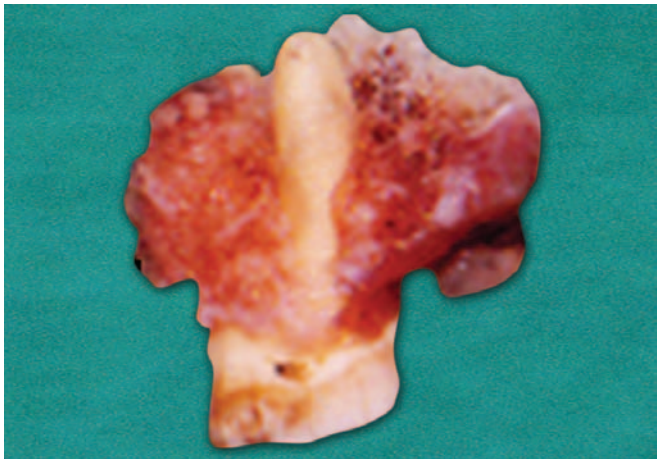
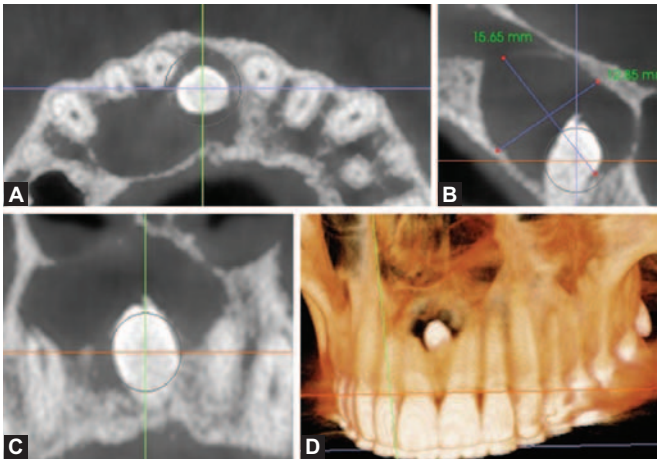


Fig. 20.1: Ankylosed upper third molar extraction ending in maxillary tuberosity fracture



Figs 20.2A to D: Inverted mesiodens with cystic lesion [cone beam computed tomography (CBCT) views]

- **An ectopic eruption:** When the tooth is erupted away from its normal location and may be erupted in the position of another tooth or malposed in an abnormal location. Ectopic teeth are commonly seen in the palate and maxillary sinus, but cases also have been reported at unusual sites, such as the mandibular condyle, coronoid process, orbit and nasal cavity. Probable causes are trauma, pathology or congenital factors and genetics.
- **Transmigration of a tooth:** Movement of a tooth from normal position to another abnormal location.
- **A supernumerary tooth:** It is an extratooth in addition to the normal permanent or deciduous teeth series.
- **Prenatal teeth:** Extrateeth seen in infants.
- **Hyperdontia:** It is a condition of having supernumerary teeth, which appear in addition to regular number of teeth. They appear in any area of the dental arch and can affect any dental organ.

Supernumerary Teeth

They may be erupted or unerupted or assume an abnormal path of eruption and either resemble or are unlike the other teeth in the group to which they belong. They can be single or multiple, unilateral or bilateral. They can have normal morphology (eumorphic) and are known as supplementary teeth. Supernumerary teeth may be rudimentary/smaller in size and shape, with different morphology (dysmorphic) **(Figs 20.2A to D)**.

They are classified as per the location, number, form, shape, etc. Conical supernumerary is peg shaped, Tuberculate is barrel shaped. Supernumerary teeth can be associated with various syndromes, at the same time they can be detected in non-syndromic patients also. As per their position in the dental arch, they are labeled as follows:

- **Mesiodens:** Those occur between or just posterior to the central incisors.
- **Paramolars:** Those erupt buccally or palatally to molars.
- **Distomolars:** Situated distal to the third molars.
- **Prevalence:**
  - 0.1–3.8% in permanent dentition
  - 0.3–0.6% in deciduous dentition.
- **Number:**
  - Single in 76–86%
  - Double in 12–23%
  - Multiple are seen in less than 1%.
- **Location:** More frequent in premaxilla than in mandible 79.0–88.9%. Most frequently seen in the maxillary anterior and molar region.
- **Sex predilection:** Predominance in males (2: 1)
- **Etiology (various theories):** Genetic plus environmental factors are thought to be responsible for this developmental anomaly. Atavism, dichotomy, dental lamina hyperactivity may be instrumental. Most accepted theory is development from epithelial remnants of the dental lamina.

Impacted Supernumerary Teeth Seen in the Following Order of Frequency

Multiple supernumeraries appear in premolar or premaxillary zone:

- Mesiodens
- Upper central incisors
- Premolars

- Upper lateral incisors
- Fourth molars/paramolars
- Fifth, sixth and seventh molars are also mentioned in literature, which are rare.

Clinical Problems/Indications for Extraction of Supernumerary Teeth

- Prevention or delay of eruption, displacement or rotation, retention/ectopic eruption of adjacent teeth.
- Crowding/malocclusion
- Incomplete space closure during orthodontic treatment
- Dilaceration, delayed or abnormal root development, root resorption of adjacent teeth (root resorption of lateral incisor may be seen associated with an impacted maxillary or mandibular canine).
- Migration into nasal cavity, hard palate, maxillary sinus, etc.
- Cyst formation
- Compromised esthetics
- Development of traumatic bite, caries, periodontal problems
- Multiple supernumeraries associated with developmental disorders needing treatment.
- Other impacted teeth seen in an order of frequency **(Table 20.1)**.

Causes of Impaction of Teeth

Various Theories Responsible for Causing Impaction of Teeth—Especially Third Molar

The causes of impaction of teeth are still not clearly understood. They appear to be multifactorial. Currently, insufficient amount of space in the jaw distal to second molar is considered to be the most significant reason. Other factors implicated are delayed third molar mineralization, premature loss of the primary teeth with subsequent partial closure of space, rotation/abnormal positioning of tooth buds, obstacles in eruptive path, an aberrant path of eruption, late eruption sequence, etc.

Table 20.1: Other impacted teeth (order of frequency)

Tooth	*Incidence (%)*
Mandibular third molars	17–32
Maxillary third molars	--
Maxillary canine	3.58–8.80
Mandibular premolar	2.0–2.7
Maxillary premolar	--
Mandibular canine	0.3
Maxillary central incisors	--
Maxillary lateral incisors	--
Mandibular second molar—rare	0.10–0.06

- **Durbeck orthodontic theory (inadequate space in the dental arch for eruption):** Growth of the jaw and teeth occurs in forward direction, any interference in growth pattern will cause impaction because of small jaw with decreased space.
- **Phylogenic theory (Nodine 1943):** Due to the evolution over centuries, the human jaw size is becoming smaller than our ape-like ancestors, and since the third molar tooth is last to erupt, there may not be room for it to emerge in the oral cavity. The modern food habits are changed from earlier raw, fibrous diet to cooked/processed food, which does not require forceful mastication, which offers less stimulation for jaw growth (Disuse theory).
- **Mendelian theory:** Here genetic variations/genetics play a major role. If the individual genetically receives a small jaw from one of the parents and/or large teeth from the other parent, then impacted teeth can be seen, because of "lack of space".

Causes of impaction of a tooth can be divided into local and systemic causes **(Table 20.2)**.

Mandibular third molars erupt at 17 to 25 years of age that is why they are called "wisdom teeth". However, tooth movement/eruption can continue beyond the age of 25 years, at times even till the 3rd decade of life. In many persons, they are never erupted in the oral cavity (9–25%) and frequency of impaction is more in mandible than maxilla, with significantly higher frequency in females than males (Hellman's theory states that the jaws of females stop growing, when third molars just begin to erupt, whereas in males, growth of jaws continues beyond the time of eruption of third molars). The 80% of adolescents and young adults have four third molars. A 19.7 to 25.9% third molars show agenesis. Mandibular third molars may acquire a range of patterns and positions and can lead to various pathologies. One out of four individuals has a maxillary third molar impacted.

Many impacted third molars remain asymptomatic for years, but often extracted to prevent the development of future complications and pathologic conditions. The universal recommendation is to consider each case on an individual merits and demerits, to balance the benefits and risks of retention versus extraction of impacted third molar. When non-extraction strategy is adopted, then patient should be educated regarding the presence of

Table 20.2: Local and systemic causative factor responsible for impaction of a tooth (Archer 1975)

Local causes	*Systemic causes*
• Obstruction for eruption: ▪ Irregularity in position and presence of an adjacent tooth ▪ Density of the overlying and surrounding bone. Condensing osteitis	• **Prenatal causes:** heredity
• Lack of space in the dental arch—crowding, supernumerary teeth—micrognathia or retrognathia	• **Postnatal:** rickets, anemia, tuberculosis, congenital syphilis, malnutrition
• Ankylosis of primary or permanent teeth	• Endocrinal disorders/metabolic disorders of thyroid, parathyroid, pituitary glands like hypothyroidism, hypopituitarism, achondroplasia, mucopolysaccharidoses, etc. Here the primary retention of teeth is seen due to lack of osteoclastic activity, which does not provide resorption of the bone overlying the developing tooth
• Nonabsorbing, overretained deciduous teeth	• **Hereditary-linked disorders:** Down's syndrome, Hurler's syndrome, osteopetrosis. Cleidocranial dysostosis, cleft palate, Treacher-Collin's syndrome, occipitomandibular syndrome, Gardener syndrome, Yunis-Varon syndrome, etc. Here failure of the overlying bone to resorb and develop an eruption pathway is absent. So, multiple impacted teeth are often found in syndromic patients
• Nonabsorbing alveolar bone	
• Ectopic position of tooth bud	
• Dilaceration of roots (trauma)	
• **Associated soft tissue or bony lesions:** cysts, tumors, thick fibrous growths	
• Habits involving tongue, finger, thumb, cheek, pencil, etc. (secondary retention: ankylosis of teeth. Infraocclusion of the tooth is seen due to arrested eruption, after initial emergence without any obvious barrier such as a tooth, tissue or habit to block eruption)	

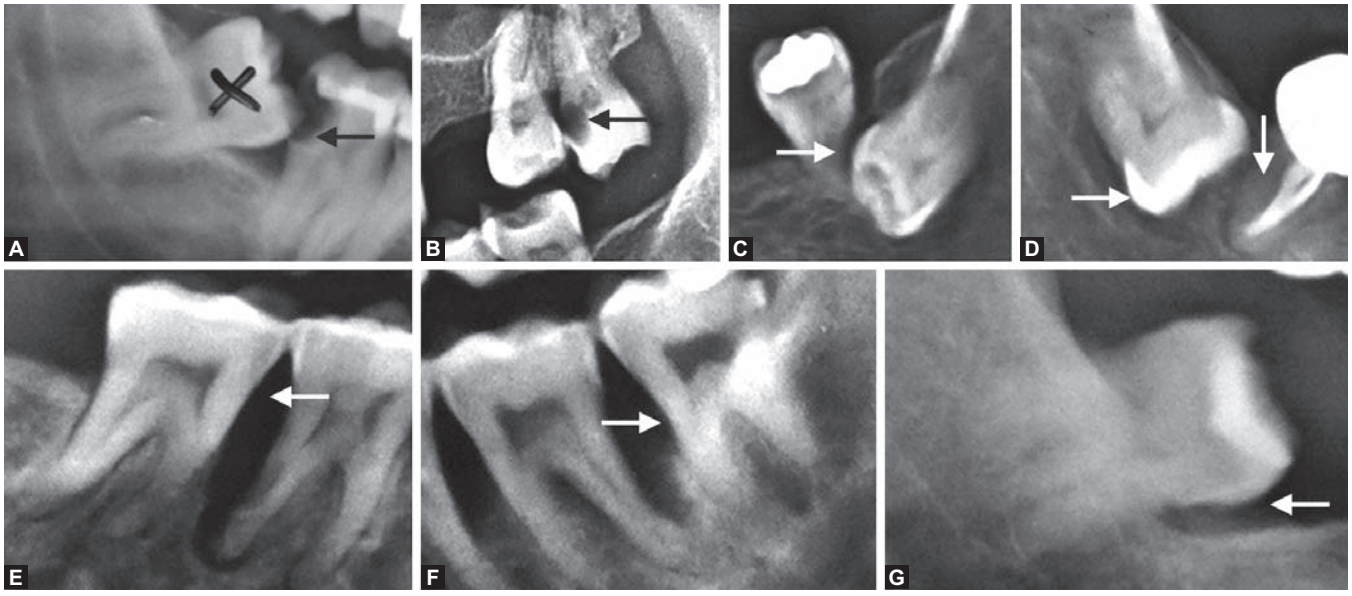
impacted third molar and then long-term clinical and radiographic follow-up is advised. This will help undertake surgical intervention as soon as some pathology starts to develop.

Dodson (2012) reported about the percentage of patients having impacted third molars with symptoms and presence of actual disease:

- 12% show evidence of disease and are symptomatic
- 0.6% are symptomatic, but no disease
- 51% are asymptomatic and have disease
- 37% are asymptomatic, but no disease.

Indications for Removal/Extraction of Impacted Third Molar Teeth

- **Recurrent pericoronitis/pain/infection:** Pericoronitis is the inflammation/infection of the gingiva surrounding a crown of a partially erupted tooth. A 27 to 34% of patients develop pericoronitis. Third molars with pericoronitis are removed either to prevent recurrent episodes or as treatment of it **(Fig. 20.3A to G)**.
- **Recurrent infection** may lead to cellulitis, abscess, periapical pathology, especially in medically compromised patients.
- **Impacted third molar** may decrease the amount of bone on the distal aspect of second molar and may lead to periodontal defect. 25% of patients with asymptomatic third molars were found to have increased periodontal probing depth and attachment loss, increased periodontal pathogen colonization and increased levels of inflammatory mediators. Deep periodontal pocket more than or equal to 5 mm depth, distal to third molar associated with partially erupted tooth is often difficult to manage.
- **Prevention of root resorption and caries:** Caries of the impacted tooth crown and the adjacent tooth at cervical area (3–28%) can be seen due to the accumulation of



Figs 20.3A to G: Indications for removal/extraction of impacted third molar teeth: (A) Caries in second molar and distal periodontal pocket; (B) Supraerupted upper third molar with caries; (C) Resorption of second molar; (D) Follicular space around impacted lower third molar; (E to G) Periodontal pocket between second and third molars

biofilm and an inability to access and clean the area. It is also inaccessible for restoration by a dentist. Root resorption of the distal root of the adjacent second molar is seen usually at the 21–30 years of age group (7–24%). This is probably due to pressure from the eruptive force of third molar and chemical mediators secreted by reduced enamel epithelium. In these cases, prophylactic removal of impacted tooth can benefit the patient.

- **Prior to orthodontic treatment:** To control the tooth crowding in the mandible or to prevent obstruction to orthodontic treatment.
- **Prevention or management of cysts and tumors associated with impacted third molar of odontogenic origin (associated lesions):** Odontogenic tissue surrounding the impacted teeth has potential to differentiate into a variety of tissue types and may lead to cyst or tumor formation. One to five percent chances for cystic changes and tumors may range from 0.1% to 0.2% from dental follicle (seen under 40 years of age), which decrease with age.
- **Prevention of pathological fractures or jaw angle fracture:** Sinn et al. reported that impacted or submerged third molar decreases the amount of bone support and weakens the angle of the mandible.

  Patients engaged in contact sports, like football, rugby, martial arts, etc. may get their impacted third molars removed to prevent angle fracture.
- **For the preparation of orthognathic surgery:** Prior to sagittal split osteotomy of ramus in order to avoid bad split/inadvertent fracture of the mandible, lower third molars are extracted at least 1 month or 2 months before major surgery. Maxillary third molars are removed during LeFort I osteotomy procedure.
- **Management of preprosthetic concerns:** Presence of impacted tooth in the residual ridge may cause obstruction to the placement of a partial or complete denture. Before the fabrication of the prosthesis, impacted teeth should be removed, where an impacted tooth is covered by only soft tissue or 1 to 2 mm of bone. Otherwise, it can cause ulceration or dehiscence of the mucosa under the denture.
- Impacted teeth in the line of fracture
- Buccoversion of partially erupted impacted molars may cause constant trauma to the cheek, leading to ulceration, frictional keratosis or irritational fibroma.
- Hindrance to the normal eruption of adjoining permanent teeth.
- Soft-tissue impacted mandibular third molar tooth can be used for transplantation in accidental or planned extraction region of first molar.
- **Prevention of pain of unexplained origin:** When other causes are ruled out and pain is persistent, inform the patient that the pain may not be relieved after surgery.

- Prophylactic removal in patients with certain medical or surgical conditions, e.g. organ transplants, alloplastic implants, chemotherapy, radiation therapy, etc.
- For facilitating management in trauma or reconstructive surgery.

Pericoronitis

It is an acute infection with associated inflammation of gingival and contiguous soft tissue, covering the crown of the partially erupted impacted mandibular third molar and its associated follicle (the gingival tissue covering is also called as operculum). Partial or submucosal impacted third molar is at risk of developing pericoronitis, as there is constant food entrapment in the operculum and at times supraerupted maxillary third molar may further aggravate the situation by causing constant trauma. Pericoronitis is reported to be common in vertical (23%), followed by mesioangular (15%), and distoangular (8%) and horizontal type of impactions (3%). Pericoronitis has been implicated with multiple facultative anaerobic bacteria. Microbes responsible are *Peptostreptococcus*, *Fusobacterium* and *Bacterioides* (*Porphyromonas*) **(Figs 20.4A to C)**.

Clinical Features

It includes pain, tenderness, redness, swelling of retromolar tissue, difficulty in mastication, trismus, pain may radiate to the ear, throat, floor of the mouth, halitosis. Extraoral swelling may be present at the angle of the jaw, lymphadenopathy and raised body temperature may be also present.

Complications

Pericoronitis may lead to spread of pericoronal abscess, cellulitis, Ludwig's angina, etc.

Treatment

- Antibiotics, anti-inflammatory drugs, debridement of the area with irrigation, chlorhexidine/hydrogen peroxide mouthwash (frequent gargles).
- Extraction of opposite impinging maxillary third molar or operculectomy if only soft-tissue impaction or if recurrent episodes of acute pericoronitis, then surgical extraction of impacted lower third molar should be carried out.

Risk and Benefits of Nonintervention or Intervention of Surgical Extraction of Impacted Third Molar

Risk of Nonintervention

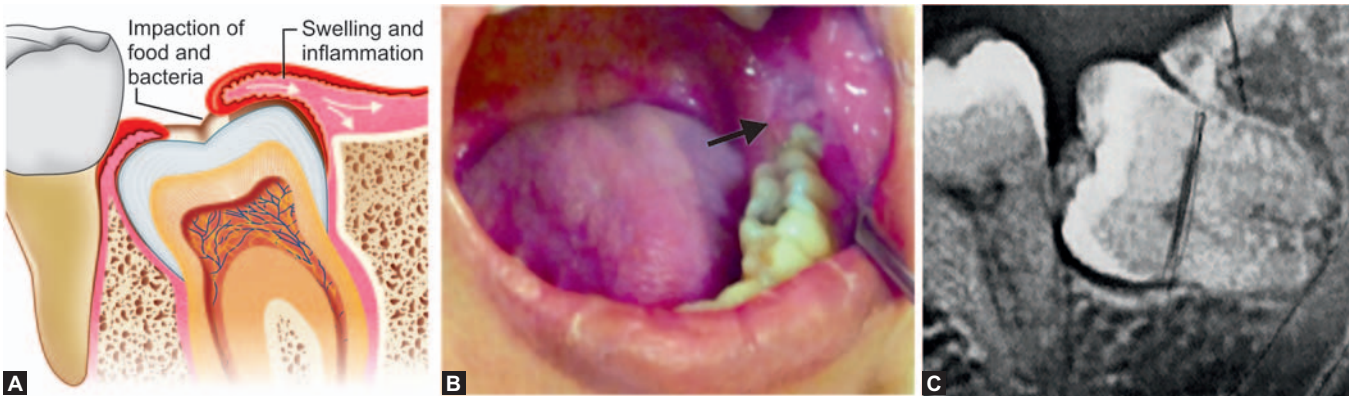
- Crowding of dentition based on growth prediction
- Resorption of adjacent tooth and periodontal status
- Development of pathological conditions, such as infection, cyst, tumor.

Risk of Intervention

- **Minor transient:** Sensory nerve alteration, alveolitis, trismus and infection; hemorrhage, dentoalveolar fracture and displacement of tooth.
- **Minor permanent:** Periodontal injury, adjacent tooth injury, temporomandibular joint injury.
- **Major:** Altered sensation, vital organ infection, fracture of the mandible/maxillary tuberosity, injury and litigation.

Benefits of Nonintervention

- Avoidance of risk
- Preservation of functional teeth
- Preservation of residual ridge.



Figs 20.4A to C: (A) Diagrammatic representation of pericoronitis; (B) Clinical picture of recurrent pericoronitis; (C) Radiologic picture of an impacted third molar with recurrent pericoronitis

Benefits of Intervention

- In relation to age: In young patients, less morbidity
- In relation to different therapeutic measures: Local measures against alveolitis, pain, swelling and trismus, etc.

Classification of Impacted Teeth

General Classification of All Impacted Teeth

Classifications into various categories help in communication, record keeping, diagnostic coding and billing accordingly as well as for treatment planning.

Modified American Association of Maxillofacial Surgeons (AAOMS) Classification

- **Soft-tissue impaction:** Normal eruption is prevented by overlying fibrous tissue. More often seen in cases of permanent central incisors or supernumerary teeth. Excision of overlying tissue and if required exposing the permanent tooth or extraction of supernumerary teeth.
- **Partial bony impaction:** Incision, elevation of flap, bone cutting, may be tooth sectioning and extraction.
- **Complete hard/bony tissue impaction:** Normal eruption is prevented due to complete encasement of a tooth by overlying bone, seen in lower third molars, maxillary canines, transmigrated mandibular canines, paramolars, etc. Surgical procedure same as mentioned above in "partial bony impaction".
- **Complete bony impaction with unusual surgical complication (not anticipated):** Lingual plate fracture, slippage of tooth in lingual pouch, tuberosity fracture, fracture mandible, excessive bleeding, etc.

CLASSIFICATION OF IMPACTED THIRD MOLARS

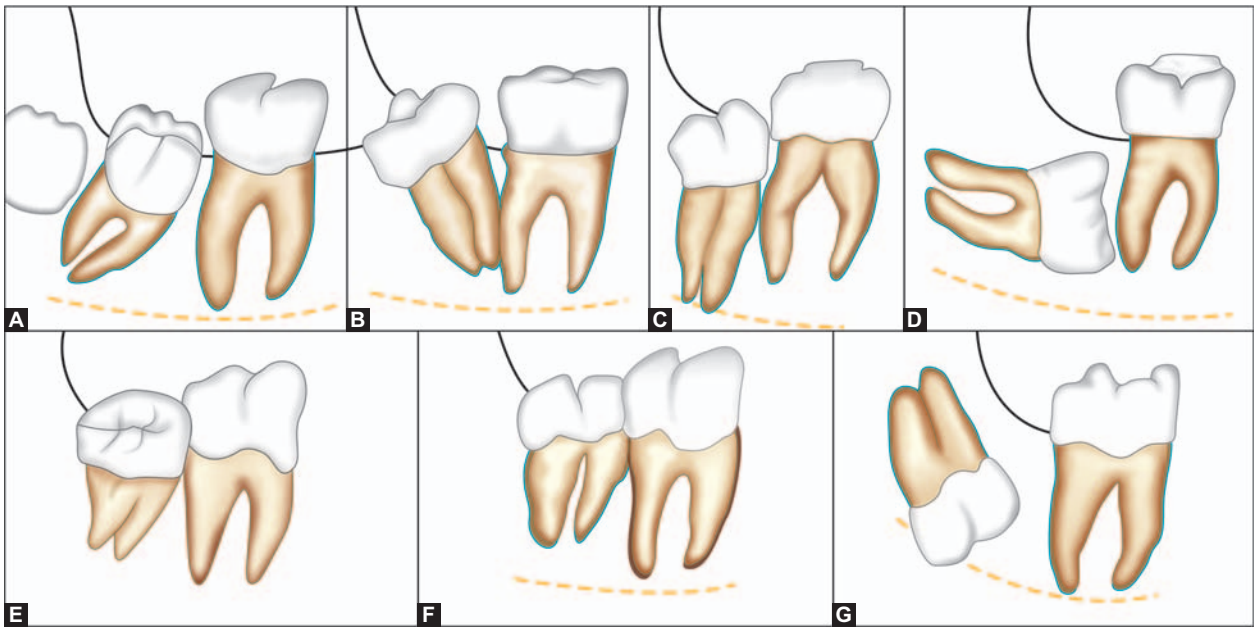
Maxillary and mandibular impacted third molars are traditionally classified radiographically by angulation, depth and arch length or by relationship to the anterior aspect of the ascending mandibular ramus, in case of mandibular third molar. These classifications are based on the analysis of periapical or more commonly, panoramic radiographs.

Winter's Classification (1926)

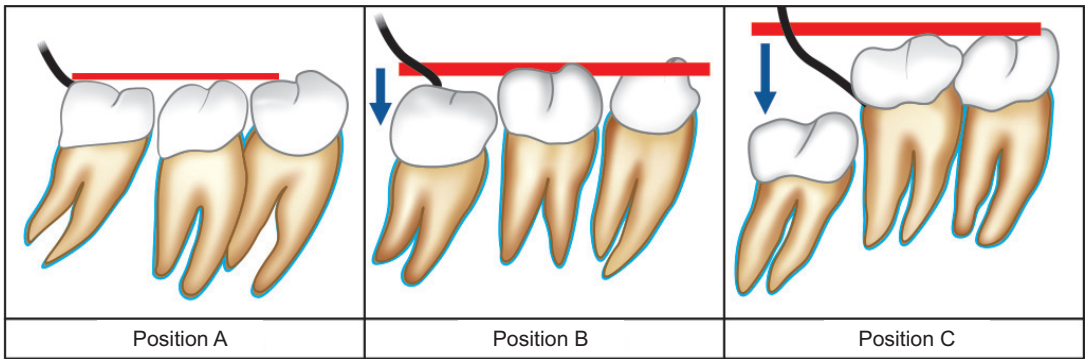
Angulation

According to the position of the impacted third molar to the long-axis of the second molar, the Winter's classification is suggested for **(Figs 20.5A to G)**:

1. Mesioangular impaction	**These may occur simultaneously in:**
2. Horizontal impaction	
3. Vertical impaction	a. Buccal version
4. Distoangular impaction	b. Lingual version
5. Transverse impaction	c. Torsoversion
6. Inverted impaction	



Figs 20.5A to G: Winter's classification of impacted mandibular third molars: (A) Mesioangular; (B) Distoangular; (C) Vertical; (D) Horizontal; (E) Bucco-version/angular; (F) Linguo-version/angular; and (G) Inverted



Figs 20.6A to C: Classification of impacted mandibular third molars according to the depth of impaction

Depth

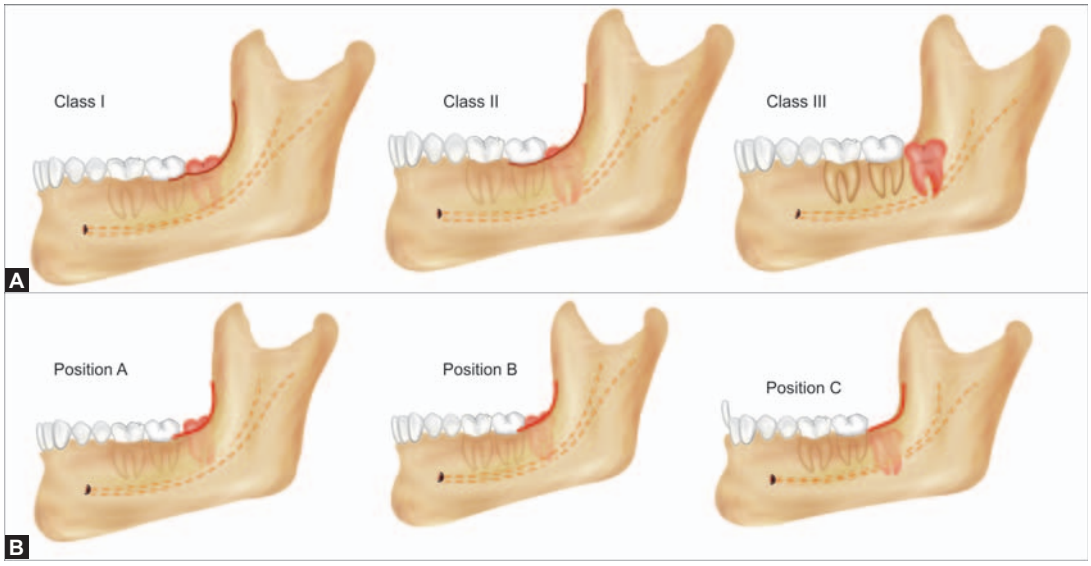
As per the relationship to the occlusal surface of the adjoining second molar of the impacted maxillary or mandibular third molar, the depth can be judged **(Figs 20.6A to C)**:

- **Position A:** The highest position of the tooth is on a level with or above the occlusal line.
- **Position B:** The highest position of the tooth is below the occlusal plane, but above the cervical level of the second molar.
- **Position C:** The highest position of the tooth is below the cervical level of the second molar.

The deeper the impacted tooth, the more overlying bone is present and the more the angulation of impaction deviates from parallel to the long-axis of the adjacent tooth, the more difficult it is to remove the impacted tooth.

Pell and Gregory Classification (1933)

- Relationship of the impacted lower third molar to the ramus of the mandible and the second molar [based on the space available distal to the second molar **(Figs 20.7A and B)**]:
  - **Class I:** Sufficient space available between the anterior border of the ascending ramus and the distal side of the second molar for the eruption of the third molar.
  - **Class II:** The space available between the anterior border of the ramus and the distal side of the second molar is less than the mesiodistal width of the crown of the third molar. It denotes that the distal portion of the third molar crown is covered by the bone from the ascending ramus.
  - **Class III:** The third molar is totally embedded in the bone from the ascending ramus, because of absolute lack of space.



Figs 20.7A and B: Pell and Gregory classification: (A) Classes I, II and III; (B) Positions A, B and C

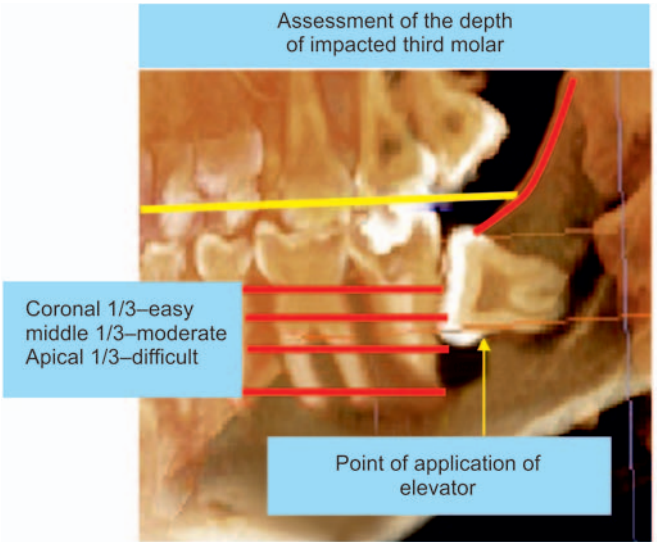


Fig. 20.8: Assessment of degree of difficulty for surgery as per depth from point of elevation and classification as easy, moderate and difficult

- As per the relation with the depth of the third molar in the jaw (as in Winter's classification) **(Figs 20.6A to C and Figs 20.7A and B)**.
- As per the angulation of the impacted third molar to the long-axis of the second molar (as in Winter's classification) **(Figs 20.5A to G)**.

According to the Depth of Impaction from the Point of Elevation

Santamaria and Arteagatia et al. in 1997 and Ghotolorun et al. in 2007 added one more variable as important indicator for degree of difficulty. They considered depth from the point of elevation based on the lines originally described by Ward in 1953. Depth from point of elevation is estimated from the length of a perpendicular drawn from the distal cementoenamel junction (CEJ) of the second molar distally and the point of application of elevator. The point of elevator for the mesioangular and horizontal impactions will be at mesial CEJ of the third molar, while for vertical and distoangular at the bifurcation. Assessment of the depth of impacted third molar also can be done as shown in **Figure 20.8**.

Quek et al. (2003) Introduced Measurement of Angulation of Impaction

Here, the angle is measured by a protractor in degrees formed between the intersected long-axis of the second and third molars **(Fig. 20.9)**:

- Vertical (10–10°)

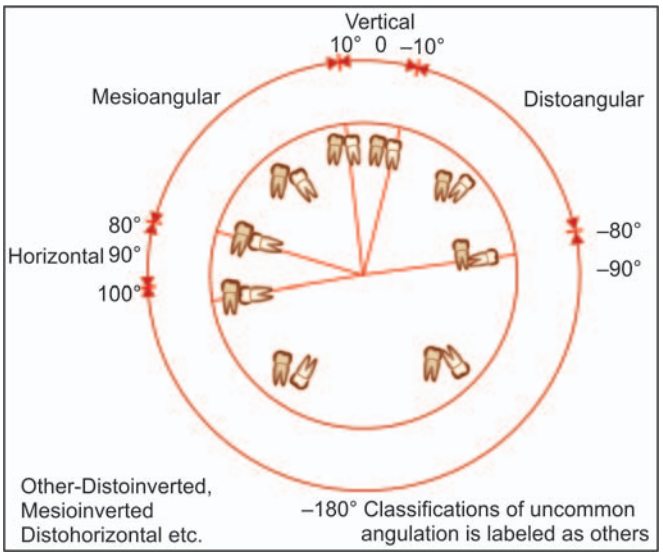


Fig. 20.9: Quek et al. (2003) classification of impaction; a system of measurement, using protractor

- Mesioangular (11–79°)
- Horizontal (80–100°)
- Distoangular (–11° to –79°)
- **Others:** Distoangular/mesioangular/horizontally inverted (111° to –80°).

Combination of Winter and Quek Classification

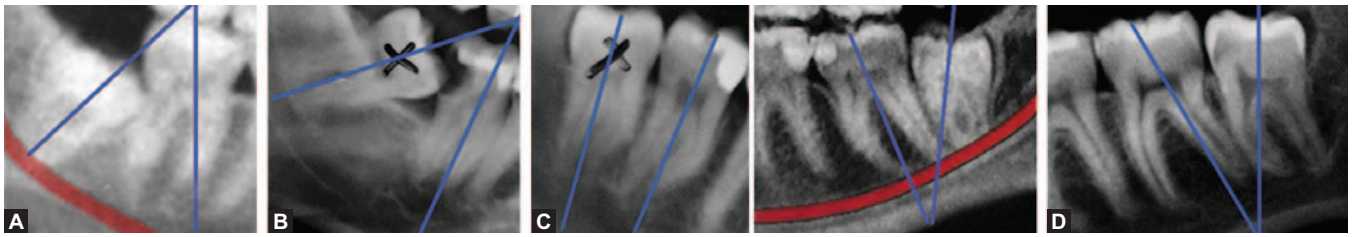
One can measure the angulation and put them into various classifications and at the same time predict the difficulty, which will be encountered during surgery **(Figs 20.10A to D)**.

Maxillary Third Molars' Classification

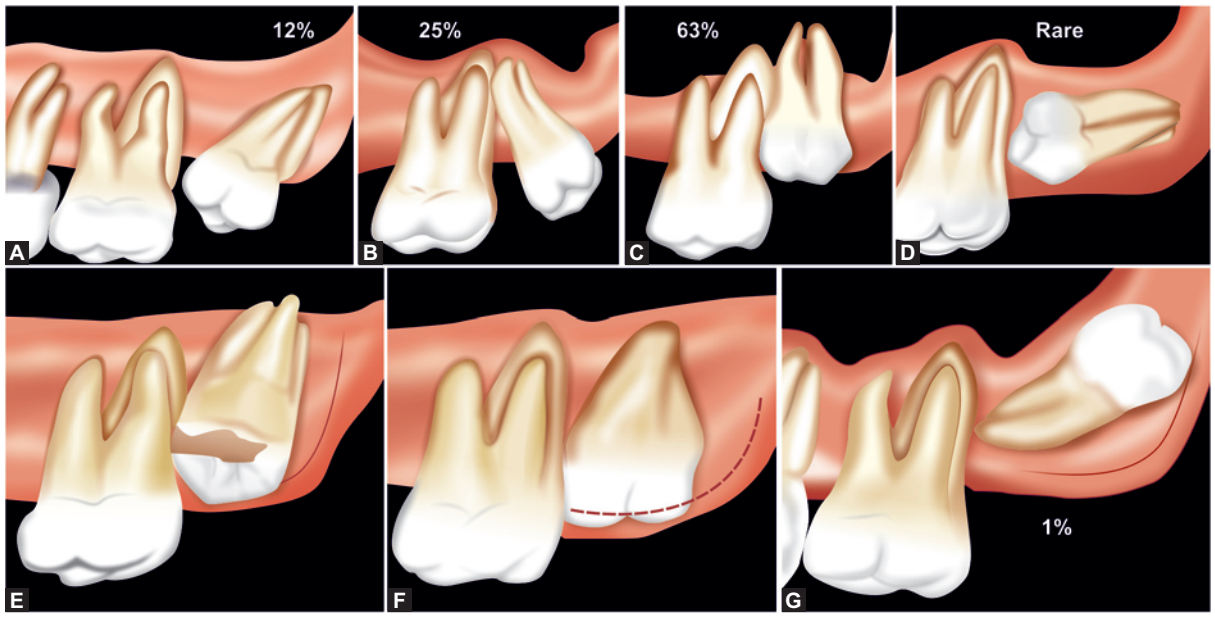
- Angulation and depth classification is same as mandibular third molars **(Figs 20.11A to G)**
- Classification of the maxillary third molar in relation to the floor of maxillary sinus **(Figs 20.12A to D)**:
  - **Sinus approximation (SA):** No bone or a thin bony partition present between impacted maxillary third molar and the floor of the maxillary sinus.
  - **No sinus approximation (NSA):** 2 mm or more bone is present between the sinus floor and the impacted maxillary third molar.

Classification of Impacted Maxillary Canines

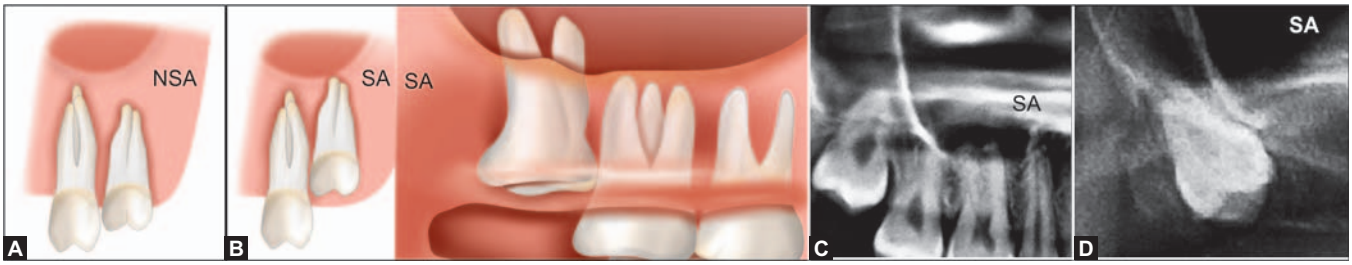
- Labial or palatal placement of impacted maxillary canine **(Figs 20.13A to E and 20.14A to H)**
- Intermediate position:



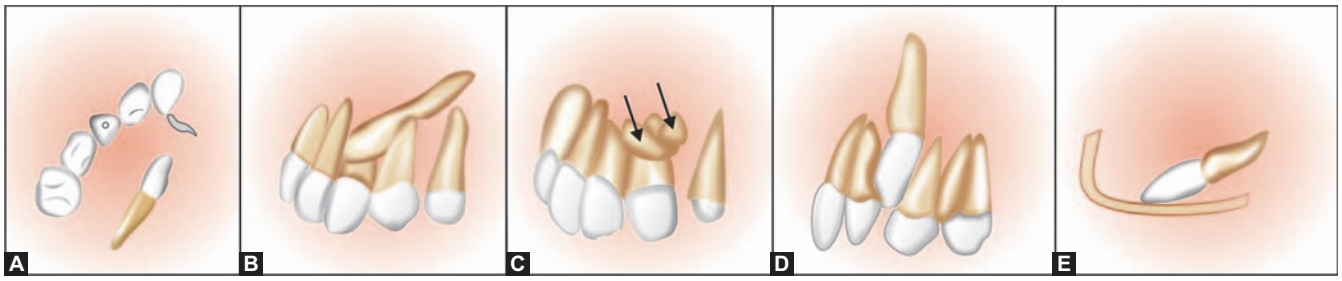
Figs 20.10A to D: Application of combination of winter and quek classification-on (CBCT) and X-ray images: (A) Mesioangular:43% incidence, least difficult and 11-79°; (B) Horizontal:3% incidence, more difficult and 80–100°; (C) Vertical:38% incidence; third in difficulty and 10 to -10°; and (D) Distoangular, 6% incidence, most difficult and -11 to -79°



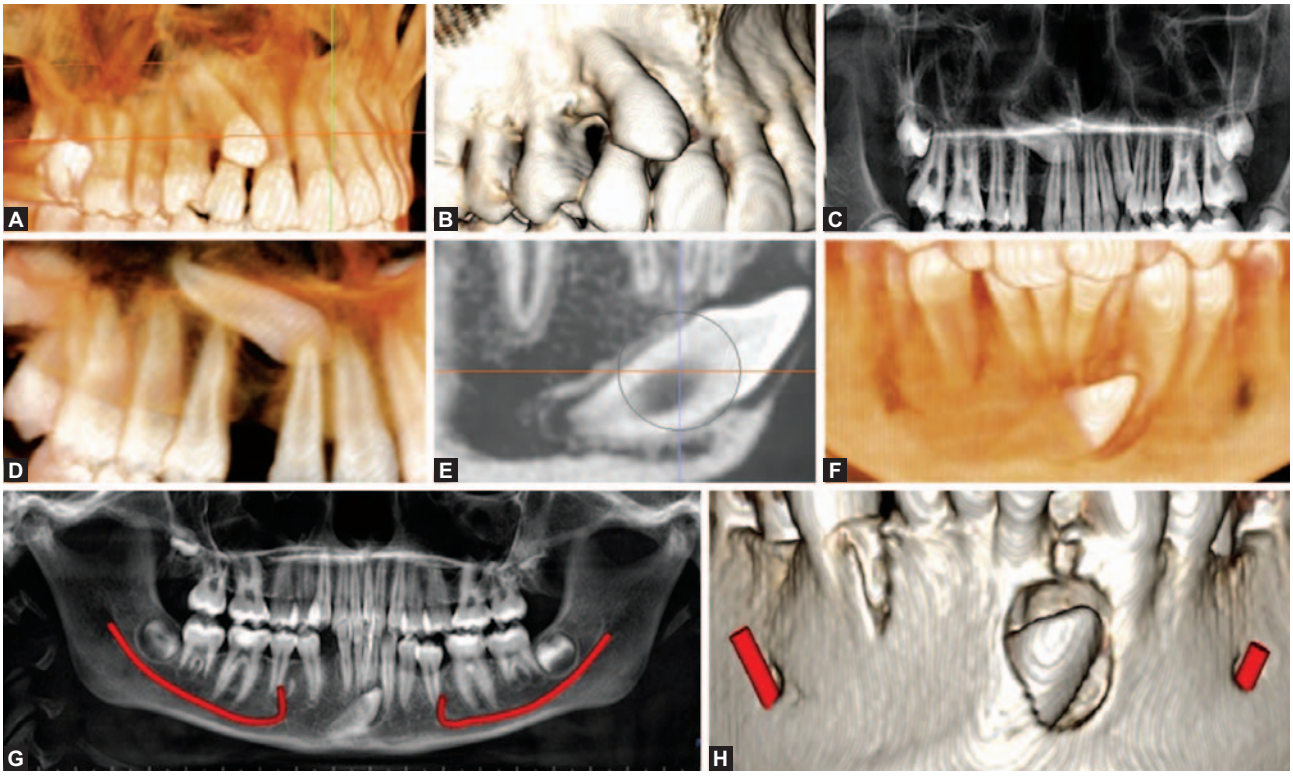
Figs 20.11A to G: Classification of impacted maxillary third molars: (A) Mesioangular; (B) Distoangular; (C) Vertical; (D) Horizontal; (E) Bucco-version; (F) Linguo-version; and (G) Inverted



Figs 20.12A to D: Classification of impacted maxillary third molars in relation to maxillary sinus: (A) No sinus approximation (NSA); (B) Sinus approximation (SA); (C and D) SA



Figs 13A to E: Impacted maxillary canine position: (A) Palatally placed; (B) Labially placed; (C) Partly on the labial side and partly on palatal side; (D) Canine locked between the roots of adjacent teeth and (E) Canine in the edentulous maxilla



Figs 20.14A to H: Cone beam computed tomography (CBCT) views of impacted maxillary and mandibular canines: (A and B) Labially placed canine; (C and D) Palatally placed canine; (E) Completely horizontally placed canine; (F to H) Mandibular impacted canine

- Crown between the lateral incisors and premolar
- Crown above the root tip with labial/palatal orientation of the lateral incisor or premolar.

- **Aberrant position:** Impacted maxillary canines lie in the maxillary sinus or nasal cavity:
  - **Class I:** Palatally placed maxillary canine:
    - Horizontal
    - Vertical
    - Semivertical
  - **Class II:** Labially or buccally placed maxillary canine:
    - Horizontal
    - Vertical
    - Semivertical
  - **Class III:** Involving both buccal and palatal bone, e.g. crown is placed on the palatal aspect and the root is towards the buccal alveolar process.
  - **Class IV:** Impacted in the alveolar process between the incisors and first premolar.

Table 20.3: Classification for impacted mandibular canine

Labial	*Aberrant*
Vertical	At inferior border
Oblique	On the opposite side
Horizontal	

- **Class V:** Impacted in the edentulous maxilla.
- Classification for impacted mandibular canine **(Table 20.3).**

Radiological Examination of Impacted Teeth

Intraoral X-ray

- Intraoral X-rays are possible, if tooth is in the alveolus and not in the ramus.
- Possible if oral opening is adequate.
- If there is no gagging
- Useful to study the relation with adjoining tooth
- Useful to study the configuration of the roots and status of the crown (caries, size, etc.).
- Useful to record the relationship with inferior alveolar canal
- Tube shift or buccal object rule should be followed for periapical X-rays.
- For bucco-version or Linguo-version "tube shift" method should be used or occlusal film is taken.

Extraoral X-rays

- For mandibular teeth **(Figs 20.15, 20.16A to G and 20.17A to D)**:
  - Orthopantomogram (OPG)
  - Lateral oblique view
  - Mandible
- For maxillary teeth:
  - Orthopantomogram
  - Posteroanterior (PA) view Water's position

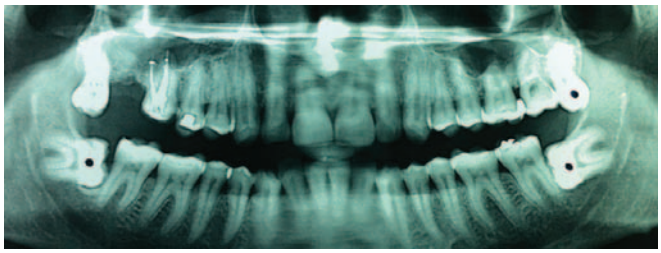


Fig. 20.15: Extraoral X-rays for detection of impacted teeth: orthopantomogram (OPG)—lower right and left third molars are impacted and upper third molars are supraerupted and buccally placed

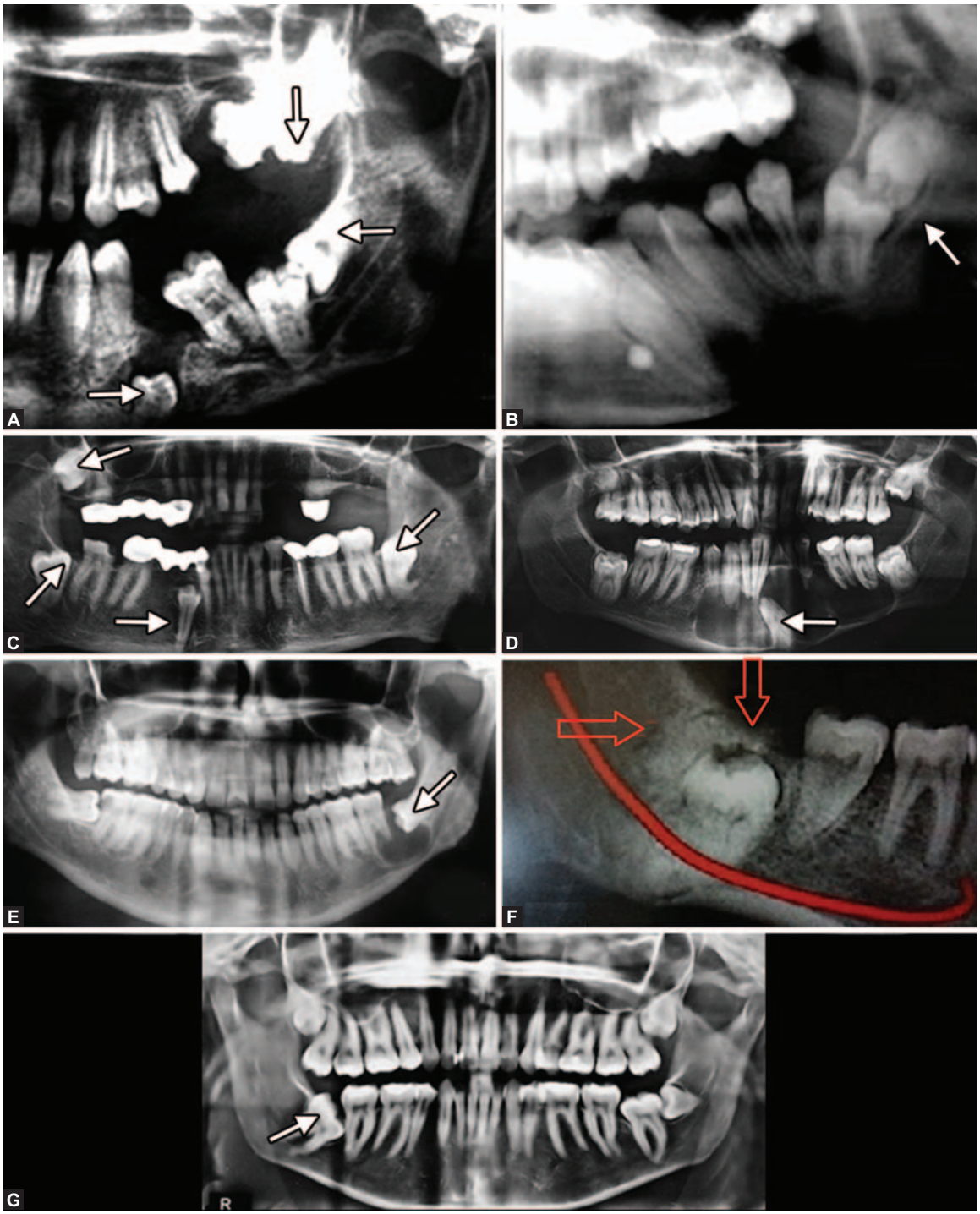
  - Occlusal view maxilla
- Indicated in:
  - Patients with restricted oral opening/trismus/ excessive gagging.
  - Impacted tooth in an aberrant position
  - For ruling out associated pathology
  - To study the relationship of the tooth to inferior alveolar nerve (IAN) **(Figs 20.18A to G and 20.19A to N)** and for maxillary teeth—relationship to the maxillary sinus **(Figs 20.12A to C)**.

Cone-beam Computed Tomography

Superior in showing tooth and root shape, crown/root relationship, tooth inclination and more importantly it gives exact idea of the proximity of the IAN and canal to the roots {[all cone-beam computed tomography (CBCT) pictures are courtesy of Insight CBCT Center, Mumbai, Maharashtra, India] **(Table 20.4, Figs 20.18A to G, 20.19A to N, 20.20A to E and 20.21A to E)**}.

FACTORS RESPONSIBLE FOR INCREASING THE DIFFICULTY SCORE FOR REMOVAL OF IMPACTED TEETH

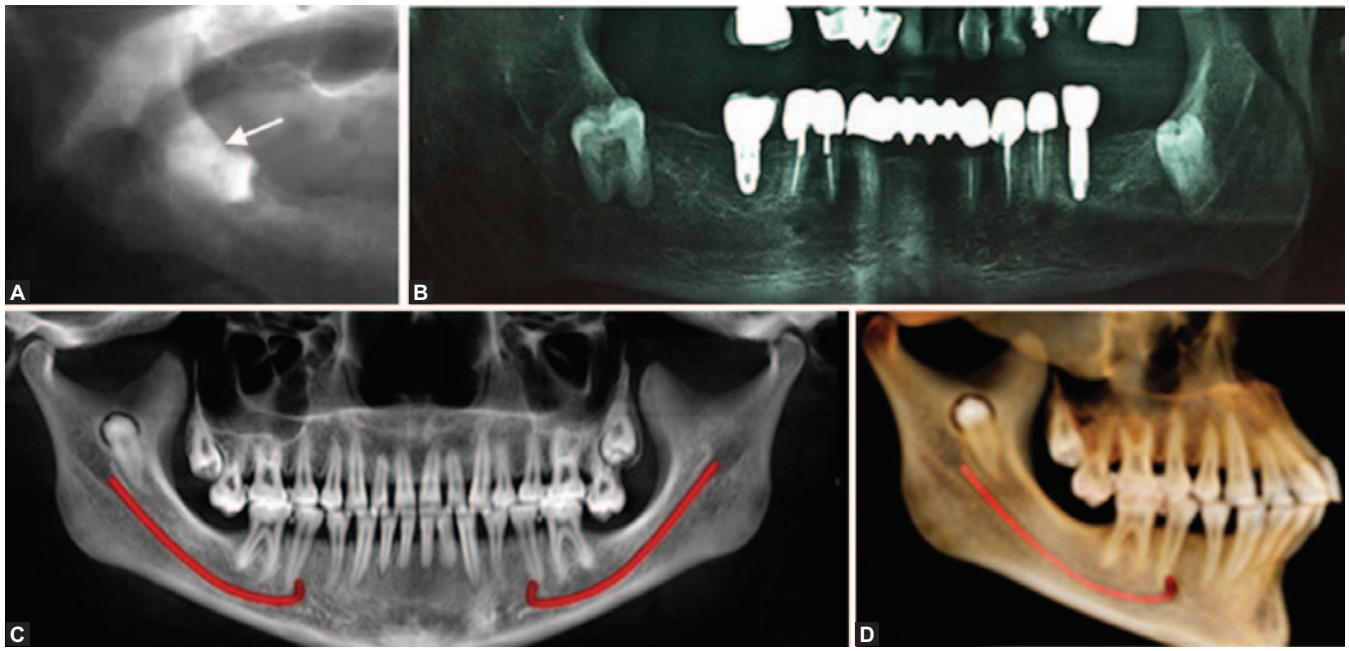
- As per the angulation
- As per the depth
- As per the space available for the eruption
- **Crown size:** Large bulbous crown increases the difficulty
- **Configuration of the roots of the impacted tooth:** The point of application of the elevator and the path of delivery of the impacted tooth depends mainly on the configuration of the roots:
  - **Length of the roots:** Longer the roots, more difficult the extraction.
  - **Root development:** If the root development is (less than one-third) insufficient, then the tooth is more difficult to remove. It moves like a ball in the socket and difficult to elevate.
  - **Curvature of the roots:** Dilacerated, curved, divergent roots are difficult to remove. Fused conical roots are easy.
  - **Root size:** Thin, slender roots are difficult to remove. Stout, bulbous, hypercementosed roots also increase the difficulty **(Figs 20.22A to C)**.
- **Bone texture and density:** It depends on the age, sex and systemic problems. Younger patients have spongy, elastic pliable bone, while older group of patients may exhibit sclerosed bone.



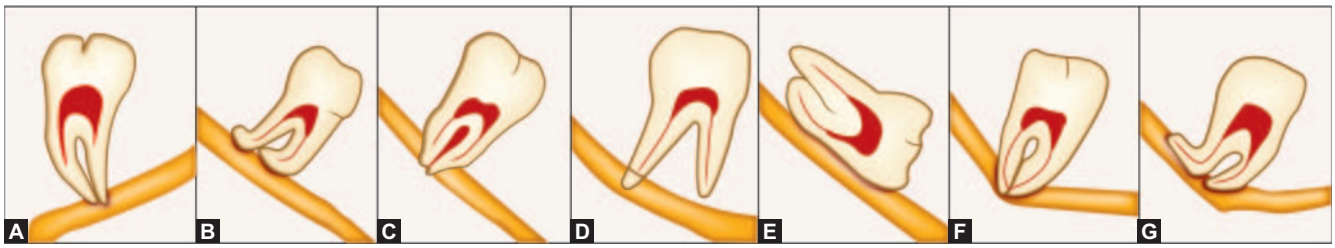
Figs 20.16A to G: (A) Multiple impacted teeth; (B) Kissing molars; (C) Multiple impacted teeth; (D) Multiple impacted teeth plus associated keratocyst with impacted lower canine; (E) Orthopantomogram (OPG) showing upper right peg-shaped third molar and bilateral impacted lower third molars: left third molar associated with cystic lesion; (F) Deep impacted lower third molar, almost touching the lower border of mandible and associated with odontome; (G) A rare case of impacted fourth molars, right lower fourth molar is geminated with third molar

Table 20.4: Radiological prediction of injury to the inferior alveolar nerve (IAN): Depends on the relationship of the root to the canal (Figs 18A to G, 19A to N, 20A to E and 21A to E)

Related, but not involving the canal	*Related to changes in root*	*Related with changes in canal*
Close proximity of the root to the canal, but intervening bone separates the both (i) separated (ii) adjacent, (iii) superimposed. Trace the outline of the root as well as the canal, which will show no disturbance	i. Darkening of the root (radiolucent) ii. Dark and bifid root iii. Narrowing of the root iv. Deflected root	Interruption (loss of lines)—the dense roof and floor of the canal is seen as two white radiopaque lines (Tram lines)
	a. Density of the root is altered, when the root impinges on the canal	Either of these two lines or both may be disrupted to indicate deep grooving of the roots
	b. When the canal crosses the root apex, it can be identified by the double periodontal membrane shadow of the bifid root apex	Converging (narrowing) canal: When canal crosses root apex, there is reduction in its diameter. Hour glass appearance indicates partial encirclement of the canal
	c. If sudden narrowing of the root is noted where the canal crosses, it indicates the deep grooving or perforation of the root or involvement of the root with the canal	Diverted canal: The canal appears diverted, when it changes its direction. This is due to an upward displacement of the canal passing through the root
	d. The root may be seen deflected buccally, lingually or mesially distally, when it reaches the canal	



Figs 20.17A to D: (A) Lateral view: impacted lower third molar in the edentulous jaw; (B) Presence of lower third molars which are remained asymptomatic in a patient 75 years old; (C and D) Impacted molar in the ramus in inverted position



Figs 20.18A to G: Radiological prediction for inferior alveolar nerve (IAN) proximity: Diagrammatic representation related to changes seen in the roots: (A) Darkening of root; (B) Deflection of root; (C) Narrowing of root; (D) Dark and bifid apex, and related to changes in the canal: (E) Interruption of white line of the canal; (F) Diversion of canal and (G) Narrowing of canal

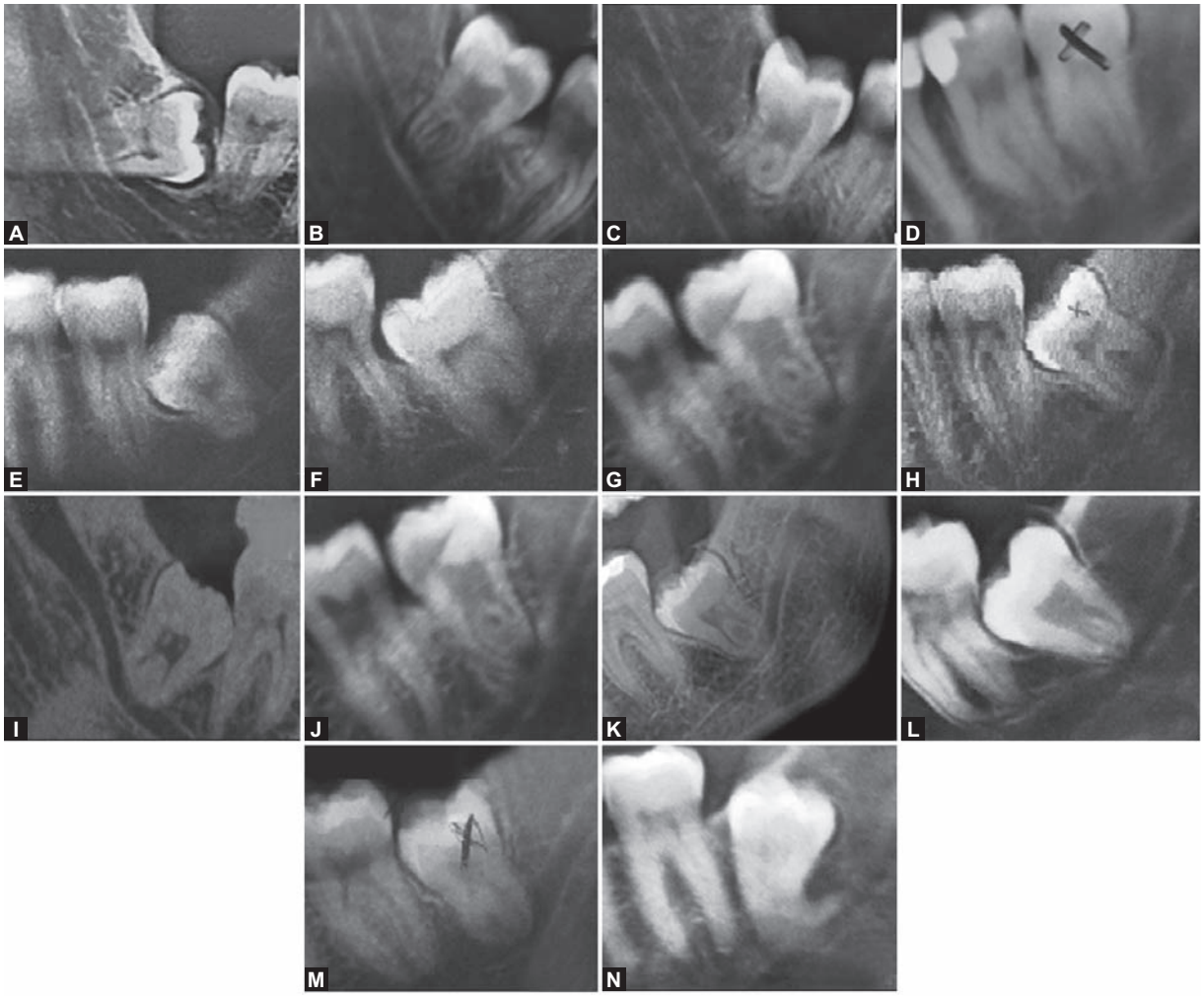
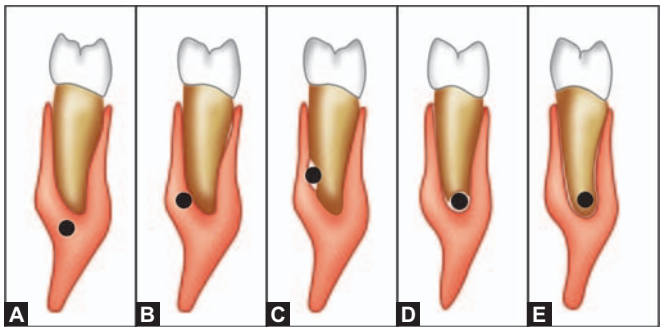
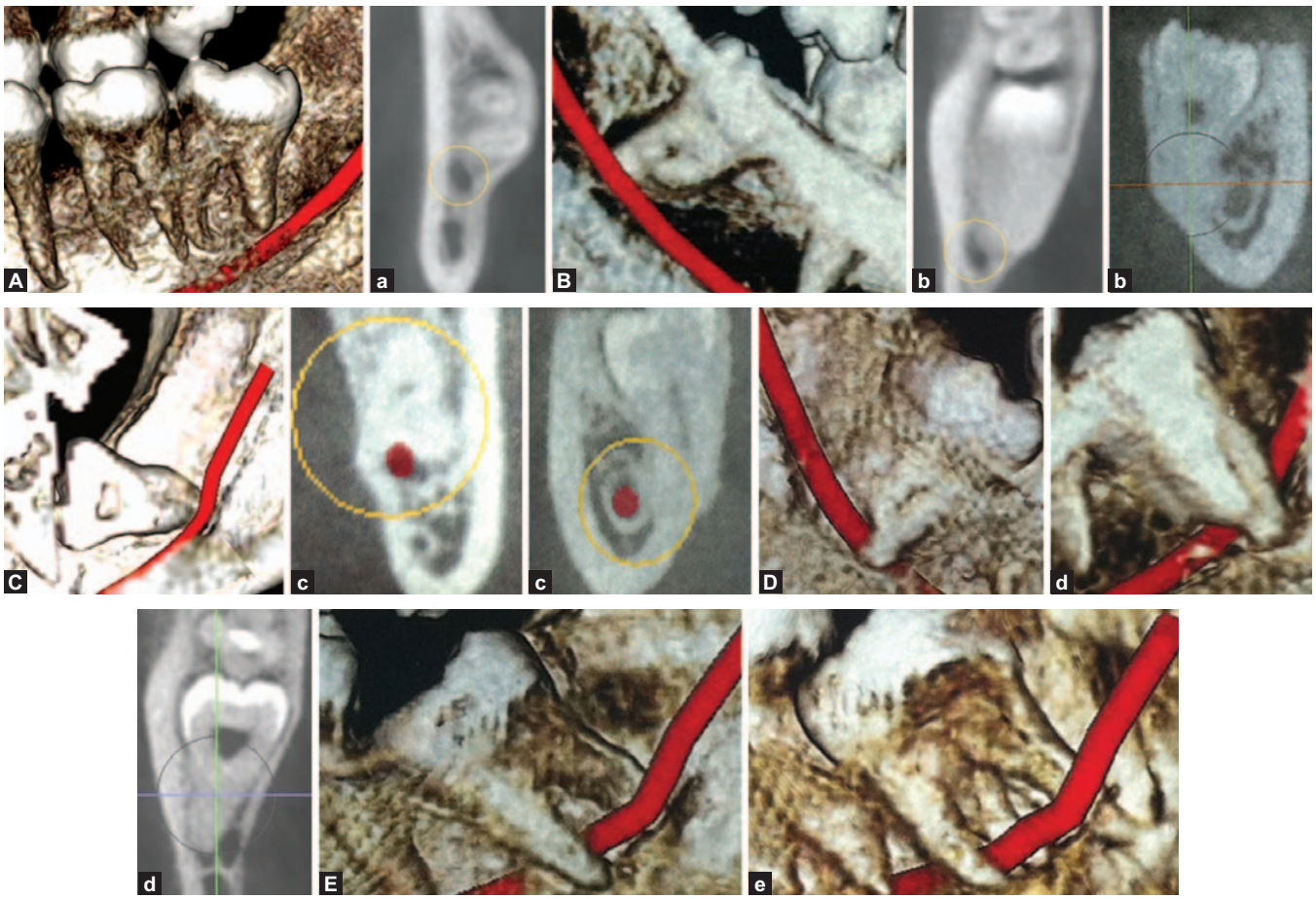


Fig.20.19 A to N: Actual radiographic pictures of inferior alveolar nerve canal proximity and radiographic changes seen: (A) and (B)Darkening of roots, (C and D) Deflection of roots; (E) Narrowing of root; (F and G) Dark and bifid apex; (H and I) Interruption of white line of the canal; (J, K and L) Diversion of canal; (M and N) Narrowing of canal

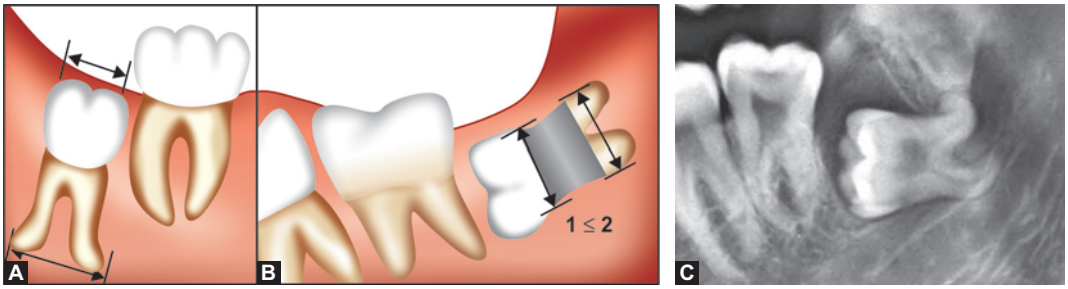


Figs 20.20A to E: (A) Root apex and inferior alveolar nerve (IAN) canal separated; (B) Root in contact with IAN canal; (C) Lingual aspect of the root is grooved by the canal; (D) Root apex is grooved by the canal; (E) Root tunnel through the canal

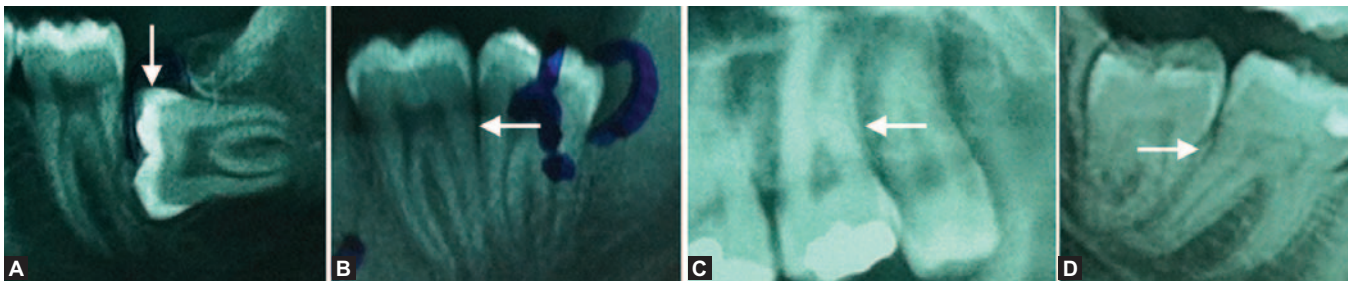
- **Size of the follicular sac:** Presence of large follicular sac makes the extraction easier, as the amount of bone removal is less. Nonexistent or narrow follicular sac around the crown will require bone cutting around the crown (difficult extraction).
- **Space or contact in relation to mandibular second molar:** If the impacted tooth is locked against the crown of the second molar and there is no space for elevation, then sectioning of the tooth should be planned **(Figs 20.23A to D)**.
- **Relationship to the inferior alveolar neurovascular bundle:** Proximity of the roots to the neurovascular bundle increases the possibility of the damage/injury



Figs 20.21A to E: Cone beam computed tomography (CBCT) pictures showing the relation of root apex to inferior alveolar nerve (IAN): (A, a) Root apex and IAN canal separated; (B, b, b) Root in contact with IAN canal; (C, c, c) Lingual aspect of the root is grooved by the canal; (D, d) Root apex is grooved by the canal; (E, e) Root tunnel through the canal



Figs 20.22A to C: (A) If divergent roots total width is more than the crown width, increases the difficulty; (B-1)—width of the crown at cementoenamel junction (CEJ) ≤ than, (B-2)—width of the roots at apical end, difficulty increases; (C) X-ray pic



Figs 20.23A to D: Tight contact of the impacted third molar with second molar: no space for elevation

to the nerve during extraction. Temporary altered sensation of the lower lip can be experienced by the patient (paresthesia/anesthesia) which can last for few days/few months. Radiological assessment is important. Dental scan or CBCT can show exact location of the nerve **(Figs 20.20 and 20.21)**

- Nature of covering tissue:
  - Soft-tissue impaction
  - Partial bony impaction: Covered by soft tissue, as well as partially by the bone
  - Fully bony impaction.
- Access to the operative field, inability to open the mouth wide, a large uncontrollable tongue, small orbicularis oris muscle (oral sphincter).
- Severe gag reflex: Increases difficulty.

Preoperative Assessment of Surgical Difficulty Level

Surgical extraction of impacted mandibular third molar is one of the most common procedures carried out by oral and maxillofacial surgeons. Extensive training, skill and experience allow this procedure to be performed in an atraumatic fashion with local anesthesia (LA), sedation, or general anesthesia. In some of the cases, the procedure may turn out to be a difficult one than anticipation. The range of difficult extractions from various studies cited is 4.1 to 44.5%.

Value of Preoperative Assessment of Surgical Difficulty Level

- Helps in drawing proper custom made treatment plan for an individual patient.
- Decision about referral to specialist care
- Decision about choice of anesthesia
- Decision about opting for day-care set-up or hospitalization (management style).
- Estimation of approximate surgery time and scheduling the appointment time slot accordingly.
- To provide scientific evidence based information regarding degree of surgical difficulty to the patient. (equally important for the operator too).
- Explain the possible complications to the patient along with expected difficulty and obtaining informed consent for the necessary surgical management.

Assessment of Surgical Difficulty

It is of prime importance for drawing an optimal treatment plan with minimum or no complications. A compilation

of both clinical and radiological information is a must to make tentative estimate of the difficulty to be encountered and the time required for this surgery.

A perusal of literature has shown that many studies are attempted to evaluate the elements, which can complicate surgical removal of impacted mandibular third molars.

Way back in 1926, George Winter described three imaginary lines, which can be plotted on a standard intraoral periapical X-ray (with paralleling technique or using positioning devices to avoid distortion of the image recommended by Howe in 1971).

Howe in 1971, popularized "Winter's lines" to determine the difficulty index of surgical extraction of mandibular third molar and introduced their use in the teaching program to determine the position and depth of impaction. The position and depth of the tooth can be assessed by taking intraoral X-ray or even lateral extraoral X-ray or OPG and tracing can be done (which was originally advocated by George Winter).

Three imaginary lines are drawn which are known as Winter's lines **(Fig. 20.24 and Table 20.5)**:

1. **White line** corresponds to the occlusal plane. The line is drawn touching the occlusal surfaces of first and second molar and is extended posteriorly over the third molar region. It indicates the difference in occlusal level of second and third molars.
2. **Amber line** represents the bone level. The line is drawn from the crest of the interdental septum between the molars and extended posteriorly distal to third molar or to the ascending ramus. This line denotes the alveolar bone covering the impacted tooth and the portion of tooth not covered by the bone.
3. **Red line** is drawn perpendicular from the amber line to an imaginary point of application of the elevator. It indicates the amount of bone that will have to be removed before elevation, i.e. the depth of the tooth in bone and the difficulty encountered in removing the tooth.

If the length of the red line is more than 5 mm, then the extraction is difficult. Every additional millimeter renders the removal of the impacted tooth three times more difficult (more than 9 mm—below the level of the apices of the second molar).

From **Table 20.5** difficulty index can be arrived at as follows:

- Distoangular impaction: 4
- Level B: 2

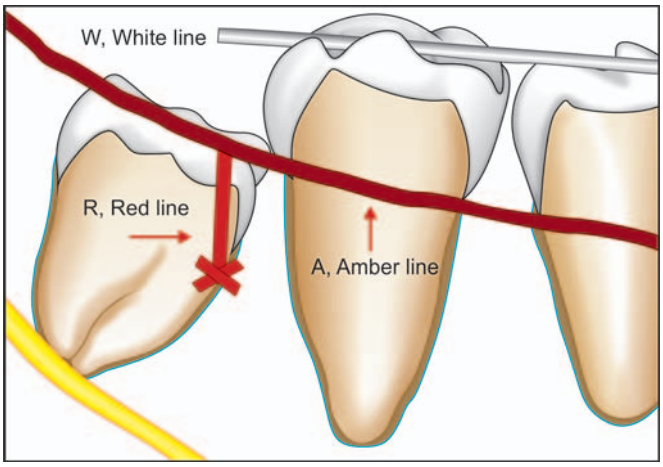


Fig. 20.24: Winter's lines

Table 20.5: Difficulty index for surgical extraction of impacted third molar

	Difficulty index
Very difficult	7–10
Moderately difficult	5–7
Minimally difficult	3–4

- Class II: 2

Eight is the total difficulty score; very difficult extraction.

Some of the authors have stated that this method of estimation has got only historical value, as periapical X-rays which are taken, may not be standardized and can give unreliable measurement to assess the surgical difficulty (change of angulation of the film, causes the "red line" to change in length significantly).

Pell and Gregory in 1933, attempted in defining the degree of difficulty through their classification, based on dental radiographic features. This method, though was used for many years, proved as unreliable indicator by Renton et al. in 2001 **(Table 20.6)**.

MacGregor in 1985, also attempted to establish a model for assessing surgical difficulty by expanding to WHARFE, which includes the Winter Lines along with other factors and has been used in various studies conducted **(Table 20.7)**.

Pederson (1988) described a method of scoring the surgical difficulty. His scale was widely used and cited in many textbooks. But it was found to be inadequate clinically by Edwards et al. (1998) and Yuasa et al. (2002) and Akadiri et al. (2009), after much evaluation **(Table 20.8)**.

Table 20.6: Difficulty index for removal of impacted lower third molars (Pell and Gregory)

Classification Angulation	*Difficulty index value*
Mesioangular	1 easiest to remove
Vertical	2
Horizontal/transverse	3
Distoangular	4
Depth	
Level A	1
Level B	2
Level C	3
Ramus relationship/space available	
Class I	1
Class II	2
Class III	3

Table 20.7: WHARFE assessment by MacGregor (1985)

Category	*Score*
Winter's classification	
• Horizontal	2
• Distoangular	2
• Mesioangular	1
• Vertical	0
Height of the mandible	
• 1–30 mm	0
• 31–34 mm	1
• 35–39 mm	2
Angulation of the third molar	
• 1–50°	0
• 60–69°	1
• 70–79°	2
• 80–89°	3
• 90° ++	4
Root shape	
• Favorable curvature	1
• Complex	2
• Unfavorable curvature	3
Follicles	
• Normal	0
• Possibly enlarged	1
• Enlarged	2

contd...

contd...

Exit path	
• Space available	0
• Distal cusps covered	1
• Mesial cusps covered	2
• Both the cusps covered	3
Total	*33*

Table 20.8: Difficulty index described by Pederson (1988) can be arrived from local anatomy observation and from radiographs

Classification	*Value*
Spatial relationship	
• Mesioangular	1
• Horizontal/transverse	2
• Vertical	3
• Distoangular	4
Depth	
• Level A: High occlusal level	1
• Level B: Medium occlusal level	2
• Level C: Deep occlusal level	3
Ramus relationship/space available	
• Class 1: Sufficient space	1
• Class 2: Reduced space	2
• Class 3: No space	3
Difficulty index	
• Very difficult	7–10
• Moderately difficult	5–7
• Slightly difficult	3–4

Table 20.9: Criteria of modified Parant scale

Easy level I	Extraction requiring forceps only
Level II	Extraction requiring osteotomy
Level III	Extraction requiring osteotomy and coronal section
Level IV	Complex extractions including root section

Parant introduced a scale in 1974, which was later modified in 1997, that takes into account the technique required for surgical extraction, as well as difficulty encountered intraoperatively as shown in **Table 20.9**. This difficulty level should be compared with preoperative assessment of surgical difficulty, carried out by other methods.

NEW INDEX PROPOSED BY NEELIMA MALIK (2016)

Predicting the degree of surgical difficulty, based on several traditional methods/scales/index is useful to certain extent, but not universally applicable. Going through the extensive literature search, we understand that it is practically difficult to evaluate all the factors that complicate removal of impacted third molars. This is due to the large variations among the patients and the difficulty which will be encountered **(Table 20.10)**.

The proposed new index by Neelima Malik uses many variables: both clinical and radiologic. It also takes into consideration of the surgeon factors. This index is extensive, but it will be useful to create awareness among the trainees, residents, dentists that emphasis should be removed only from dental variables and both clinical and radiological factors should be assessed jointly for precise prediction of the surgical difficulty. It can be used as a valuable teaching tool.

SURGICAL REMOVAL OF IMPACTED TEETH

John Tomes in 1849, first described the surgical access for removal of impacted tooth:

- Asepsis and isolation
- Local anesthesia/sedation or LA/general anesthesia
- Incision: Flap design
- Reflection of mucoperiosteal flap
- Bone removal
- Sectioning (division) of tooth
- Elevation
- Extraction
- Debridement and smoothening of bone
- Control of bleeding
- Closure—suturing
- Medications—antibiotics, analgesics, etc.
- Follow-up.

ISOLATION OF SURGICAL SITE

- Scrubbing + painting of skin and oral mucosa. Scrubbing solutions used first on skin only:
  - Cetrimide + absolute alcohol or cetrimide + povidone + iodine
  - Cetrimide + absolute alcohol + chlorhexidine.
- Cleaning solutions—used on skin only to remove residual soap solution:
  - Normal saline
  - Alcohol—spirit
- Painting solution—act topically to inhibit further growth of microbes:
  - Povidone-iodine 5% for skin, 1% for oral mucosa
  - Chlorhexidine gluconate—7.5% for skin, 0.2% for rinsing oral cavity.
- Drape the patient with sterile drapes to cover upper part of the face to isolate the oral cavity.

Local Anesthesia

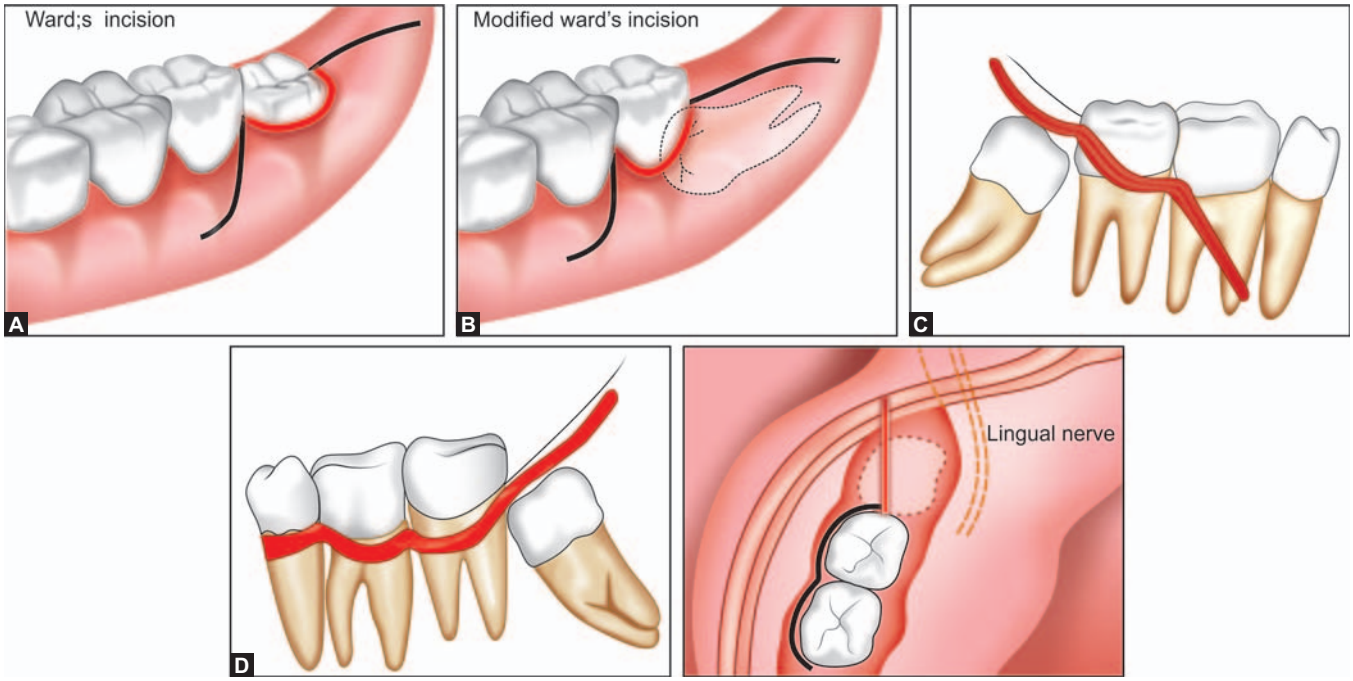
- **For mandibular molars and canines—** Pterygomandibular nerve block
- **For maxillary molars—**posterior superior alveolar nerve block and palatine nerve block or infiltration
- **For maxillary canines—**infraorbital nerve block + palatal infiltration of incisive canal and bilateral palatine nerve blocks.
- **Good infiltration** is a must to provide hemostasis and to define the tissue planes
- Saline adrenaline in concentration of 1: 400,000
- Plain saline (in case of hypertensive patients)
- LA solution with adrenaline.

Incision (Flap Design)

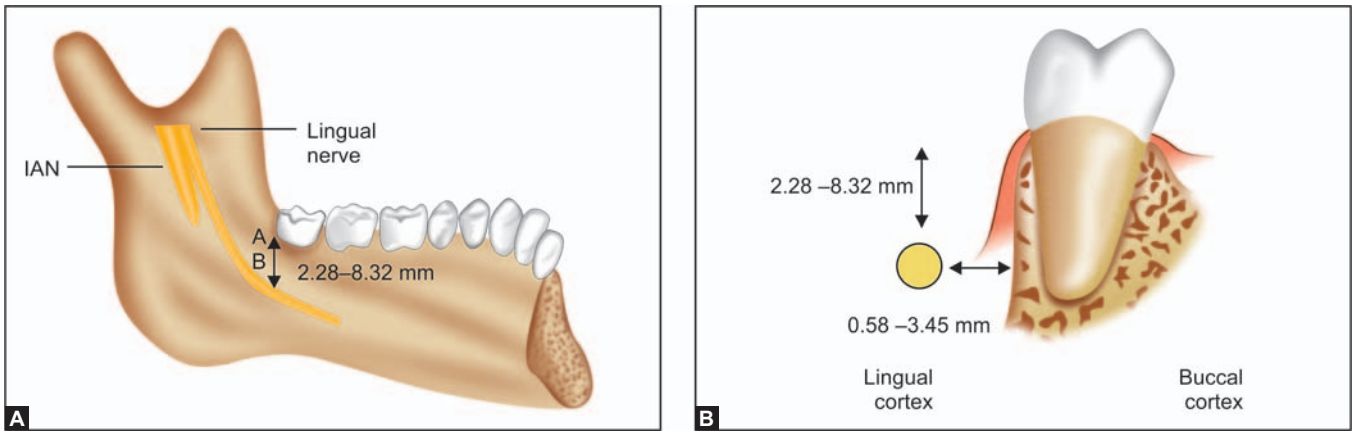
The mucoperiosteal flap for removal of impacted tooth is required to be designed well for adequate access, visualization of the tooth and for enough placement of retractor, drilling equipment as well as for elimination of obstruction to the pathway of removal. The incision for this mucoperiosteal flap will have an anterior limb and a posterior limb connected with or without an intermediate limb. The incision is made with no. 15 blade **(Figs 20.25A to D)**.

Reflection of Mucoperiosteal Flap for Mandibular Molars

Anterior releasing incision should begin from the vestibule upwards towards midway of the CEJ of second molar at an angle. If third molar is deep and surgery requires more removal of bone, this incision should be placed anterior to the second molar. The incision is then continued in the gingival sulcus (over the alveolar crest, if tooth is fully embedded) up to the distal aspect of third molar. Distal releasing incision is started from the distal most point of third molar across external oblique ridge into the buccal mucosa. This incision should not be taken on the lingual aspect of the ridge, as the lingual nerve can be found at or above the crest of the alveolar ridge, in approximately 17% of the population, immediately



Figs 20.25A to D: (A to C) Vertical mucoperiosteal flap design; and (D) An envelope flap design



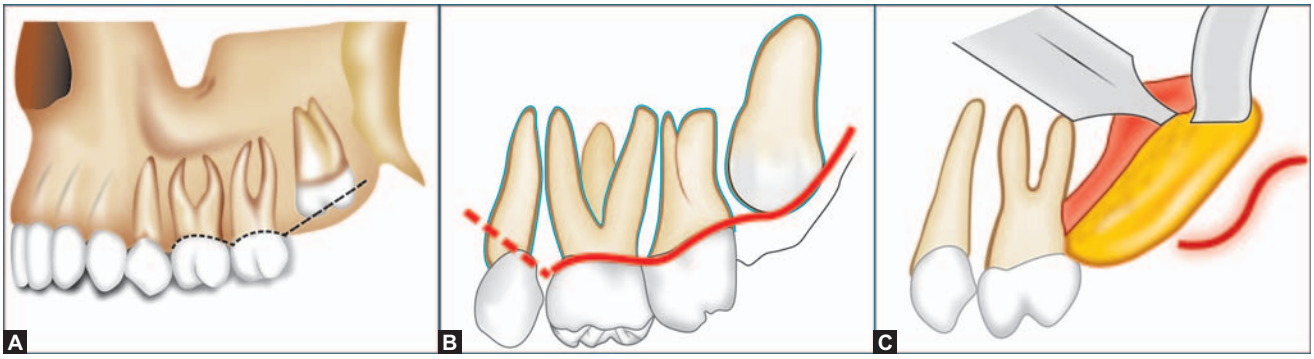
Figs 20.26A and B: Relationship of lingual nerve location to lingual cortex

beneath the periosteum and at risk from trauma. However, the normal position of the lingual nerve is 2 mm inferior to the crest and 0.5 mm lingual to the lingual cortex of the mandible in the third molar region. In order to protect the lingual nerve trauma, careful elevation of a lingual flap with an appropriate sharp periosteal elevator and placement of a suitable retractor is the key factor **(20.26A and B)**.

The length of this mucoperiosteal flap and the number of teeth included will be determined by the amount of exposure necessary to gain the visibility of the region and the experience of the clinician.

The incision should not be extended too far upward distally to avoid:

- Intraoperative brisk bleeding from the buccal vessels and anastomosing branches from lingual and facial arteries
- Postoperative trismus due to cutting through the fibers of temporalis muscle
- Herniation of buccal pad of fat into the surgical field.



Figs 20.27A to C: Mucoperiosteal flap design for the removal of impacted maxillary third molar. Dotted line indicates possible extension of the incision for additional access

The sharp point of periosteal elevator is used to carefully elevate a mucoperiosteal flap beginning at the point of the incision behind the second molar. The elevator is brought forward to elevate the periosteum around the second molar and down the releasing incision. The other flatter end of the periosteal elevator is then used to elevate the periosteum posteriorly to the ascending ramus of the mandible. A Minnesota retractor is placed just lateral to external oblique ridge and stabilized against the lateral surface of the mandible. It should be held by a few fingers at its distal end without hand holding, so that it does not block the vision of the operator.

For Maxillary Molars

The anterior releasing incision is started anterior to second molar from the vestibule and till the mesial interdental papilla of the second molar. The incision should follow the gingival sulcus of second molar and continue over the tuberosity area from the distal most point of second molar **(Figs 20.27A to C).**

For Maxillary Canines

If the canine is buccally placed:

- Flap with anterior releasing incision
- Trapezoidal flap
- Semilunar flap.

If the canine is palatally placed—the incision is taken in the gingival sulcus on the palatal side from the mesial aspect of the first molar of the same side. Releasing incision is given obliquely across the palate and should be deflected away from the palatine foramen. If unilateral—an incision is restricted to the canine region of the opposite side. If bilateral—an incision is extended to the first molar of the opposite side.

For Mandibular Canines

If buccally placed then crevicular incision from the midline is taken up to first molar. Anterior releasing incision is given close to the midline. Care should be taken to protect the mental nerve. If the canine is placed on the lingual side, then lingual envelope flap is taken.

Bone Removal

Aim

- To expose/uncover the crown by removing the bone overlying it
- To remove the bone obstructing the pathway for removal of a tooth.

How much Bone is to be Removed?

Adequate amount of bone should be removed to enable the elevation and deliver the tooth. But the extensive bone removal can be minimized by sectioning the tooth.

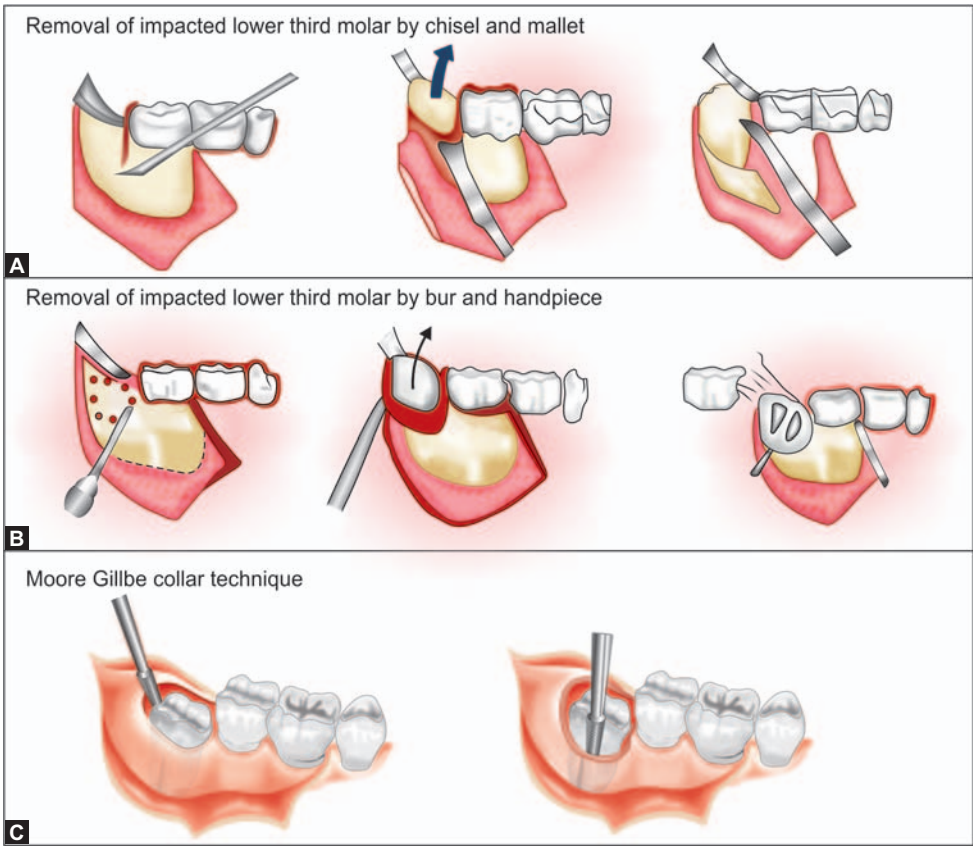
Two Ways of Bone Removal (Figs 20.28A to C)

- High speed, high torque handpiece and bur technique: Micromotor –12,000 to 20,000 rpm preferred for dentoalveolar surgery
- Chisel and mallet technique.

Bur Technique

Either no. 7/8 round bur or a straight no. 702 or 703 carbide fissure bur is used. Either of these burs can be used for bone removal or for sectioning of a tooth. Burs should be always used along with copious saline irrigation to avoid thermal trauma to the bone.

- **First step:** The bur is used in a sweeping motion around the occlusal, buccal and distal aspects of the



Figs 20.28A to C: Removal of impacted lower third molar by:(A) Chisel and mallet; (B) With bur and handpiece; (C) Moore Gillbe collar technique

mandibular third molar crown to expose it and to have its orientation.

- **Second step (Moore Gillbe Collar technique):** Once the crown has been located, the buccal surface of the tooth is exposed with the bur to the cervical level of the crown contour and a buccal trough or gutter/collar is created. The buccal trough should be made in the cancellous bone. It is important that the adequate amount of trough is created to remove any bony obstruction for exposure and the delivery of the tooth, especially around the distal aspect of the crown. The distolingual portion of the tooth should be exposed without cutting through the lingual bony plate to prevent damage to the lingual nerve.

For the canine removal, the gutter/trough is created around the surface of the crown free from the contact with the neighboring/overlying teeth. The bone removal around the crown is done till CEJ and to expose the crown beyond the greatest width.

Important precautions while drilling the bone:

- Protect overlying soft tissues by retraction with either Minnesota retractor or periosteal elevator or Langenbeck retractor
- Continuous irrigation either with 1% povidone-iodine or with normal saline to reduce the thermal necrosis of bone.

Chisel and mallet technique:

- Historical importance
- Very rarely used
- Less bone necrosis than bur technique
- Can cause inadvertent fracture of the bone
- The jaw bone should be supported, while using this technique.
  - **First step:** For mandibular/maxillary molars, the first step is the placement of vertical stop cut,

which is made by placing a 3 mm or 5 mm chisel vertically at the distal aspect of the second molar with bevel facing posteriorly (5–6 mm height). The aim is to prevent the force transmission anterior to the direction of the bone removal.

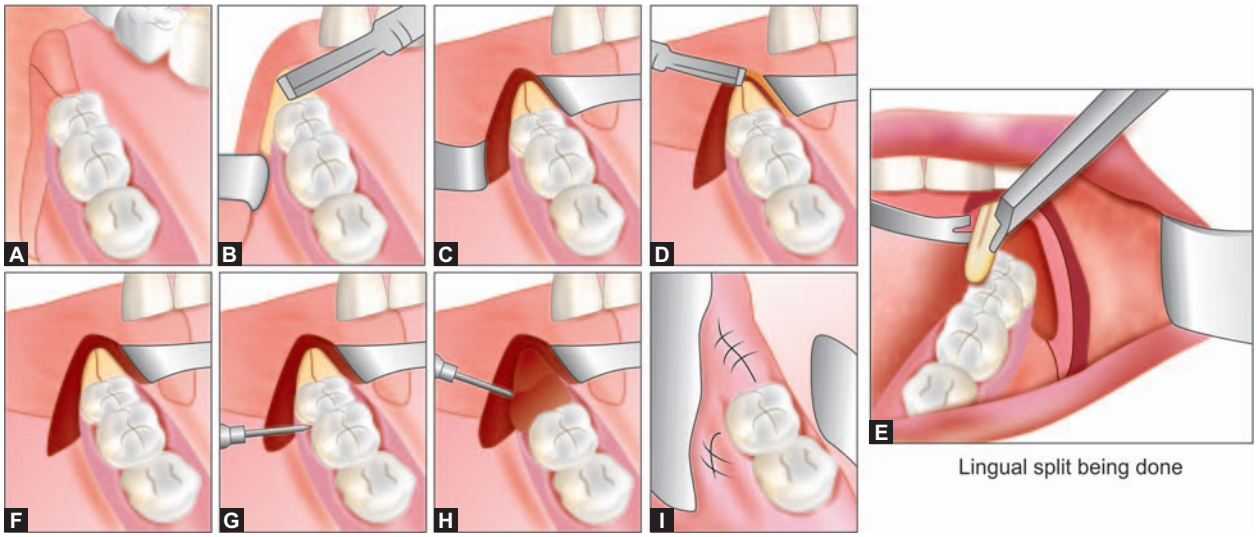
- **Second step:** At the base of the vertical stop (limiting) cut, the chisel is placed at an angle of 45° with the bevel facing upwards or occlusally, and oblique cut is made till the distal most point of third molar. This will result in the removal of a triangular piece of buccal plate distal to second molar. Additional triangular piece of bone is removed at the junction of vertical and oblique bone cut to gain the entry of the elevator tip. Finally, the distal bone must be removed, so that when the tooth is elevated, there should be no obstruction at the distobuccal aspect.

Lingual Split Bone Technique

- It is described originally by Sir William Kelsey Fry in 1933 **(Figs 20.29A to I)**
- Later popularized by T Ward
- Quick and clean technique
- Creates a saucerization of the socket, thereby reduces the size of the residual blood clot
- Used for mandibular third molar removal, especially those which are placed lingually
- Support the mandible at the inferior border.

Steps

1. Vertical stop cut is made by placing the chisel with the bevel facing posteriorly, distal to the second molar.
2. With the chisel bevel downward, a horizontal cut is made backward from the lower end of the vertical limiting stop cut.
3. The buccal bone plate is removed above the horizontal cut.
4. The distolingual bone is then fractured inward by placing the cutting edge of the chisel along the dotted line. Bevel side of the chisel is facing upward and cutting edge is parallel to the external oblique ridge. The chisel is held at 45° to the bone surface.
5. Finally, small wedge of bone, which then remaining distal to the tooth and between the buccal and lingual cut, is excised and removed.
6. A sharp straight elevator is then applied and minimum force is used to elevate the tooth. As the tooth moves upward and backward, the lingual plate gets fractured and facilitates the delivery of the tooth.
7. After the tooth is removed, the lingual plate is grasped with the hemostat and freed from the soft tissue and removed.
8. Smoothening of the edges is done with bone file. Wound irrigated and sutured.



Figs 20.29A to I: Lingual split bone technique

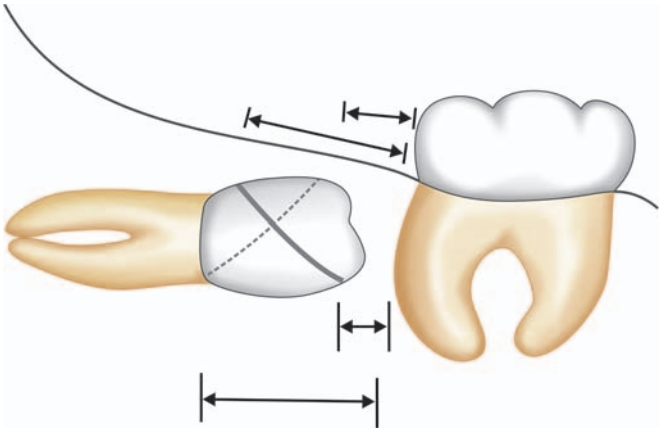


Fig. 20.30: Broken line: Incorrect sectioning leaves the segment that is bigger at the bottom than top and creates obstruction for elevation

TOOTH/ROOT SECTIONING: SPLITTING OF TOOTH/ROOT-ODONTECTOMY

- Reduces the amount of bone removal (conserves the bone) required prior to elevation of the tooth **(Figs 20.30 and 20.31A to C)**
- Reduces the risk of damage to the neighboring teeth/inadvertent luxation
- Avoids inadvertent jaw fracture
- Reduces total surgery time
- Reduces postoperative edema
- Planned sectioning permits the parts of the tooth to be removed separately in an atraumatic manner by creating space into which it is displaced and the remaining crown or root segments removed
- The direction in which the impacted tooth should be sectioned is dependent on the angulation of the impacted tooth, based on the line of draw of the segments
- Can be performed either with a bur or chisel. Bur use is preferable. Mallet blows may give psychological discomfort to the patient
- The bur is used in a controlled fashion to avoid damage to the vital structures and surrounding teeth and soft tissues
- The tooth is usually sectioned one-half to three-fourths with the bur and then it is completely sectioned with the elevator
- While sectioning care should be taken that the segment at the top should be bigger than at the bottom **(Fig. 20.30)**.
- Purchase points also can be placed at the time of sectioning
- Fissure bur size—1.5 mm in diameter and at least 7 mm in head length.

Indications for Odontectomy

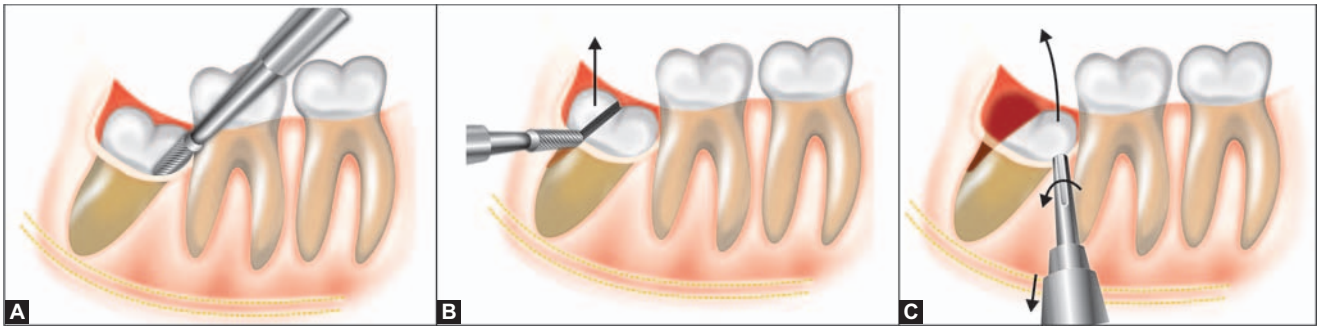
- Deep impacted tooth, with lot of bone coverage
- Large bulbous crown, locked under second molar
- Unfavorable root anatomy: divergent, dilacerated, hooked, curved, extra roots, hypercementosis
- Roots with close proximity to IAN
- Extensively carious tooth
- Bulbous roots with mesiodistal diameter more than the tooth diameter at the cervical line
- Narrow periodontal ligament space: Difficult placement for elevator.

Horizontal Impaction

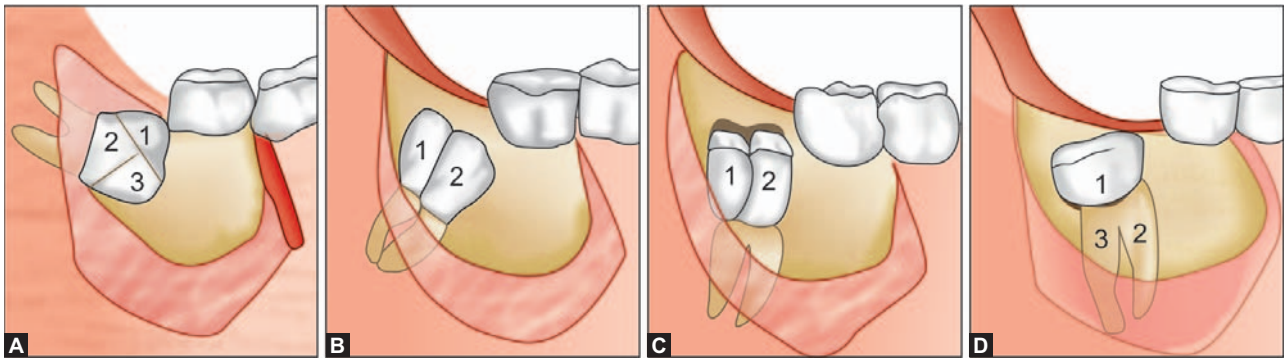
This is same as that for distoangular impaction **(Fig 20.32A)**.

Mesioangular Impaction

Distal half of the crown is sectioned off from the buccal groove till the CEJ; from buccal to lingual and extended into the furcation. A straight elevator is placed in the cut



Figs 20.31A to C: Sectioning and elevating the third molar



Figs 20.32A to D: Sectioning method during removal of impacted lower third molar: (A) Sectioning of the horizontally placed lower third molar; (B) Sectioning of the mesioangularly placed lower third molar; (C) Sectioning of the vertically placed lower third molar; (D) Sectioning of the distoangularly placed lower third molar

and rotated to fracture the distal portion of the crown which is removed. Then a straight elevator is placed on the mesial aspect of the third molar below the cervical area. A purchase point can be prepared into the crown at the mesiobuccal line angle with a small round bur, if the access to the elevator is not possible. Then a Cryer or crane pick elevator can be used to elevate the tooth, engaging the purchase point **(Fig. 20.32B)**.

Vertical Impaction

Sectioning is similar to mesioangular disimpaction procedure **(Fig. 20.32C)**.

Distoangular Impaction

It is most difficult to remove, because of its pathway of delivery into the ascending ramus. Large amount of distal bone removal is required. The crown is sectioned from the roots just above the cervical line after sufficient bone is removed from the occlusal and distobuccal aspect. The entire crown is removed to improve the visibility and access to the roots. If the roots are divergent, they are further sectioned into two pieces and delivered individually. If the roots are convergent the simple use of straight elevator is sufficient **(Fig. 20.32D)**.

Elevation

- **Coupland elevator:** Placed at the base of the crown
- **Winter Cryer's:** It may be used in wedging action/buccal elevation. Buccal elevation may be done in molar and canines by drilling a purchase point in the roots just below CEJ
- Wedging action is useful, when molar crown is split vertically down to bifurcation of roots.

Important Precautions

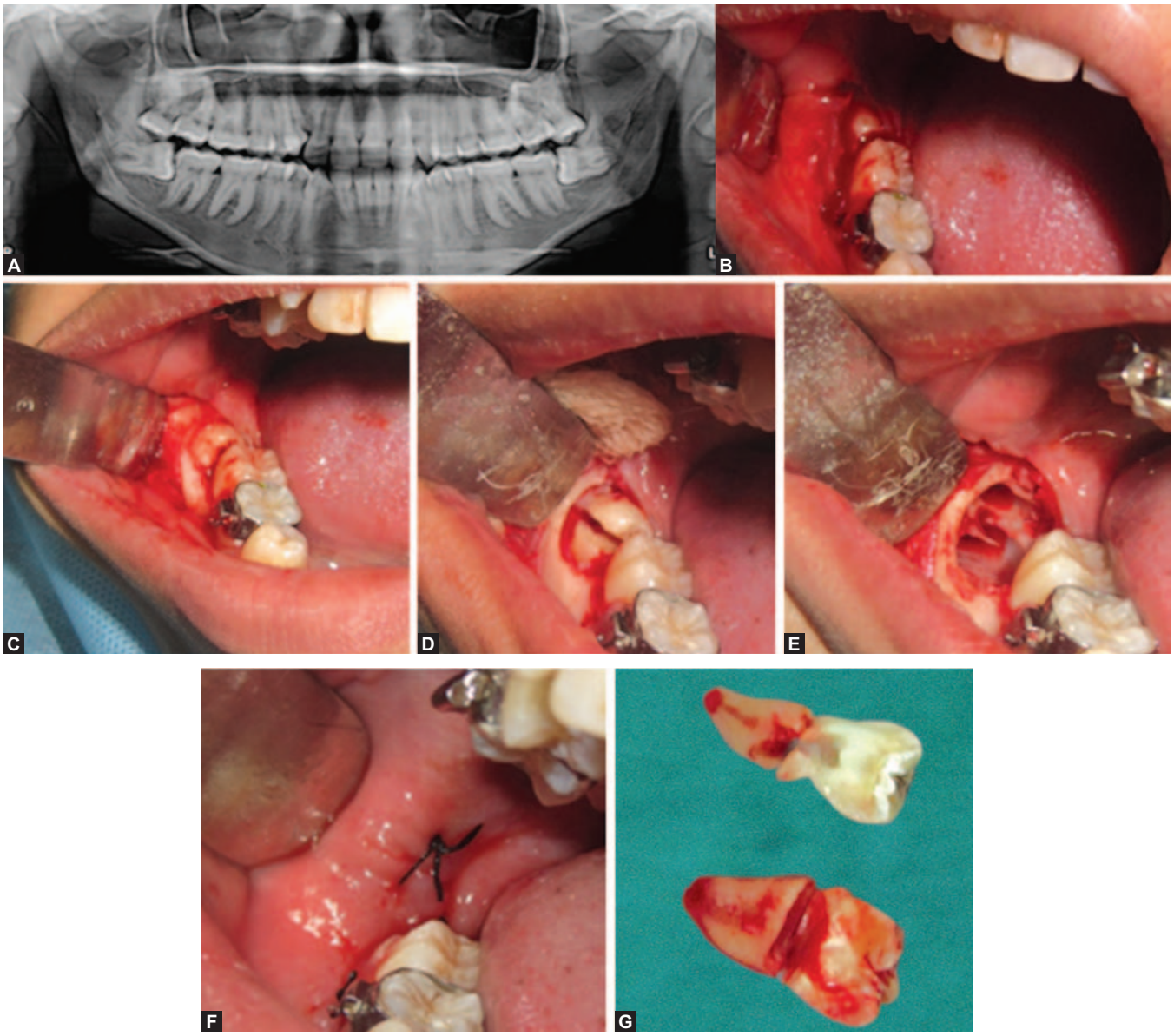
- Support the inferior border and lingual cortex of the bone in the mandibular impaction
- Support to the palatal bone in the maxillary third molar or canine impactions during elevation should be given
- Support the neighboring tooth to prevent luxation of the same.

Debridement, Decontamination and Smoothening of Bone Margins

- Irrigation of the socket
- Curetting to remove any remaining dental follicle and epithelium.
- Look for pieces of coronal portion (especially in carious teeth/sectioned teeth), check for remnants of bone/granulation tissue, bleeding points.
- Inspection for the fracture of lingual plate or sharp margin on the lingual margin.
- Check for caries (root/crown/erosion/damage) to the adjacent teeth.
- Round off the margins of the socket with large vulcanite round bur or bone file.
- Irrigate the socket again and inspect again
- Control bleeding before suturing.

Closure with Proper Approximation

A 3-0 black silk is used. Interrupted sutures given and maintained for 7 days. 21 mm or 22 mm half circle or 1.25



Figs 20.33A to G: Surgical procedure for removal of lower right impacted third molar: (A) Orthopantomogram (OPG) of horizontally impacted lower right third molar; (B) Intraoral clinical picture; (C) Incision and mucoperiosteal flap reflection; (D) Sectioning of a tooth; (E) Surgical extraction done; (F) Suturing; (G) Extracted tooth

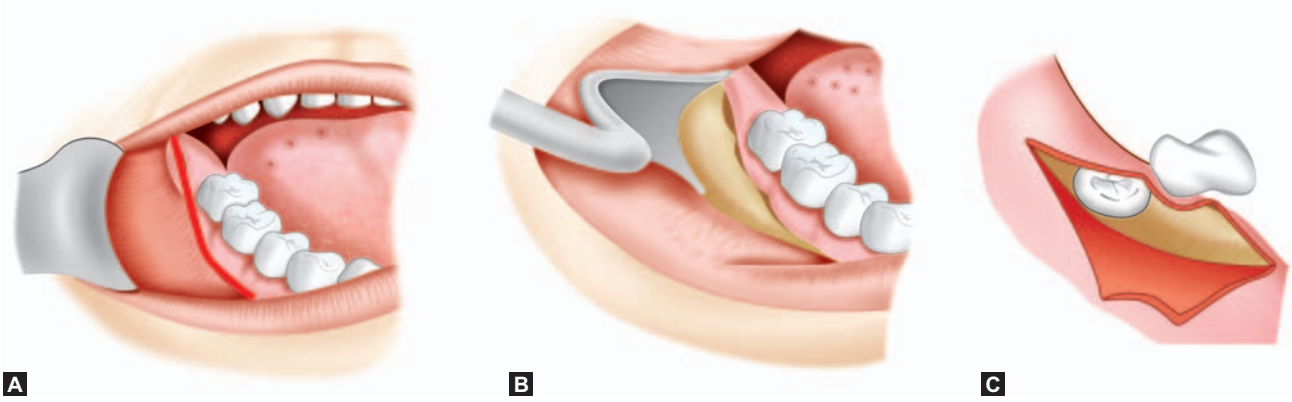
mm 5/8 circle cutting needle is used. Complete surgical procedure for the removal of lower impacted third molar is shown in **(Figs 20.33A to G)**.

In case of molars, suture distal to second molar should be placed first and should be water tight to prevent pocket formation. Use as few sutures as possible.

In case of palatally impacted canines, incisive papilla should be sutured carefully to reduce postoperative bleeding.

EARLY REMOVAL OR GERMECTOMY: LATERAL TREPHINATION TECHNIQUE

- Described by Bowdler Henry **(Figs 20.34A to C)**
- Removal of the unerupted wisdom tooth, with less than one-third root formation (9–16 years age)
- Advocated, when prediction of interference with the proper development or eruption of second molar is made



Figs 20.34A to C: (A) S-shaped incision; (B) Mucoperiosteal flap reflection; (C) Exposure of the crypt by lateral trephination



Figs 20.35A to C: (A) Proximity to inferior alveolar nerve (IAN); B) Coronectomy; (C) Reduction of roots

- A modified S-shaped incision is used, from retromolar fossa, across external oblique ridge to the first molar. It leaves behind 5 mm cuff of attached gingiva. Round bur is used to trephine the crypt of the third molar
- Lower complication rate
- Quick postoperative recovery
- Avoidance of future complications associated with the presence of impacted third molar.

CORONECTOMY

It is the alternative surgical option, suggested for impacted mandibular third molars, which are in significantly close proximity to IAN. This method avoids injury to IAN **(Figs 20.35A to C)**.

Basis for Coronectomy

It is a common practice for broken root fragments, which are difficult to remove, to be left behind in situ and most of them heal uneventfully.

It involves removal of a crown of mandibular healthy impacted third molar from the roots, in healthy patients (40 years and above). It is also termed as intentional partial odontectomy.

Procedure

The tooth is decoronated, with the help of a bur, at an angle of 45°, below CEJ and the roots are reduced 2–4 mm below the crest of buccal and lingual cortical plates. The crown of the tooth is removed, leaving behind the vital roots in situ, untouched. This procedure was first proposed by Ecuyer and Debien in 1984. But it was not very popular, as there was a concern that the roots are left behind, will eventually become a source of infection. But since 2005, the renewed interest was generated in this procedure and then many oral surgery departments in UK and USA started using it routinely in selected cases.

Through some studies, it was claimed that in 14–81% of cases, there was subsequent migration of the remaining roots. Otherwise, roots encased in the bone, can remain

Table 20.10: New index proposed by Neelima Malik (2016)

Radiographic dental variables available on periapical X-ray or orthopantomographs	*Dr. Neelima malik`s new proposed index 2016 for assessing surgical difficulty of removal of impacted third molar.*
Anatomical features based on X-ray study	**Score**
1. Pederson`s modified index	
A. Angulation of the tooth	
• Vertical	1
• Mesioangular	2
• Horizontal	3
• Distoangular	4
B. Depth-occlusal level of third molar compared with second molar	
• Level A—High occlusal Level	1
• Level B—Medium occlusal level	2
• Level C—Deep occlusal level	3
C. Ramus /retromolar space relationship	
• Class I—Sufficient space-ratio ≥1	1
• Class II—Reduced space-ratio <1, but >0.5	2
• Class I—No space-ratio <0.5	3
D. Follicular space	
• Present	1
• Absent	2
E. Relative horizontal position of third molar	
• Center	1
• Buccal deflection	2
• Lingual deflection	3
F. Angulation of impaction Angle measured by a protractor in degrees formed between the intersected long axis of the second and third molar	**Gbotolorun, 2007**
• Vertical 10° to –10°	1
• Mesioangular 11° to 79°	2
• Horizontal 80° to 100°	3
• Distoangular –11° to –79°	4
• Others 111° to –80°	5
2. Depth from point of elevation	**Santamaria Arteagatia et al.,1997** **Gbotolorun-2007**
• Slightly Difficult 0–3 mm	1
• Moderately Difficult 4–6 mm	2
• Very Difficult >6 mm	3
3. A. Tooth crown status	
• Intact/slightly carious	1
• Extensively carious	2
B. Tooth crown lock under second molar	
• Absent	1
• Present	2 to 3

Contd...

Contd...

C. Shape of crown locked under second molar-	
• Small	1
• Big/bulbous	2
4. Root morphology	
A. Width of the root	**Kharma et al., 2014**
• Thin (A ≥ B)—Slender/short-easy	1
• Bulbous (B > A)—Moderately difficult	2
• Thick-Multiple Roots—B > A, B > Thickness of all roots combined	3
• Hypercementosis/ankylosed roots	4
B. Number of roots	
• Singular	1
• Two Roots	2
• Three or More Roots	3
C. Root development status	
• Complete	1
• Incomplete	2
• In case of ⅓ root formation-Ball & Socket type	4
D. Curvature of the roots to the long axis of the second molar	**Favorable:** When the roots are curved in the direction and towards the path of elevation **Unfavorable:** Roots are curved in opposite direction and against path of elevation
• Straight---Favorable	1
• Convergent--- Favorable	2
• Divergent--- Unfavorable	3
• Dilacerated--- Unfavorable	4
5. A. Root—periodontal membrane/ligament interface/space	
• All around the tooth clear	1
• Partly, in some areas around the tooth clear	2
• Nil/sclerosed/not clear all around the tooth	3 to 4
B. Root contact of third molar with second molar	
• No contact with second molar	1
• Contact with crown only	2
• Contact with crown and root	3
• Contact with root only	4
• Overlap	5
6. Root proximity to inferior alveolar nerve canal	
• No contact—Distance between root apex and canal is more than 2 mm	0
• Approximation—Root apex <2 mm from canal, but no direct contact	1
• Contact with root apex and canal, impinging, overlap, touching	2
• Nerve passing/crossing between the roots	3

Contd...

Contd...

7. Bone density	
• Normal pattern	1
• Thick sclerotic bone	2 to 3
Clinical assessment	***Patient variables***
1. Age	
• 16 to 24 years	1
• 25 to 35 years	3
• Above 35 years	3
2. Ethnic background-if you are dealing with international patient groups	Difference in bone density is seen in different ethnic groups. Crown width, unfavorable root formation is seen more in Black American groups.
3. Gender	
• Male	1
• Female	2 (Nakagawa 2007-Mandibular lesser bone thickness in females)
3. BMI—body mass index Weight in Kg.divided by height in meters squared.	**Overweight-BMI >25 kg/m²**
• Below 18	1
• 18 to below 25	2
• 25 to below 30	3
• Above 30	4
4. Maximum mouth opening	**Interincisal distance with prop in place-mean 42 mm**
• Adequate 42 to 50 mm	1
• Little Restricted 35-40 mm	2
• More Restricted below 30 mm	3
5. A. Cheek flexibility/retractability	Distance from the cheek retractor to the dental midline.(Inelastic/ chubby cheeks-problematic)
• Adequate	1
• Less than <5 mm	2 to 3
B. Oral commissure	
• Normal	0
• Macrostomia	0
• Microstomia	2 to 3
6. Tongue size	
• Normal	1
• Macroglossia	2 to 3
7. Gag reflex-vomiting reflex	
• Absent	0
• Present	2 to 3
8. Patient fear factor	
• Cooperative patient	1
• Uncooperative patient	2 to 3
9. Preexisting TMJ disorders	Pain on opening,subluxation,dislocation of TMJ
• Absent	0
• Present	2 to 3

Contd...

Contd...

10. Developmental jaw disorders	
• Retrognathia	1
• Micrognathia	2 to 3
Surgical Variables	
• Type of Anesthesia	
• Surgeon-senior/Junior/Trainee	
• Surgeon`s skill,experience,speed	
• Competency of assistant	
• Total surgery time	

buried for years together and rarely cause problem. In 3% of cases, the root migration, away from IAN is seen within first 24 months. Pogrel and Renton has also stated that within 2–5 years, roots may erupt away from IAN. Therefore, additional possibility of surgical procedure should be intimated to the patient.

Special Consent

It should be taken from the patient that this procedure is relatively new preventive method to decrease the prevalence of IAN injury and there may be risk of early or late infection following coronectomy. Also, there can be chances of "root walkout" during coronectomy, in that case the root has to be removed and chances of nerve injury may be there.

COMPLICATIONS

Intraoperative Complications

During Incision

For molars, facial vessel or buccal vessel may be cut. Injury to lingual nerve, if not careful. For lower canines, mental nerve vessels and for upper canines—incisive canal or greater palatine vessels may be damaged.

During Bone Removal

- Damage to the second molar
- Damage to the roots of overlying teeth
- Slipping of the bur into the soft tissues
- Breakage of the bur and getting embedded in the bone
- Extraoral mucosal burns
- Fracture of the mandible when using chisel and mallet.

During Elevation

- Luxation of neighboring/overlying tooth
- Fracture of the adjoining bone
- Fracture of the tuberosity
- Slipping of the tooth into pterygomandibular/temporal spaces, sublingual pouch and/maxillary sinus
- Damage to nasal wall/overlying teeth/lingual, inferior alveolar or mental nerve
- Fracture of mandible
- Soft-tissue injury
- Breakage of elevator tip
- Temporomandibular joint (TMJ) dislocation.

During Debridement

- Damage to IAN/lingual nerve
- Damage to maxillary sinus.

Postoperative Complications

- Pain, swelling, trismus, hypoesthesia, sensitivity, loss of vitality of neighboring teeth
- Hemorrhage, edema, infection, etc.
- Pocket formation
- Sinus tract formation, oroantral fistula, oronasal fistula.

Points to Remember

- Definition of impacted tooth
- Various theories responsible for causing impaction of a tooth
- Indications for extraction of impacted tooth
- Classifications of impacted teeth
- Factors responsible for increasing the surgical difficulty
- Surgical procedure for removal of impacted tooth
- Complications.

CHAPTER 21 Surgical Endodontics

INTRODUCTION

Surgical endodontics is defined as "removal of pathologic tissues, other than the contents of root canal to retain a tooth, with pulpal/periapical involvement". Apicoectomy, apical surgery, endodontic surgery, root resection, root amputation, periradicular surgery are the terms which are used for surgery involving the root apex to treat the apical infection. It is the cutting off of the apical portion of the root and curettage of periapical necrotic, granulomatous, inflammatory or cystic lesions. In spite of good endodontic treatment, if periapical lesions are not resolved, then apical surgery is undertaken. Objectives of surgical endodontics are to ensure the placement of a proper seal between the periodontium and the root canal foramina.

INDICATIONS

- **Failed nonsurgical endodontic treatment:**
  - Irretrievable root canal filling material
  - Irretrievable intraradicular post
  - **Anatomic variations:** Apical anomaly of root tip—dilacerations, intracanal calcification/calcific metamorphosis of the pulp space, open apex, internal/external root resorption
  - **Procedural errors:**
    - Instrument fragmentation, non-negotiable ledging, root perforation
    - Presence of lateral/accessory canal/apical region perforations, symptomatic overfilling
    - Extension of root canal sealant cement/filling beyond the apex
    - Fracture of apical third of the root.
- **Biopsy:**
  - Formation of periapical granuloma/cyst
  - Draining sinus tract/nonresponsive to root canal treatment (RCT)
  - When patient with chronic periapical infection, will not be available for follow-up.
- **Corrective surgery:**
  - Root resorptive defects/root caries
  - Root resection
  - Hemisection/bicuspidization
  - Teeth with ceramic crowns.

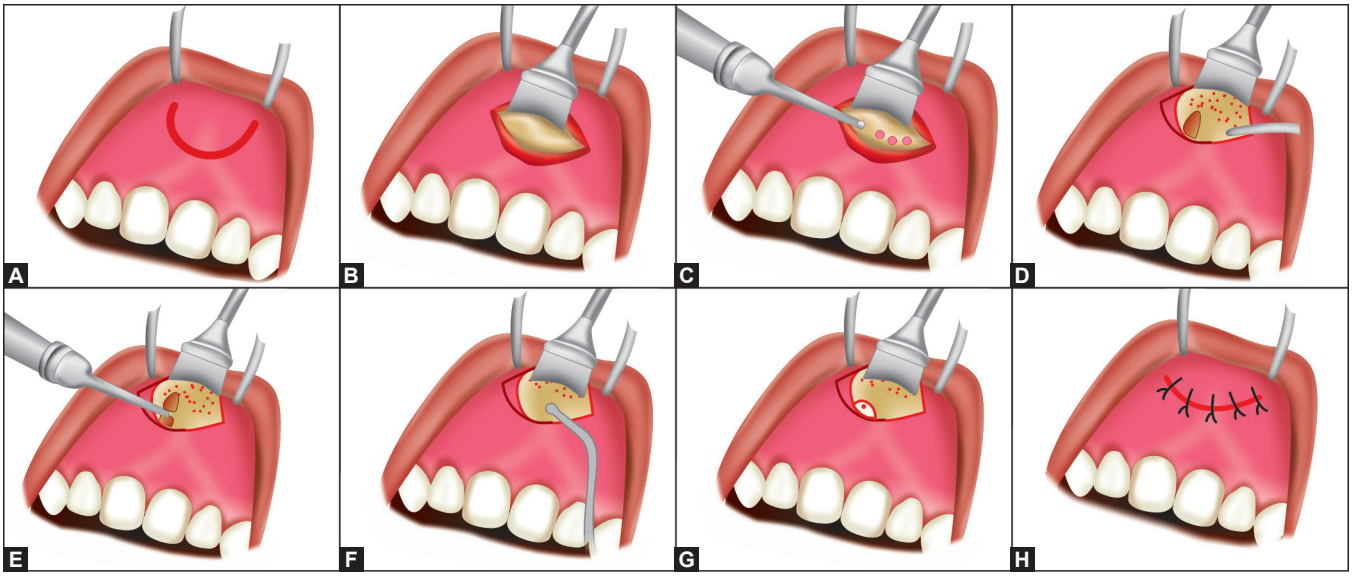
CONTRAINDICATIONS

- Presence of systemic diseases—leukemia, uncontrolled diabetes, anemia, thyrotoxicosis, etc.
- Teeth damaged beyond restoration
- Teeth with deep periodontal pockets and grade III mobility (preexisting bone loss)
- When traumatic occlusion cannot be corrected
- Short root length
- Acute infection which is nonresponsive to the treatment
- Root tips close to the nerves, e.g. mental nerve, inferior alveolar nerve or in maxilla close to the maxillary sinus.

PROCEDURE

Three accepted procedures can be used **(Figs 21.1 to 21.6)**:

1. Root canal filling and immediate apicoectomy and curettage
2. Root canal filling is done several days/weeks/months earlier followed by apicoectomy and curettage
3. Increase in the periapical lesion even after root canal filling and draining sinus. May be due to faulty filling which is redone and then followed by root amputation and curettage.



Figs 21.1A to H: Apicoectomy and curettage (surgical procedure): (A) Semilunar incision; (B) Reflection of mucoperiosteal flap; (C) Creating a bony window with bur; (D) Bony window complete to expose the root apex area; (E) Sectioning of the root tip horizontally; (F) Removal of sectioned root tip and periapical curettage; (G) Preparation of the retrograde filling and (H) Suturing

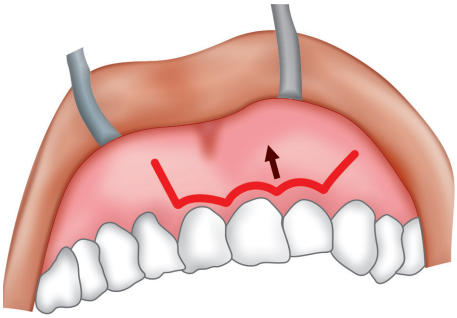
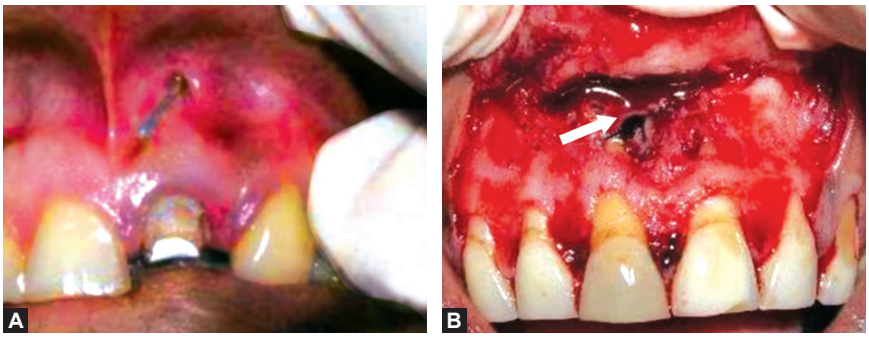


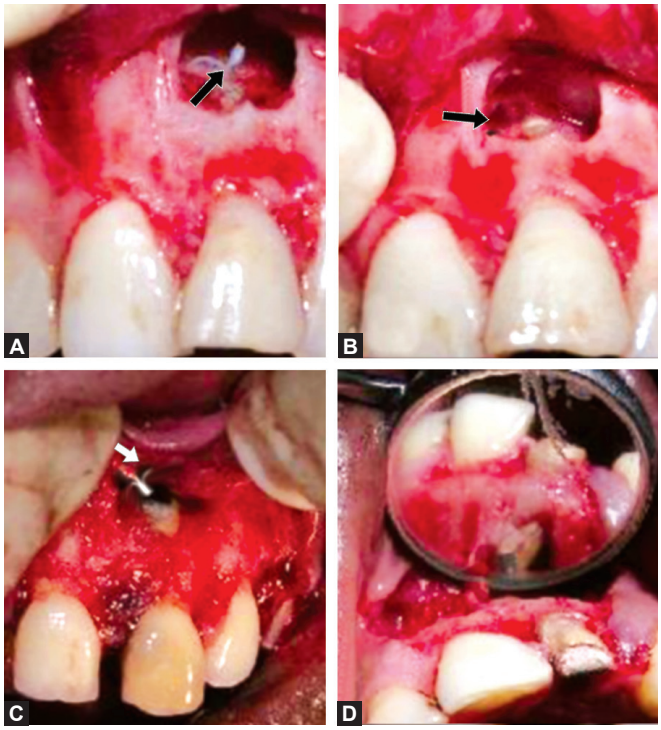
Fig. 21.2: Ochsenbein-Luebke submarginal envelope flap for apicoectomy.



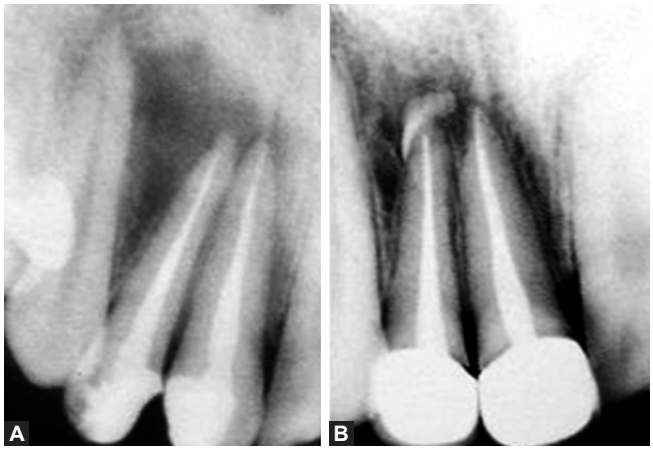
Figs 21.3A and B: Surgical procedure for apicoectomy: (A) Persistent sinus tract after root canal filling and (B) Mucoperiosteal flap reflected to expose the periapical lesion. Note the perforation of the buccal cortex



Figs 21.4A to C: (A) Bony window widened and cystic lesion enucleation is being carried out; (B) All the apices of three anterior teeth involved in the lesion are exposed for apicoectomy procedure (root canal filling is done prior to surgery) and (C) Suturing



Figs 21.5A to D: (A) Overfilled root canal beyond the root apex; (B) After burnishing of the filling at the root apex; apicoectomy was done and (C and D) Retrograde filling with amalgam



Figs 21.6A and B: (A) Preoperative periapical X-ray of a periapical lesion involving (R) central amd lateral incisors and (B) Follow-up X-ray after 2 years

STEPS

- Asepsis and isolation
- Local anesthesia with infiltration technique
- Incision design
- Mucoperiosteal flap—either semilunar or submarginal envelope flap with extension of at least one tooth on either side
- Submarginal envelope flap is known as Ochsenbein-Luebke flap design. It is indicated when the esthetics of the gingival margin cannot be compromised (maxillary teeth with crowns). A scalloped incision is made below the attached gingiva with one or two releasing incisions. Contraindication for this flap—periodontal breakdown, large periapical lesion, a short root
- Raise the mucoperiosteal flap with periosteal elevator
- Retract the flap away with Langenbeck retractor
- Identify the apex in the intact buccal plate—create a bony window with surgical bur over the root apex area. Care is taken not to damage the adjoining roots (make bur holes with round bur and then join them with tapered fissure bur). Locate the apex
- Section the root tip at an angle of 30–45° from the line perpendicular to the long-axis of the tooth facing towards the buccal aspect of the root. This is done to provide enhanced visibility to the root end preparation. Current concepts: Bevel-horizontal or maximum of 10°. After this beveling root procedure, root end preparation is done to create a cavity with small round or inverted cone bur to receive a root end filling
- Remove all periapical granulation tissue with angulated curettes
- Use hot burnisher to seal the root tip
- Close flap and suture it.

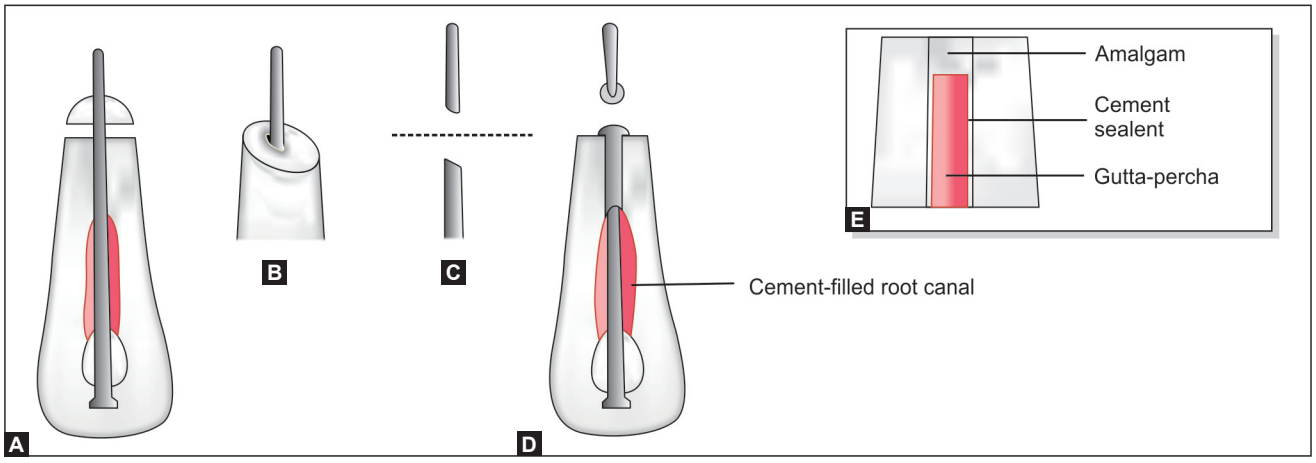
RETROPREPARATION

The ultrasonic tip is used for retropreparation. The tip is placed at the apical opening of the canal and guided gently deeper into the canal as it cuts. Once the retropreparation is completed the prepared cavity is inspected. The gutta-percha at the base is recondensed with small 0.5 mm microplugger **(Figs 21.7A to E)**.

The aim of placing root end filling material is to establish an apical seal that inhibits the leakage of residual irritants from the root canal into the surrounding tissues.

A wide variety of retrograde filling materials have been used—gutta-percha, amalgam, gold foil, titanium screws, glass ionomer, zinc oxide-eugenol, cavit, composite resin, polycarboxylate cement, silver points, mineral trioxide aggregation (MTA), etc.

In the defect in the periapical region, hydroxylapatite can be packed to enhance the bony healing.



Figs 21.7A to E: (A) Apicoectomy of one-third of the length of the root; (B) Overfilled gutta-percha point and preparation of bevel between 0° and 10°; (C) Cutting off of excess gutta-percha point; (D) Preparation for retrograde filling using amalgam and (E) Final retrograde filling

COMPLICATIONS

Intraoperative

- Bleeding—control with local application of adrenaline pack 1: 1,000, pressure pack/gelfoam
- Damage to the neighboring root
- Entry into sinus/inferior alveolar canal.

Postoperative

- Abscess formation
- Fenestration, sinus tract formation
- Increased mobility of the tooth.

Points to Remember

- Objectives and indications for surgical endodontics
- Contraindications for the same
- Procedure and steps for apicoectomy surgery
- Complications.

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Section 5

Temporomandibular Joint Disorders

22. Temporomandibular Joint: Afflictions and Management
23. Ankylosis of the Temporomandibular Joint and its Management
24. Myofascial Pain Dysfunction Syndrome

CHAPTER 22 Temporomandibular Joint: Afflictions and Management

ANATOMY OF THE TEMPOROMANDIBULAR JOINT

The temporomandibular joint (TMJ), also known as the craniomandibular joint/articulation is peculiar to mammals. It is the articulation between the squamous part of the temporal bone and the head of the mandibular condyle **(Figs 22.1A and B).** The mandibular articulation is labeled as a bilateral diarthrodial or freely movable joint. It is also considered as complex joint, because it involves two separate synovial joints (right and left), in which there is a presence of intracapsular disk or meniscus and both the joints have to function in coordination. The TMJ articulation consists of a mandibular or glenoid fossa, an articular eminence or tubercle, a condyle, a separating disk, a joint fibrous capsule and an extracapsular check ligaments.

Articulatory System

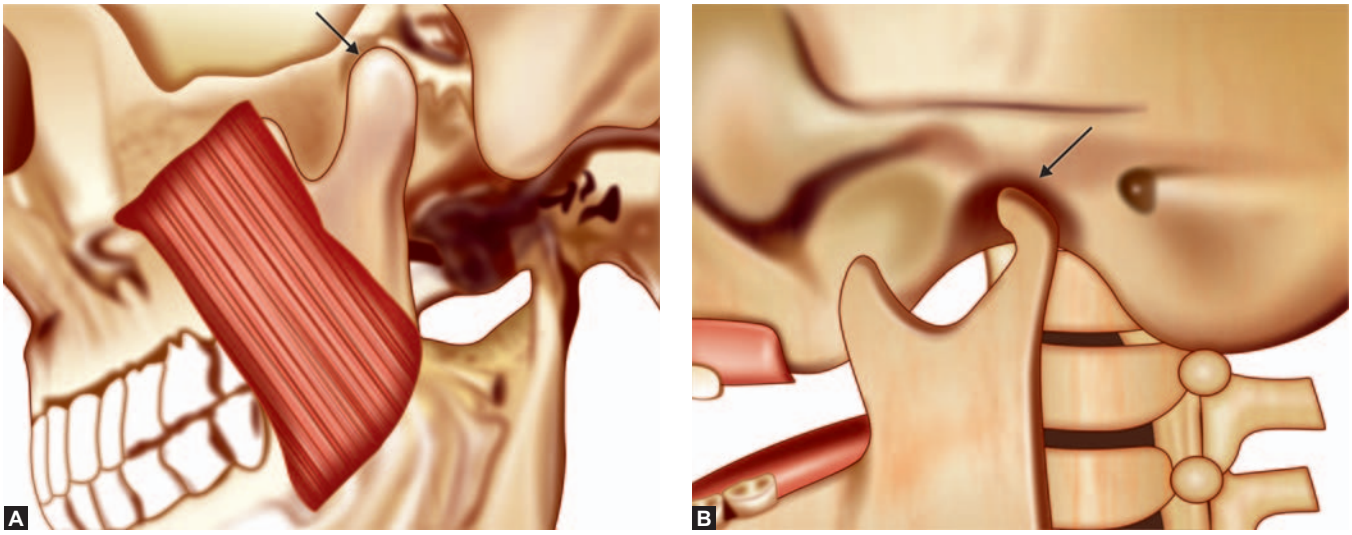
The articulatory system comprises of the following:

- Temporomandibular joint (TMJ)
- Masticatory and accessory muscles.
- Occlusion of the teeth.

The function is governed by sensory and motor branches of the third division of the trigeminal nerve (mandibular nerve) and a few fibers of the facial nerve. The occlusion of the teeth plays an important role in the function of the TMJ. Normally, the greatest part of the force of mastication is borne by the dentition of the jaws, but in case of occlusal disharmony, a great deal of force can be shifted to the joint itself.

Mandibular (Glenoid) Fossa (Cranial Component)

- **Limits:** Anteriorly, the articular eminence or tubercle and posteriorly, a small conical postglenoid tubercle.
- **Articular eminence:** It is a small prominence on the zygomatic arch. It is strongly convex anteroposteriorly and somewhat concave mediolaterally.



Figs 22.1A and B: Craniomandibular articulation

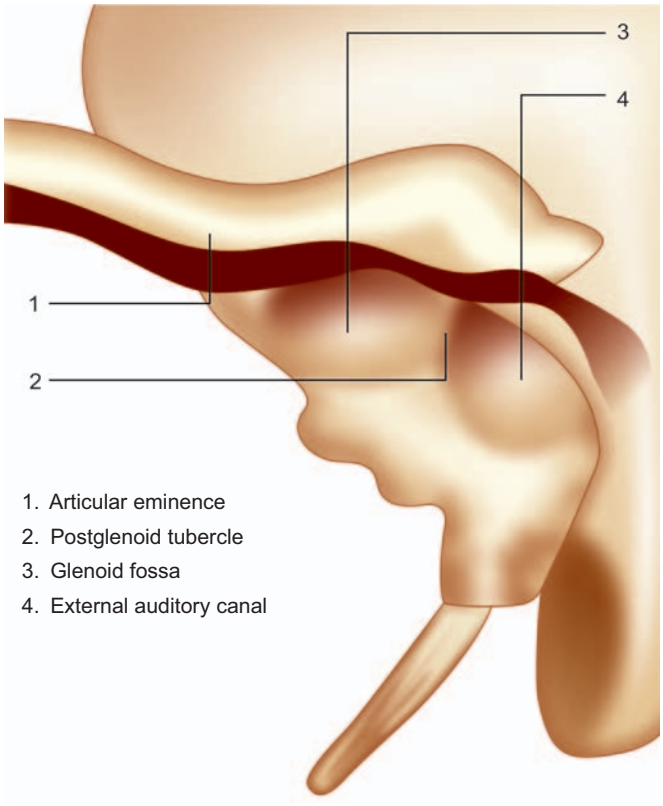
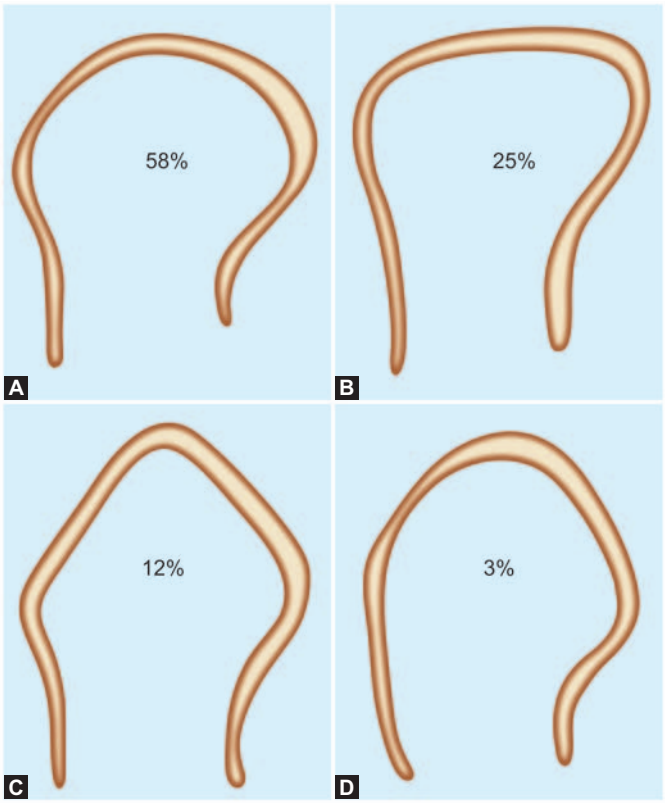


Fig. 22.2: Cranial component of the articulatory system of temporomandibular joint



Figs 22.3A to D: Shapes of the mandibular condylar head

- **Postglenoid tubercle:** It separates the articular surface of the fossa laterally from the tympanic plate. And the tympanic plate separates the TMJ from the bony part of the external auditory canal.
- **Glenoid fossa:** It has an anterior articular area formed by the inferior aspect of temporal squama. Its surface is smooth, oval and deeply hollowed out and the bone is very thin at the depth of the fossa. This roof of the glenoid fossa creates a partition between middle cranial fossa and the joint. The fossa is lined by a dense avascular fibrocartilage. In cross-section, the fossa and the eminence form a 'lazy S' posteroanteriorly. Squamotympanic fissure separates it from tympanic plate, which forms a posterior wall of the glenoid fossa **(Fig. 22.2)**.

Mandibular Component

Mandibular Condyle

The articular part of the mandible is an ovoid condylar process (head) with narrow mandibular neck. It is broad laterally and narrower medially. The mediolateral dimension varies between 13 and 25 mm and anteroposterior width varies between 5.5 and 16 mm. The majority of human condyles (58%) are slightly convex superiorly, with a radius of curvature greater than the distance from the medial to lateral poles. Twenty-five percent of condyles may be flat superiorly and approximately 12% are pointed or angular in shape and 3% are bulbous or rounded in shape **(Figs 22.3A to D)**. The surface of the articular eminence that most closely approximates the condyle is consistently congruent with the surface of the condyle. The two condyles of a patient may be asymmetric. A combination of flat condyle on one side with a convex condyle on the other side is most common. The articular part of the condyle is covered by *fibrocartilaginous tissue* and not with *hyaline cartilage*, as in most other joints in the human body.

Temporomandibular Joint Capsule

Temporomandibular joint capsule is a thin sleeve of fibrous tissue investing the joint completely. It is a funnel

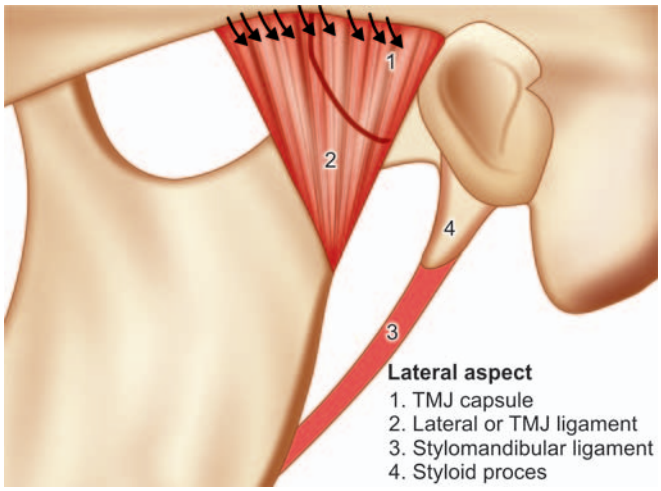


Fig. 22.4: Mandibular component of the TMJ articulation

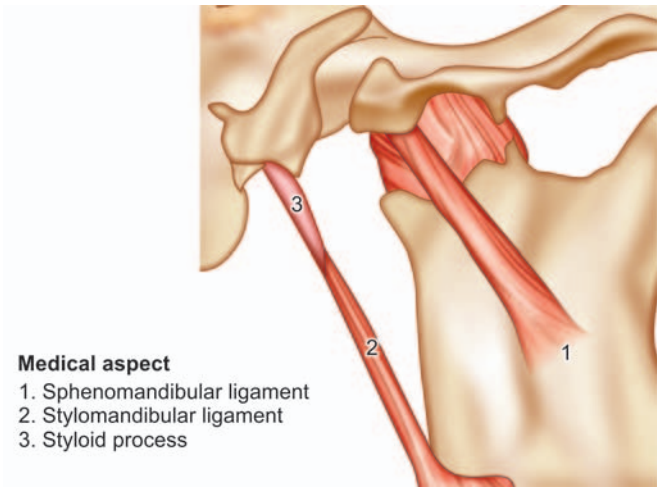


Fig. 22.5: Accessory ligament of TMJ articulation

shaped capsule, which blends with the periosteum of the mandibular neck and it envelops the meniscus. It is attached above anteriorly to the anterior border of the articular eminence and posteriorly to the lip of the squamotympanic fissure and to the anterior surface of the postglenoid process and also to the circumference of the cranial articulating surface and below to the neck of the condyle, on the lateral as well as on the medial aspect. Inside this fibrous tissue capsule, there is a lining of silky synovial membrane **(Fig. 22.4)**.

Ligaments

Lateral or Temporomandibular Joint Ligament (Fig. 22.4)

Temporomandibular joint capsule is reinforced by this main stabilizing ligament. It extends downward and backward from the articular eminence to the external and posterior side of the condylar neck. Its posterior fibers are united with the capsular fibers. This ligament is composed of collagenous fibers that have specific length and poor ability to stretch, hence, it maintains the integrity and limits the movement of TMJ. It mainly limits the anterior excursion of the jaw as well as prevents posterior dislocation, hence, it is called as "*check ligament*" of TMJ. But in certain situations, if the joint movements consistently function against ligament, then the ligament elongates and this can create change in the joint biomechanics and can lead to certain pathologic changes.

Accessory Ligaments

Accessory ligaments make no contribution to joint activity.

- **Sphenomandibular ligament:** A flat band arising from the sphenoid spine and the petrotympanic fissure, runs downward and medial to the TMJ capsule and gets inserted on the lingula of the mandible. It is a remnant of Meckel's cartilage. Sphenomandibular ligament is an important landmark during surgery, as internal maxillary artery and auriculotemporal nerve lies between it and the mandibular neck.
- **Stylomandibular ligament:** It is dense, thick band of the deep cervical fascia extending from the styloid process to the mandibular angle **(Figs 22.4 and 22.5)**.

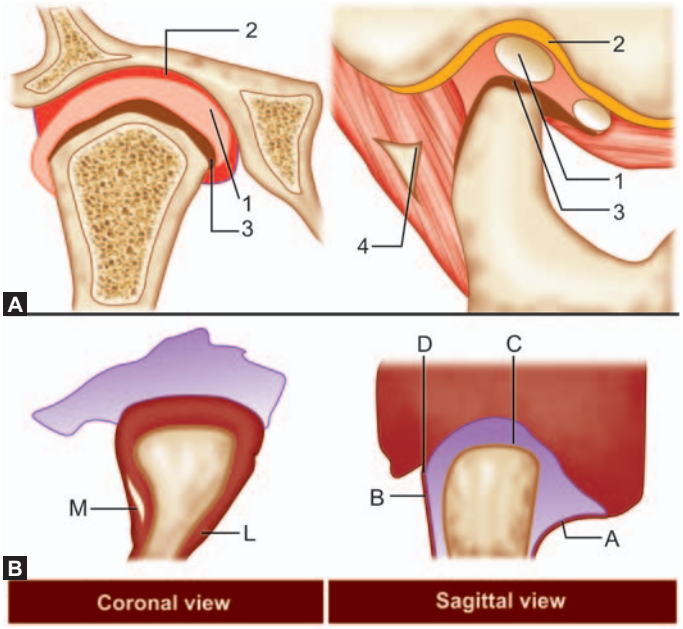
Articular Disk or Meniscus

The TMJ is a diarthrodial synovial paired joint. This means that there are two joint movements, which occur in separate compartments of this synovial joint and that one joint cannot operate without the other.

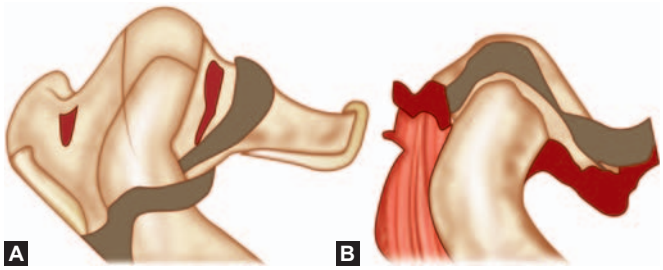
The meniscus or an intervening disk divides the articular space into two compartments:

1. **Lower or inferior compartment:** Condylodiskal complex between the condyle and the disk.
2. **Upper (temporodiskal) or superior compartment** between the disk and the temporal bone or glenoid fossa **(Figs 22.6A and B).**

The disk is biconcave in the sagittal section. The superior surface is concavo-convex to match the anatomy of the glenoid fossa and inferior surface is concave to fit over the condylar head. A detailed study by Rees in 1954,



Figs 22.6A and B: (A) TMJ articular space compartments: (1) Articular disk or meniscus, (2) Temporodiskal or superior compartment, (3) Condylodiskal or inferior compartment, (4) Retrodiskal tissue; (B) Attachment of the disk and capsule to the condylar head. L and M—Lateral and medial capsular attachments. A—Anterior band, B—Bilaminar zone, C—Intermediate band, D—Posterior band of the disk



Figs 22.7A and B: Rees described the shape of the meniscus as Jockey's cap, which overlaps the condylar head

reported that the shape of the articular disk or meniscus is like a school boy's or Jockey's cap, which overlaps the condylar head **(Figs 22.7A and B).**

The disk blends medially and laterally with the capsule, which is attached to the medial and lateral poles of the condyle. Anteriorly, the disk is attached to the *articular eminence* above and to the articular margin of the condyle below. It is also confluent anteriorly with the capsule as well as with the fascia of the superior head of the lateral pterygoid muscle. Posteriorly, the disk is attached to the posterior wall of the glenoid fossa above and to the distal aspect of the neck of the condyle below. This area is called as the *posterior bilaminar zone* or *retrodiskal tissue,* which has a rich neurovascular supply. Sensory branches of auriculotemporal nerve are abundant here.

The upper joint space always extends farther anteriorly than the lower joint space, which is smaller and more tightly reinforced by the disk attachments, whereas the upper joint space is larger and not as well-reinforced.

The volume of the upper joint space is about 1.2 mL and of the lower joint space is about 0.9 mL.

The disk is a firm, but flexible structure. Rees in 1954, described three zones: (1) *posterior band,* (2) *intermediate zone, and* (3) *anterior band.* The anterior band is moderately thick (about 2 mm), but narrow anteroposteriorly. The thickest and widest is the posterior band (3 mm), whereas the intermediate band is the thinnest (1 mm). The interposition of the thin intermediate zone between the two thicker zones gives the meniscus more flexibility and enables it to alter shape from concave to convex during forward movement.

Histologically, the disk is a meshwork of firmly woven avascular fibrous connective tissue and it is also noninnervated with possible exceptions around its periphery. These collagen fibers impart flexibility to the disk. The disk is designed to transmit the forces generated through the condyle to the articular eminence. It promotes lubrication, energy absorption and joint range of motion. It acts as a main shock absorber enabling the articulating bones to move against each other with minimum friction and heat production. Disk has a very little potential for repair after insult. The pliable disk is able to support stabilization of the condyle against the articular eminence.

The posterior attachments of the disk are complicated. This region of the disk is known as bilaminar zone, because it contains two strata of fibers with loose areolar connective tissue filling the space between them. The superior stratum is attached to the tympanic plate and is comprised of elastin rather than collagen, which allows the disk to translate forward with the condyle. It also has got fat and blood vessels. The inferior stratum consists of a fairly compact, inelastic sheets of collagen fibers that attach to the posterior surface of the condyle.

The posterior attachment tissues are highly innervated by the auriculotemporal nerve. Histological examination of this tissue reveals that it is not designed for loading. Above the posterosuperior aspect of the condyle and anterior to the bilaminar zone, the disk is very vascular and this region is called the *vascular knee (genu vasculosa).* The anterior extensions of the disk at its attachment to the superior belly of the lateral pterygoid is also vascular.

The articular surfaces of the condyle and eminence are covered by dense fibrous connective tissue. This connective tissue layer is thickest on the anterior and superior surfaces of the condyle and on the posterior slope and crest of the articular eminence. *The absence of hyaline cartilage on the articulating surface has been wrongly interpreted as indicating that the joint is not a stress bearing joint.*

The hyaline cartilage present in the head of the condyle is the growth center of the condylar process and lies beneath the articular surface (a thin band of cells—the intermediate or proliferative zone). In older joints, this layer may not be very distinct, but the cells of this zone are capable of proliferative activity throughout life and play an important part in the remodeling and repair of the articular surface.

The synovial tissue is a connective tissue membrane, which lines the joint cavities or spaces and secretes synovial fluid for lubrication of the joint. The upper and lower joint spaces are bathed in a viscous synovial fluid. This fluid is an ultrafiltrate of blood plasma plus a mucin. It is composed chiefly of highly polymerized hyaluronic acid, which is responsible for its viscous quality and is capable of absorbing tremendous shearing forces applied to the joint. The synovial membrane is the innermost layer of the fibrous capsule and unlike avascular articular tissue, it has got excellent regenerative capacity.

Function of the synovium (besides lubrication) is to provide *nutrition, phagocytosis and immunological response* (Synovitis—proliferation of the synovial cells with the concomitant release of prostaglandins and large quantity of collagenase—pain).

Blood Supply

Lateral aspect is supplied by superficial temporal branch of the external carotid artery. Rich vascular supply to the deep and posterior aspect of retrodiskal capsular part by deep auricular, posterior auricular and masseteric branches of the internal maxillary artery. Vascular supply to the lateral pterygoid muscle also supplies to the head of the condyle by penetration of numerous nutrient foramina vessels. The venous pattern is more diffuse, forming a plentiful plexus all around the capsule.

Nerve Supply

The mandibular nerve, the third division of the fifth cranial nerve innervates the jaw joint. Three branches from the mandibular nerve send terminals to the joint capsule.

1. The largest is the auriculotemporal nerve which supplies the posterior, medial and lateral parts of the joint.
2. Masseteric nerve.
3. A branch from the posterior deep temporal nerve, supplies the anterior parts of the joint.

Movements

The mandible can be depressed, elevated, protruded or retruded. Lateral excursions can also be carried out **(Fig. 22.8).** There is a variation of normal patterns of motion in different individuals, which are caused by many factors, including the following:

- Condyle head size, shape and inclination
- Glenoid fossa depth and angulation
- Articular eminence height and degree of inclination
- Length and laxity of ligaments comprising the joint capsule
- Degenerative joint disease state resulting either from local causes or from systemic diseases.
- Strength, length, position and tonicity of muscles of mastication and the suprahyoid musculature.
- Neuromuscular control of the muscles (Both the afferent proprioceptor and the efferent motor impulses

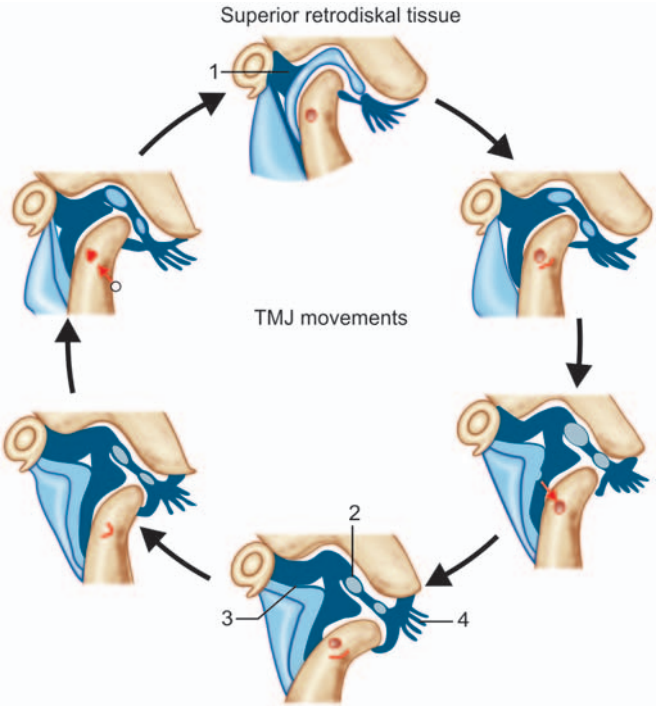


Fig. 22.8: TMJ movements: (1) Superior retrodiskal tissue; (2) Posterior band of the disk; (3) Retrodiskal tissue; (4) Superior head of the lateral pterygoid muscle

through the fifth and seventh cranial nerves can be affected by stimuli from the hypothalamic nuclei to the cerebral cortex and vary according to the emotional status of the patient).

The movements of TMJ are manifold. It is ginglymus, diarthroidial type of joint, as it is capable of rotating around more than one axis and is capable of hinge/rotatory movement (ginglymoid) and also capable of gliding/translatory movement (diarthroidial). Some amount of vertical motion is also possible. By alternate action of the homologous joints, it allows lateral motion and by combination of all, circumduction. Rotation and some slight translation takes place in the lower joint space between the condyle and the articular disk. Translation of the condyle disk complex takes place in the upper joint space.

The disk is attached to the condyle both medially and laterally by the collateral ligaments. These ligaments allow rotation of the disk across the articular surface of the condyle in an anteroposterior direction, while restricting medial and lateral movements. The condylar head can rotate within the encompassing disk (condyle disk complex) and together with disk, it translates against the articular eminence. At rest, the condyle articulates on the intermediate zone of the disk and is maintained in this position by constant interarticular pressure provided by the elevator muscles.

During mouth opening, when the condyle disk complex translates down the articular eminence, the disk rotates posteriorly on the condyle.

The superior retrodiskal lamina, which is composed of loose connective tissue and elastic fibers, allows the condyle disk complex to translate forward without damage to the retrodiskal tissues. During full mouth opening, the superior retrodiskal tissue is fully stretched and offers a posterior retractive force on the disk, limiting the further sliding of the disk. Simultaneously, there is contraction of the fibers of the superior head of the lateral pterygoid muscle. Further gliding and hinging of the condyles brings them in contact with the most anterior parts of the disks as the mouth fully opens.

In closure, movements are reversed. Each head glides back and hinges on its disk. Here the lateral pterygoid muscle relaxes, to allow the disk to glide back and up into the mandibular fossa. During opening and closing, the disk and the condyle move together because of two features—the morphology of the disk and intra-articular pressure. If there is any change in intra-articular pressure or in the morphology of the disk, then condyle disk movements can be altered leading towards dysfunction of the complex co-ordinate.

Muscle function: The functions of the muscles of mastication in jaw movements are coordinated and balanced by normal muscle tone. Abnormal contraction of any one individual muscle, disrupts the synchronous function that produces coordinated movements. The muscles of mastication (medial and lateral pterygoid, masseter, buccinator, mylohyoid, temporalis and anterior belly of the digastric) are assisted by the suprahyoid and digastric muscles, especially in the jaw opening movements. The tongue with motor innervation accomplished by the hypoglossal nerve, is a strong muscular structure, whose action and position affects jaw movements.

Jaw opening (depression): It is dominated by digastric muscle contraction, which depresses the body of the mandible. This action is assisted by the suprahyoid, sternohyoid and geniohyoid muscles. The lateral pterygoid muscle is believed to be the 'trigger' for opening and contracts to pull the condylar head downward and forward on the articular eminence.

Jaw closure (elevation): It is accomplished by the simultaneous contraction of the masseter, medial pterygoid and temporalis muscles.

Protrusive movement: It requires equal and simultaneous contracture of lateral and medial pterygoid muscles.

Retrusion: It is brought about by posterior fibers of temporalis muscle, assisted by middle and deep parts of the masseter, digastric and geniohyoid muscles.

Lateral movements: These are carried out by unilateral contracture of medial and lateral pterygoid of each side acting alternatively.

The TMJ is thus classified as a complex, multiaxial, synovial, bicondylar and ginglymodiarthrodial type of joint. It is highly specialized unique joint and has got many distinctive characteristics:

- Articular surfaces of TMJ are not covered by a hyaline cartilage, but by an avascular fibrocartilage
  (This is attributed to the membranous ossification by which the mandible, temporal bone and clavicle are formed. Clavicular end of sternoclavicular joint is also covered by avascular fibrocartilage).
- The right and left articulations are connected by the mandible, the movements are coupled. The individual movement of one articulation directly affects the other.

- Mandible is stabilized by three functionally linked articulations—the dentition and the two TMJs. Any discrepancy of the dentition will affect the movements of the TMJ.
- The function of this unique joint is also dependent on delicate neuromuscular balance.
- The TMJ is the only joint to have a rigid end point of closure, produced as a consequence of teeth contacting.
- The TMJ is in close proximity to the upper part of the cervical spine. Functionally, the cervical spine, the TMJ and occlusion of teeth are interrelated. Abnormality of any of these components can alter the function.
- The joint functions as a regional adaptive growth center for the growth and development of the mandible and the middle-third of the face, in response to changes in the "functional matrix" of surrounding masticatory muscle and other soft tissues (In case of restricted stimulus from the soft tissues, as a result of trauma or infection or neuromuscular congenital anomalies, condylar growth response will be restricted. It will also affect the growth and development of facial structure).

  The clinicians must recognize dissimilarities between the TMJ and other articulations in contemplating corrective or replacement surgery:
- The functional stresses on the TMJ are more subtle, than those on most other joints, but they can be easily modified by extraneous factors and are more influential in determining the morphology of the articular elements.
- Reconstruction of many other articulations is often impossible with anything but alloplasts. But, it is not true with the TMJ.
- The TMJ has more intimate proximity to vital structures than any other articulation (Except portions of the vertebral column).

TEMPOROMANDIBULAR JOINT DISORDERS

Classification

1. Intra-articular origin or intrinsic disorders.
2. Extra-articular origin or extrinsic disorders.

Extrinsic factors are those not directly associated with the TMJ, whereas intrinsic factors relate to those conditions existing within the confines of the capsule of the joint.

Disorders due to Extrinsic Factors

Masticatory Muscle Disorders

- Protective muscle splinting
- Masticatory muscle spasm (MPD syndrome)
- Masticatory muscle inflammation (myositis).

Problems that Result from Extrinsic Trauma

- Traumatic arthritis
- Fracture
- Internal disk derangement
- Myositis, myospasm
- Tendonitis
- Contracture of elevator muscle—myofibrotic contractures.

Because of these extra-articular factors, the function of the TMJ may be hampered.

Trismus

Whenever, there is a restriction of normal oral opening or inability to open the mouth fully, the term trismus is used. Trismus is brought about by extra-articular causes and it is also labeled as false ankylosis. Trismus is also defined as a condition in which muscle spasm or contracture prevents opening of the mouth (due to infection or other conditions which alter muscle structure).

Causes of Trismus

- **Due to infection:** Orofacial infections around the joint area can bring about trismus or limitation of oral opening. Odontogenic acute infections like pericoronitis, Ludwig's angina, submasseteric and infratemporal abscess, etc. Chronic infections affecting the jaws also can bring about trismus. Tuberculous osteomyelitis of ramus and/or body mandible, etc.
- **Trauma:** Fracture of the zygomatic arch may impinge on the coronoid process and restrict the oral opening. Fracture of the mandible also can bring about trismus, because of pain and tenderness or muscle spasm.
- **Inflammation:** Myositis or muscular atrophy can bring about trismus.
- **Myositis ossificans:** Following trauma, a hematoma can be formed within the fibers of the masticatory group of muscles, especially in the masseter, which can progress into ossification and the muscle stiffness. Clinical and radiographic examination will confirm the presence of these changes.
- **Tetany:** Typical carpopedal spasm along with trismus can be seen due to hypocalcemia.

- **Tetanus:** Following acute infection by *Clostridium tetani*, the typical lockjaw symptom can be seen associated with other symptoms, because of persistent tonic muscle spasm.
- **Neurological disorders:** Epilepsy, brain tumor, bulbar paralysis, embolic hemorrhage in medulla oblongata can bring about trismus.
- **Psychosomatic trismus:** It is also known as trismus hystericus. Due to extreme fear, anxiety associated with hysterical fits.
- **Drug induced trismus:** Strychnine poisoning can bring about spasms leading to trismus.
- **Mechanical blockage:** Elongation, exostosis, osteoma, osteochondroma of coronoid process will cause mechanical blockage and interfere with the normal mandibular movements.
- **Extra-articular fibrosis:** Chronic cervicofacial sepsis, postradiation therapy, ossification of sphenomandibular ligament, bands of scars and burns of the face and neck region, oral submucous fibrosis will lead toward progressive trismus.

A classical clinical example of trismus is seen occasionally, following the injection of the inferior alveolar nerve block with local anesthetic agent. Bleeding, created by needle puncture in the medial pterygoid muscle, produces a hematoma followed by fibrosis and subsequent trismus. In most cases, the hematoma is spontaneously resolved and normal jaw function returns within a week or two. In some of the cases, under sedation or general anesthesia (GA), manipulation of the jaw, with jaw stretcher may be required to break-up the adhesions and restore the function.

Disorders due to Intrinsic Factors

- **Trauma**
  - Dislocation, subluxation
  - Hemarthrosis
  - Intracapsular fracture, extracapsular fracture.
- **Internal disk displacement**
  - Anterior disk displacement with reduction
  - Anterior disk displacement without reduction.
- **Arthritis**
  - Osteoarthrosis (degenerative arthritis, osteoarthritis)
  - Rheumatoid arthritis
  - Juvenile rheumatoid arthritis
  - Infectious arthritis.
- **Developmental defects**
  - Condylar agenesis or aplasia—unilateral/bilateral
  - Bifid condyle
  - Condylar hypoplasia
  - Condylar hyperplasia
- **Ankylosis**
- **Neoplasms**
  - **Benign tumors:** Osteoma, osteochondroma and chondroma.
  - **Malignant tumors:** Chondrosarcoma, fibrosarcoma, synovial sarcoma.

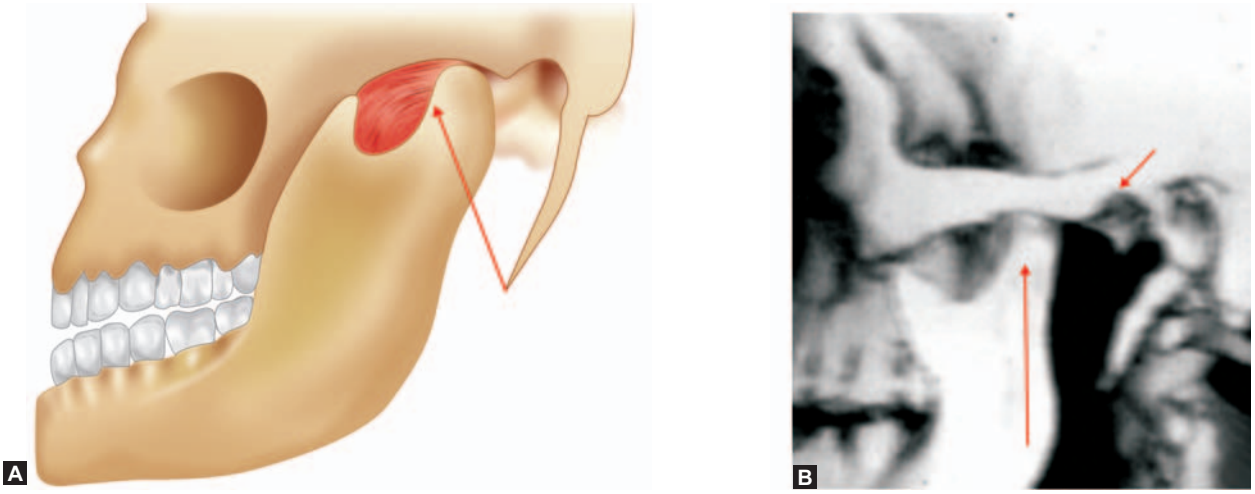
Dislocation, Subluxation, Hypermobility of Temporomandibular Joint

During normal or unstrained opening of the mouth, the condylar heads translate forward to a position under the apices of the articular eminences. If oral opening proceeds to its maximum capacity, the condylar heads move to the anterior slope of the articular eminences in many normal individuals. Excursion of the condylar heads beyond these limits may be viewed as abnormal and termed as dislocation. In contrast to the fracture dislocation of the condylar head, here the intact condylar head is displaced out of glenoid fossa, much anteriorly beyond articular eminence, but still remains within the capsule of the joint. Dislocation is defined as displacement of the condyles past the articular eminence, which must be manually reduced. As far back as 3,000 BC in Egypt, Hippocrates first reported a dislocation of the mandible. His method of reduction has survived the ages and is still being used in modern times. Mandibular condylar dislocation is uncommon, compared to the other joints in the body. Its incidence is reported to be 3.1% of all reported dislocated joints.

The dislocation can be unilateral or bilateral, as well as Partial or complete. *Anterior mandibular dislocation,* which occurs more commonly, can be classified as:

- Acute dislocation (complete luxation)
- Chronic recurrent (habitual) subluxation
- Long-standing or chronic protracted dislocation

The term luxation is also used for acute dislocation and the terms, *subluxation or hypermobility or habitual chronic recurrent dislocation* is substituted for the term recurrent dislocation, when it is incomplete or partial. Subluxation refers to self-reducing displacement of the condyles out of the mandibular fossa and past the articular eminence **(Figs 22.9A and B, Tables 22.1 and 22.2).** Anteromedial acute dislocation is the most common, while superior, lateral or posterior dislocation is also reported rarely in the literature.



Figs 22.9A and B: (A) Acute dislocation of TMJ; (B) Three dimensional scan showing the position of condylar head beyond articular eminence. (Acute dislocation)

Table 22.1: Types of dislocation

1. Acute dislocation-complete luxation	79 cases reported
2. Chronic recurrent Subluxation	311 cases reported
3. Chronic protracted/long standing dislocation	35 cases reported
4. Unilateral bilateral	4 cases reported 421 cases reported
5. Anterior dislocation-most common	79 cases reported. The masseter and temporalis elevate mandible, before lateral pterygoid relaxes. Spasm of all these muscles
Superior or central dislocation	Rare, 8 cases reported, direct blow to a partially opened mouth. Fracture of the roof of glenoid fossa, dislocation into the middle skull base
Medial dislocation Lateral dislocation/posterior dislocation	11 cases reported. Sustained pull of the lateral pterygoid on the affected side 2 cases reported. Associated with mandibular fracture

Table 22.2: On basis of clinico-radiological examination, Akinbami in 2011, classified TMJ dislocation into the three types

Type I	The head of the condyle is directly below the tip of the articular eminence
Type II	The head of the condyle is in front of the tip of the articular eminence
Type III	The head of the condyle is high-up in front of the base of the eminence

Causes of Acute Dislocation

- Extrinsic forces or iatrogenic causes.
- Intrinsic or self-induced forces.

Anterior acute dislocation of the condyle occurs, in which the normal anatomic relationships within the joint have been completely disrupted with the condyle fixed anterior to the articular eminence. Relocation of the condyle in its normal position in the glenoid fossa does not occur voluntarily. It can occur as a single acute event or as chronic recurrent episodes.

Extrinsic or iatrogenic causes: In 60% of cases, it is induced due to trauma to the joint. Acute dislocation is common and can be brought about by a blow on the chin, while mouth is open. Injudicious use of mouth gag during GA or excessive pressure on the mandible, during dental extraction can lead to acute dislocation. It can be post-traumatic, spontaneous or associated with psychiatric illness.

Intrinsic or self-induced forces *bring about dislocation in 40% of cases, as* excessive yawning, vomiting, singing loudly, blowing wind instruments, laughing loudly or opening mouth too wide for eating or hysterical fits or during seizures can also bring about episode of acute dislocation. There is associated spasm of the lateral pterygoid muscle, as well as spasm of the other muscles of

mastication and therefore, the condylar head gets locked into the abnormal anterior position in the infratemporal fossa and cannot be manipulated back to close the mouth. In this situation, unassisted reduction becomes impossible.

Predisposing factors *may be altered structural components of TMJ* laxity of ligaments, capsule and abnormality of skeletal form. Previous injuries, occlusal disharmonies can bring about laxity of the capsule. Flattened eminence and shallow fossa, systemic diseases like Parkinson's disease, epilepsy, Ehlers-Danlos syndrome, etc., can be the predisposing factors. The use of antipsychotic drugs may cause extrapyramidal reactions and dislocation.

Clinical picture of acute dislocation: Dislocation is a dramatic event. It may be unilateral or bilateral. History of the patient may be diagnostic.

Unilateral acute dislocation: It is characterized by difficulty in mastication and swallowing. Speaking may be difficult and profuse drooling of saliva can be present in the early stages. A deviation of the chin toward contralateral side is seen. The deviation produces a



Figs 22.10A and B: Unilateral acute dislocation of (R) TMJ: (A) Extraoral picture showing inability to close the mouth and deviation of the mandible on the unaffected side; and (B) Intraoral picture showing the deviation of the mandible

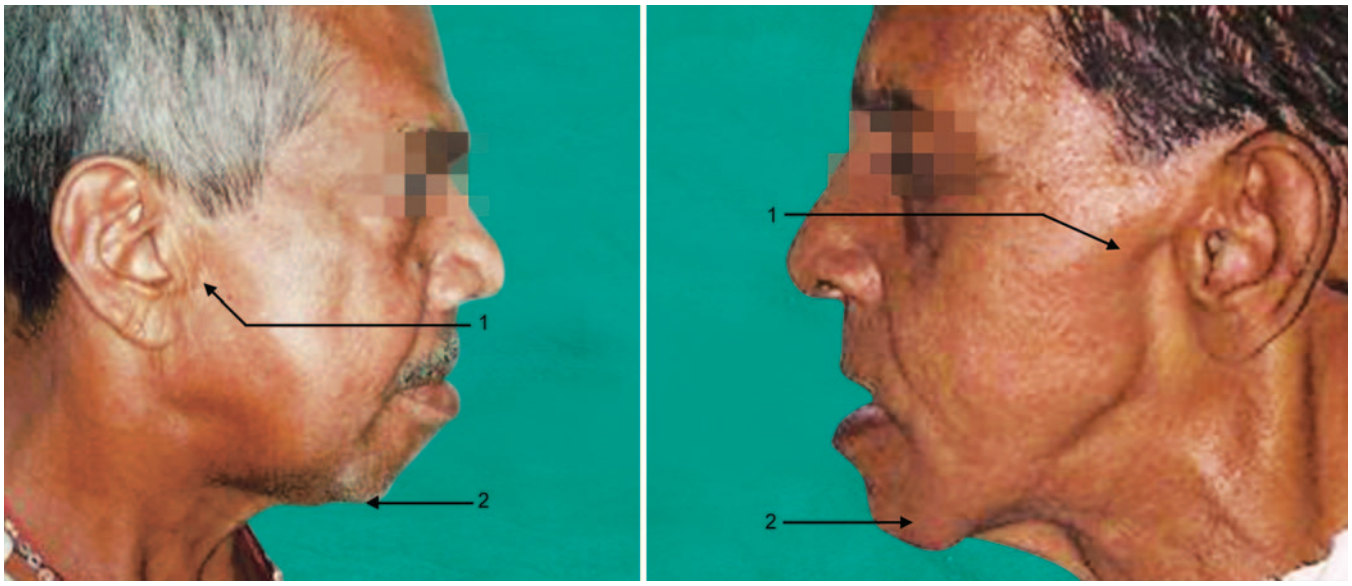
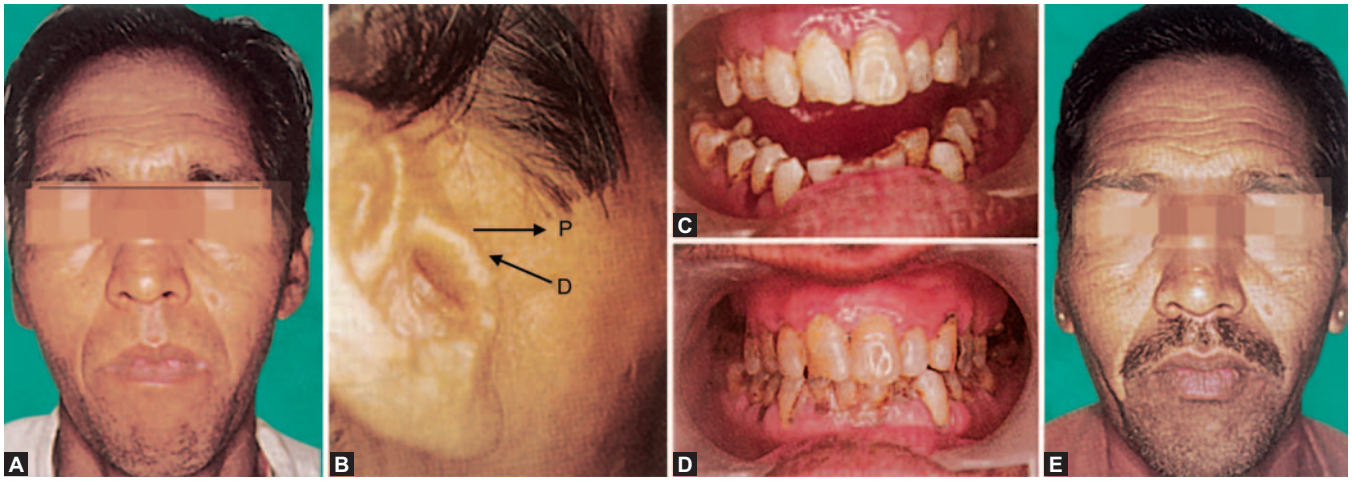


Fig. 22.11: Unilateral acute dislocation of TMJ: (1) Note the preauricular area depression; and (2) laterognathia of the mandible

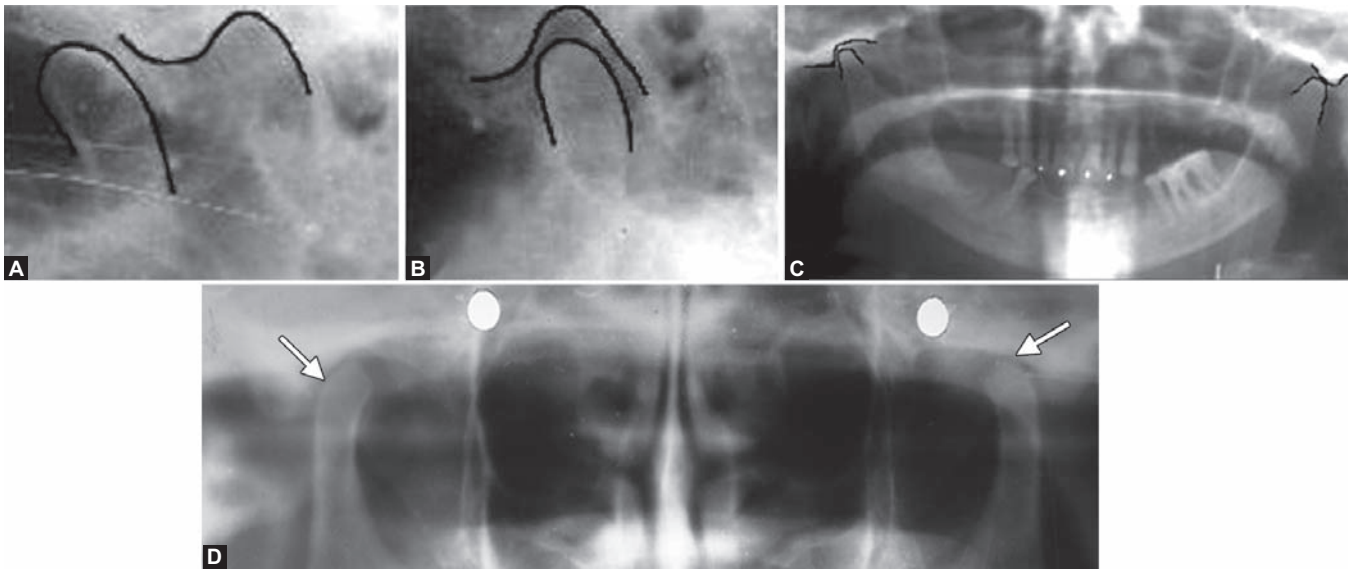
lateral cross and open bite on the contralateral side **(Figs 22.10 and 22.11).**

The mouth is partly open and the affected condyle cannot be palpable. In obese person, absence of condyle from the glenoid fossa may not be apparent, but in others a definite depression will be seen and felt in front of the tragus **(Fig. 22.11).**

Bilateral acute dislocation: It is associated with pain, inability to close the mouth, tense masticatory muscles, difficulty in speech, excessive salivation, protruding chin. The mandible is postured forward and movements are restricted. There is a gagging of the molar teeth with the presence of anterior open bite. Difficulty in swallowing and drooling of saliva is seen. Patient will complain of pain in the temporal region rather than the joint and may be extremely apprehensive. The distinct hollowness can be felt in both the preauricular regions. Associated muscle spasm contributes to the fixed position of the condyles **(Figs 22.12 and 22.13).**



Figs 22.12A to E: Acute bilateral dislocation of TMJ: (A) Clinical frontal face of a patient having acute bilateral TMJ dislocation. Elongated face; (B) Depression in preauricular area. Prominence of dislocated head seen; (C) Anterior open bite with posterior molar gagging seen; (D) Original occlusion of patient, after reduction; (E) Normal face after reduction.
Abbreviations: D, depression; P, prominence.



Figs 22.13A to D: (A) Transcranial view of (L) TMJ showing acute dislocation; (B) After reduction, TMJ in closed position; (C and D) OPG showing bilateral acute dislocation of TMJs

Diagnosis: Clinical history and examination is very important tool. Confirmatory diagnostic aids are plain TMJ views, plain and contrast CT scans, i-CAT scans, MRI, linear and rotational plain digital tomograms are useful to assess the position of the condyle. 3D CT scan is the best imaging modality.

Management: Treatment for TMJ dislocation ranges from bimanual relocation of the condylar head to invasive surgical procedures. Conservative therapy usually is employed before more aggressive therapies are employed. The major problem in reduction of dislocation is overcoming the resistance of the severe muscle spasm. Therefore, initially attention is given to reduce tension, anxiety and muscle spasm. This can be achieved by (1) reassuring the patient, (2) tranquilizer or sedative drugs, (3) pressure and massage to the area, and (4) manipulation. Recurrent episodes of acute dislocations are both painful and frustrating to the patient. These may occur at any time and force the patient to seek expert assistance to reduce the dislocation. Longer the time span, the more difficulty in reduction procedure.

Depending on the amount of associated muscle spasm and pain experienced by the patient plus patient cooperation, the acute dislocation can be reduced by the operator as follows:

- Manipulation without any form of anesthesia
- Manipulation with local anesthesia
- Manipulation under GA/sedation with muscle relaxants.

Manipulation procedure: Remains the same irrespective of the type of anesthesia used. Under local anesthesia, the patient will be seated in a dental chair, while under GA the patient is made to lie on the operation table in a supine position. First of all, the patient should be given assurance about the procedure and asked to relax completely in a dental chair. Normally, the dislocation is maintained by muscle spasm secondary to painful stimuli arising from the capsule. Few drops of local anesthetic solution may be injected in the glenoid fossa, which will eliminate the pain factor and spontaneous reduction may be brought about due to elimination of a neural reflex **(Fig. 22.14).**

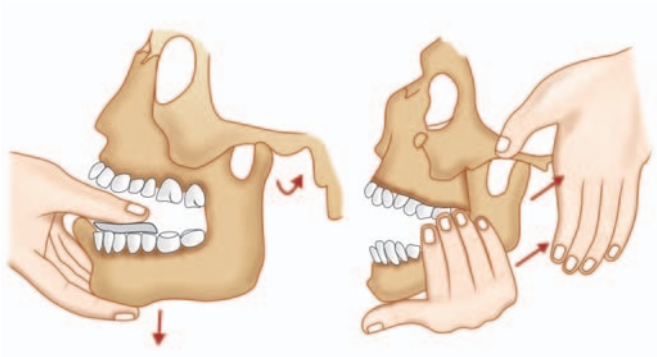


Fig. 22.14: Manipulation procedure for reduction of acute TMJ dislocation

Otherwise, the operator has to stand in front of the patient and he has to grasp the mandible with both the hands, one on each side to reverse the process of dislocation. The thumbs of the operator should be covered with gauze to prevent injury during manipulation, as sudden reduction can take place trapping the thumbs of the operator by the teeth. The thumbs are placed on the occlusal surfaces of the lower molars and fingertips are placed below the chin. Operator has to exert full body pressure and give downward pressure on the posterior teeth to depress the jaw and at the same time the fingertips are placed below the chin to elevate it by giving upward pressure. The downward pressure overcomes spasm of the muscles, plus it brings the locked condylar head below the level of articular eminence and then the backward pressure is given to push the entire mandible posteriorly. This will allow the condylar head to go back into its original position. After this reduction procedure, the mouth is closed and patient is asked to keep the oral opening restricted. Immobilization can be carried out, by giving barrel bandage to the patient for the period of 10–14 days and patient is kept on semisolid diet. This will allow to give rest to the joint. Anti-inflammatory, analgesic drugs should be prescribed for the period of 3–5 days. The patient is warned to avoid excessive oral opening and support the chin, while yawning in future. In 1987, Awang advocated a rapid method to manage acute dislocation. He induced the gag reflex by probing the soft palate, which in turn created a reflex neuromuscular action resulting in reduction **(Table 22.3).** The term "long-standing" is applicable to those cases, which remain unusually dislocated for longer than one month. Frequently, this follows extraction of teeth or tonsillectomy under GA, where the jaw is excessively forced open. Dislocation may then remain unnoticed,

Table 22.3: Treatments useful for acute dislocation of TMJ

Manual reduction without anesthesia
Manual reduction with local anesthesia plus sedation
Reduction with gag reflex induced on the soft palate—Awang`s method
Manual reduction with general anesthesia
Assisted open reduction with general anesthesia

if not examined postoperatively. Long-standing dislocations are occasionally encountered due to passive acceptance of the condition by the patient. In these cases, with passage of time, additional muscle spasm and fibrotic changes occur in the ligaments and muscles, thus, increasing the severity of the problem.

Long-standing chronic dislocation, which does not respond to the above procedure can be reduced by administering GA. If manual reduction fails, then open surgical procedure can be opted as a last resort **(Table 22.4).**

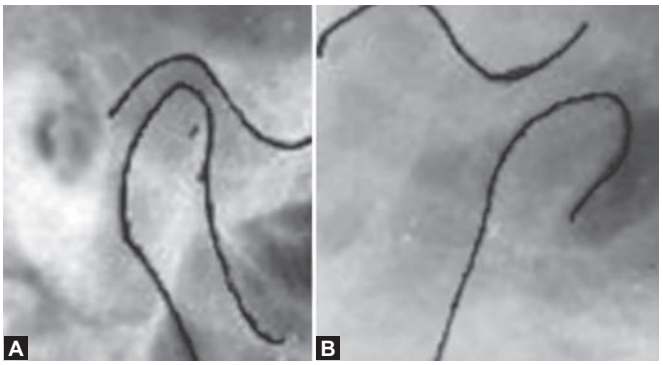
Open reduction consists of opening the joint through preauricular incision and direct vision manipulation can be done. If this also fails, then eminectomy or condylectomy procedure can be carried out, so that future locking of the condylar head can be avoided.

Chronic Recurrent or Habitual Dislocation or Subluxation

The term should be reserved for repeated episodes of dislocation, where there is *abnormal anterior excursion of the condyles beyond the articular eminence, but the patient is able to manipulate it back into normal position.* So, here the condylar head moves, unassisted, forward and backward over the articular eminence **(Figs 22.15 to 22.17).**

Table 22.4: Treatment useful for chronic protracted/long standing dislocation

Conservative treatments mentioned in Table 22.3 are tried first, along with following procedures
• Elastic traction followed by intermaxillary fixation • Traction with bone hook • Mandibular guidance therapy • Immobilization post reduction for 10 to 14 days-barrel bandage, barton bandage, MMF or by using cervical collar
To reposition the condyle in the fossa, where much restriction of TMJ movement is present
• Temporalis myotomy • High condylotomy
To correct fusion and restore the joint, where complete restriction of movement is present
• Low condylotomy • Condylectomy for chronic lateral or posterior dislocation • Gap arthroplasty for superior dislocation
To maintain new joint and correct occlusion
• Horizontal subsigmoid osteotomy • Vertical/oblique osteotomy • Inverted L-shaped osteotomy • Bilateral sagittal split osteotomy



Figs 22.15A and B: Chronic subluxation of TMJ. Transcranial X-rays of (R) TMJ in closed and open position showing hypermobility of TMJ

This *recurrent, incomplete, self-reducing, habitual dislocation is termed as hypermobility or chronic subluxation* of the TMJ. The triad of ligamentous and capsular flaccidity, eminential erosion and flattening and trauma, are well recognized in the genesis of chronic recurrent subluxation.

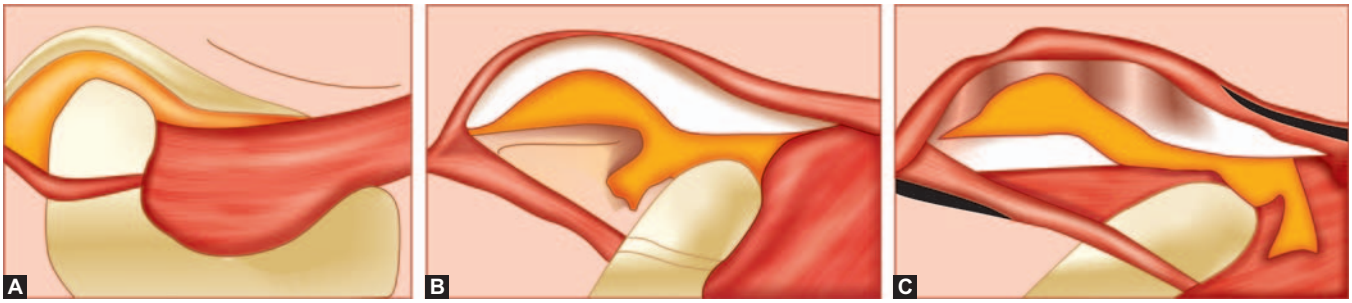
In such predisposed individuals, the acts of yawning, vomiting, laughing may precipitate subluxation. It is also seen in severe epilepsy, dystrophia myotonica and the Ehlers-Danlos syndrome. It can be also seen in professionals like teachers, speakers or musicians. It can be very embarrassing in public appearances to these patients. In recurrent subluxation, patient enters into vicious cycle. With each episode of subluxation, there is further stretching of the capsular ligament, which aggravates the condition and leads to further recurrence.

Ehlers-Danlos syndrome: This is a rare inherited disorder of the connective tissue, in which recurrent dislocation of the TMJ is seen. Four cardinal symptoms are as follows:

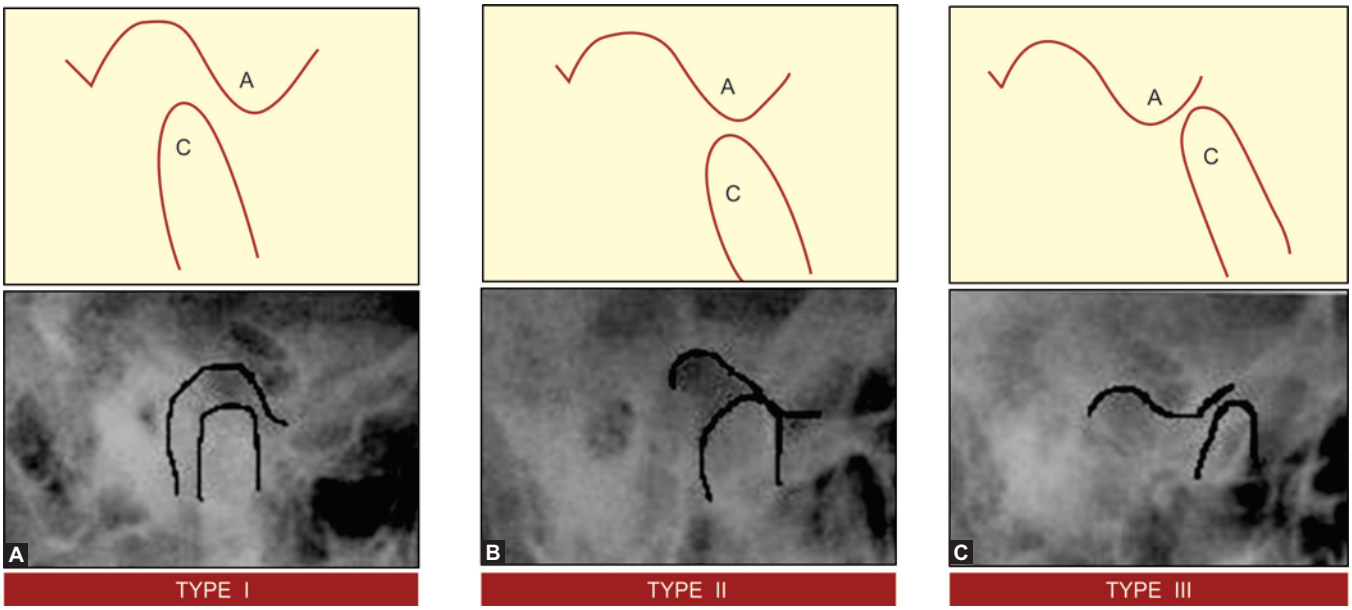
- Hyperelasticity of the skin
- Fragility of the skin
- Hypermobility of the joints
- Fragility of the blood vessels.

Chronic subluxation with pain: Excessive excursive movement or hypermobility of the mandibular condyle. It is not necessarily painful. But in some of the patients, sudden sharp and severe pain occurs when the mouth is opened widely. Occasionally, the problem is of such a magnitude, that the patient becomes reluctant to masticate food.

In literature, over a span of at least 100 years, there are descriptions of numerous and varied procedures designed to correct this abnormality. The plethora of surgical



Figs 22.16A to C: Habitual or recurrent dislocation or subluxation of TMJ: (A) Normal relationship of the condylar head and disk in rest position; (B) Maximum translated position. Rotation of the disk is seen posteriorly; (C) Subluxation of the condylar head, trapping of the disk forward, with disk space collapse above the head. Self-reducing condition

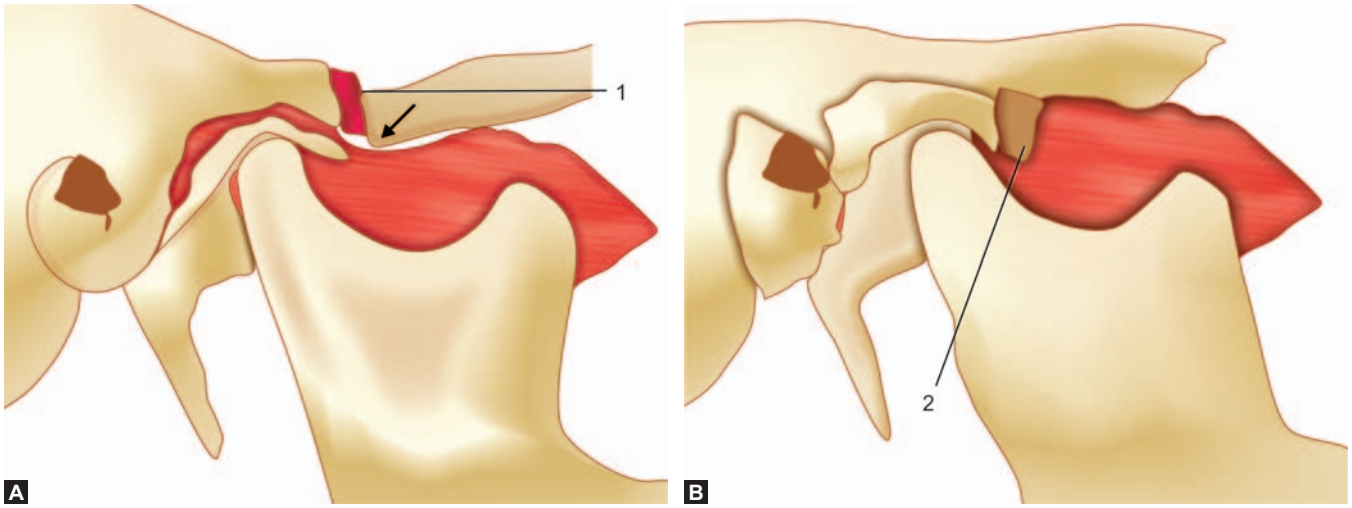


Figs 22.17A to C: Classification patterns of condylar mobility. A: Articular eminence, C: Condyle: (A) Type I: Condyle placed behind articular eminence at maximal mouth opening; (B) Type II: Condyle just under the articular eminence at maximal mouth opening; (C) Type III: Condyle situated anteriorly to the articular eminence at maximal mouth opening

procedures available suggests that not only this problem is difficult to manage, but the majority of procedures described in the literature have proved less than successful over a period of time.

The review of the different management procedures are as follows:

- **Intermaxillary fixation or limiting the oral opening by giving elastics:** Total immobilization of the jaw for the period of 3–4 weeks gives rest to the joint. But patient has to be kept on liquid diet. By applying prefabricated splint to the maxillary and mandibular arches, elastic guidance can be given to restrict oral opening or if the patient is cooperative, he/she is advised to restrict the oral opening on his/her own and instructed to eat food with the spoon or advised to take small morsels of food, thereby restricting the oral opening.
- **Use of sclerosing solution injections into the joint space:** Sodium psylliate provided consistently best results. But is no longer available. Sodium morrhuate has been used as a sclerosing agent, but has failed to produce good results. Sodium tetradecyl sulfate, which was developed for mildly sclerosing varicose veins and hemorrhoids, can be used with caution, as allergic or anaphylactic reactions have been reported. The injection of these sclerosing solution brings about fibrosis in the capsule, but the results are short lived. Hence, the use is not recommended. Recently, injecting platelet rich plasma or autologous blood into the



Figs 22.18A and B: Creating of a mechanical obstacle for preventing hypermobility (A-1) Dautry's zygomatic arch osteotomy; (B-2) Mayor's grafting technique on the eminence

joint and capsule to bring about fibrosis is becoming popular. Intramuscular injection of Botulinum toxin type A is also tried with short lived results.

In the absence of effective sclerosing agent, chronic subluxation associated with severe pain and not responding to conservative line of treatment becomes a surgical problem.

In 1976, *Miller and Murphy* divided surgical procedures to correct recurrent condylar dislocation into five categories:

1. Capsule tightening procedure.
2. Creation of a mechanical obstacle or block.
3. Direct restraint of the condyle.
4. Creation of a new muscle balance.
5. Removal of mechanical obstacle.

1. Capsule tightening procedures: These procedures were apparently effective over a short period.

(a) Capsulorrhaphy: It consists of shortening the capsule by removing a section and suturing it to make it tight.

(b) Placement of a vertical incision in the capsule and then drawing it tight by overlapping the edges and suturing.

(c) Reinforcement of the joint capsule by turning down a strip of temporal fascia and suturing to the capsule.

2. Creation of a mechanical obstacle (Figs 22.18A and B): A number of procedures have been suggested for creating an obstacle in the region of articular eminence, so that it can effectively block the excessive anterior excursion of the condyle.

(a) Lindemann performed an osteotomy on the eminence and turned it down in front of the condylar head to prevent its forward movement.

(b) Mayor advocated a placement of a graft (taken from the zygoma) over the eminence to increase the size and height.

(c) Placement of silastic block or vitallium mesh implants to add the height of eminence.

(d) Dautry advocated an osteotomy on the zygomatic arch and depressing it in front of the condylar head to serve as an obstacle to abnormal forward translation.

(e) Findlay reported the use of L-shaped pins anchored in the zygomatic process of the temporal bone and projecting it anterior to the condyle. Recently small L-shaped miniplates are used to create obstacle.

In the long-term results, it was noticed that all types of mechanical devices used to restrain the forward excursion of the condyle have certain disadvantages. Hence, not used frequently, because of poor rate of success.

3. Direct restrain of condyle: Procedures directed toward restraining the condyle from abnormal forward movements have been attempted for over half a century.

(a) Temporalis fascia turned down and sutured to the lateral surface of the articular capsule.

(b) Piece of fascia lata threaded through a hole in the zygomatic arch and second hole in the condyle. The fascia was then tightened, until half of the preoperative opening existed.

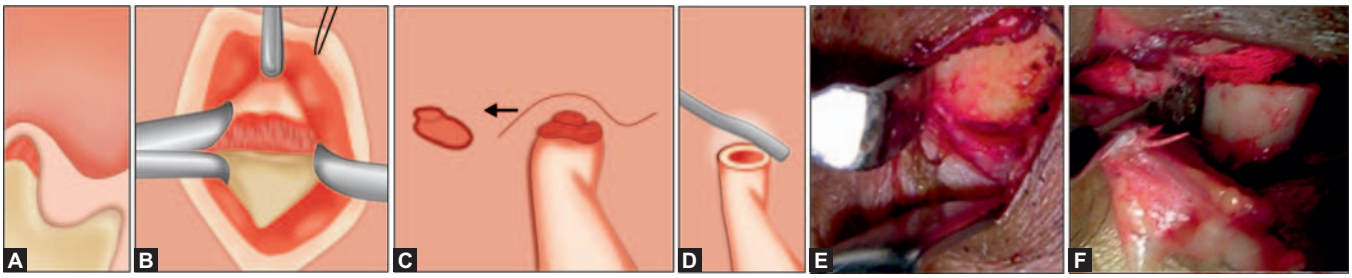
These techniques are complicated and have questionable long-term results.

4. **Creation of new Muscle Balance**
   (a) Scarification of temporalis muscle tendon: After taking intraoral incision, from the tip of the coronoid to retromolar area, the temporalis tendon and periosteum is divided, at and below the coronoid tip and masseter muscle is also partly elevated from the lateral surface of the ramus. This vertical wound is then sutured into a tight horizontal manner. The same procedure is repeated on the opposite side. This procedure brings about scar formation or fibrosis and thereby restricts the oral opening.
   (b) Medial pterygoid muscle can also be shortened (medial pterygoid myotomy procedure).
5. **Removal of mechanical obstacles:** Techniques involving surgical removal of obstacles, which are believed to block or restrict the condyle from returning to its normal position in the glenoid fossa, have been directed toward the meniscus, condylar head and articular eminence.

(a) Removal of torn meniscus or meniscectomy: Torn meniscus, which was thought as the obstacle, is removed. This technique became very popular, but unfortunately the undesirable results like protracted pain, grating, roughening of the condylar head, and an occasional ankylosis were noticed.

(b) The high condylectomy: The shortened head of the condyle will have less tendency to lock in front of the articular eminence. Here, it involves excision of the superior portion of condylar head, above the attachment of the lateral pterygoid muscle, so that the balance of the muscle function is not disturbed **(Figs 22.19A to F).**

(c) Eminectomy: In 1951, Myrhaug first reported this procedure. The rationale for this procedure is to allow the condylar head to move forward and backward free of obstruction by the excision of the articular eminence, instead of attempting to restrict the forward movement of the condylar head **(Figs 22.20 to 22.22).**



Figs 22.19A to F: High condylectomy procedure: (A to C) Excision of the superior portion of condylar head above the attachment of lateral pterygoid muscle; (D) Smoothening of the rest of the head with bone file; (E) Condyle exposed surgically, osteophyte is seen; (F) High condylectomy and contouring of condylar head; (E and F are intraoperative pictures)

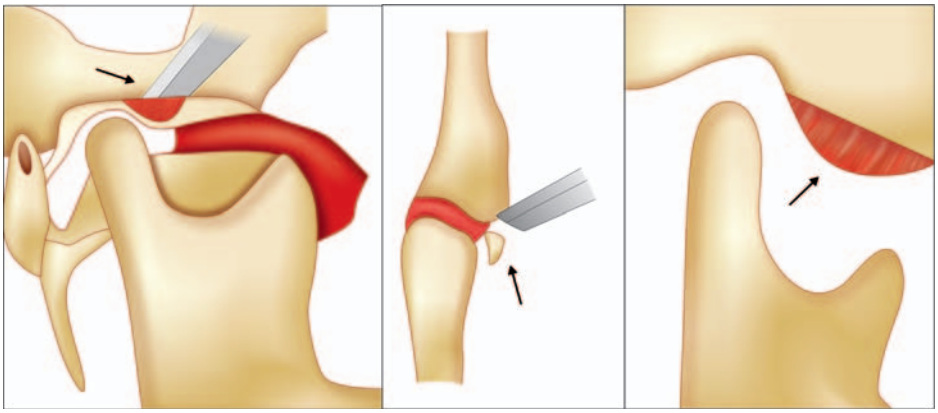
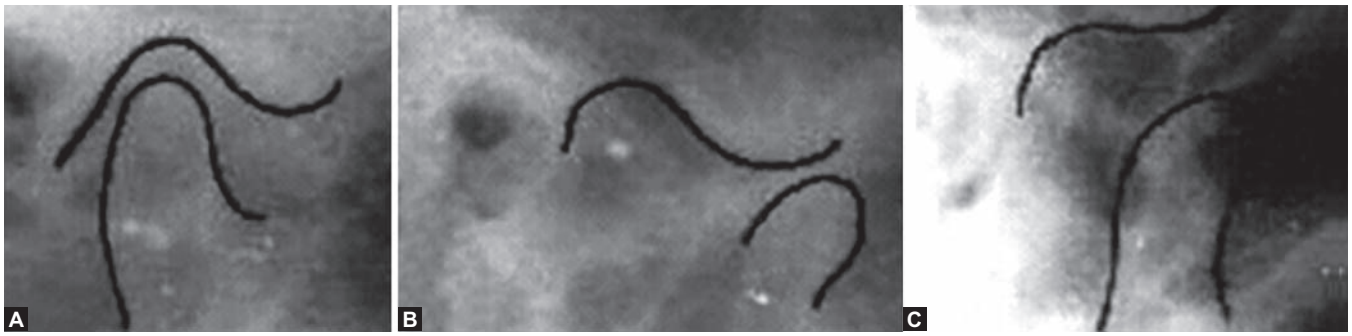
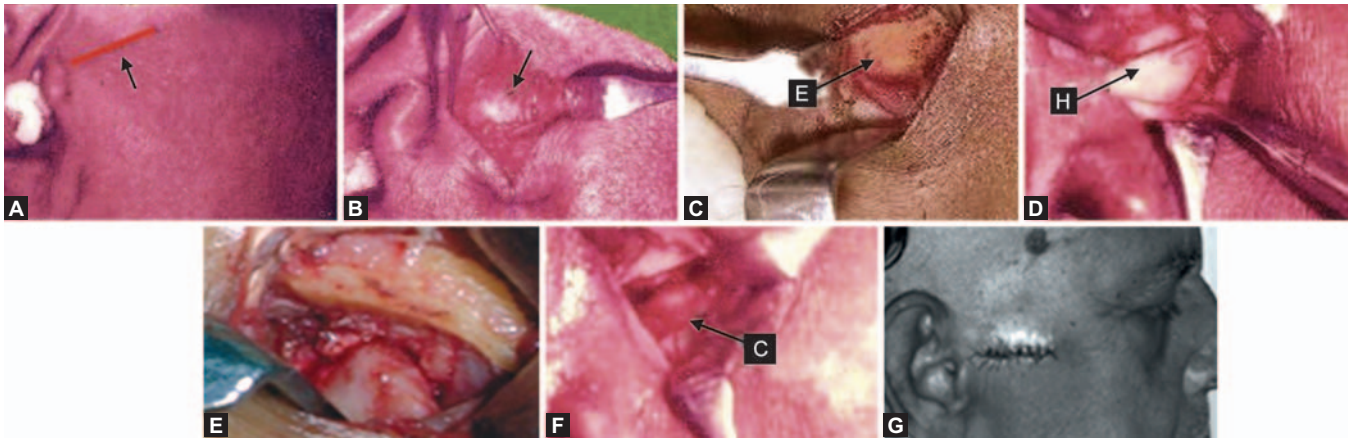


Fig. 22.20: Eminectomy procedure



Figs 22.21A to C: Transcranial X-rays of TMJ: (A) Preoperative view in closed position; (B) Preoperative view in open position showing subluxation of condylar head; (C) Postoperative view after eminectomy in open position. Patient's complaint of severe pain in open position was relieved after eminectomy



Figs 22.22A to G: Surgical procedure of eminectomy: (A) Extraoral incision parallel to zygomatic arch; (B) Surgical dissection; (C-E) Exposure of articular eminence; (D-H)—Horizontal cut with the bur at the lower portion of the eminence; (E) Eminectomy completed; (F-C)—Free condylar head movement checked; and (G) Closure

Indications for Eminectomy

- Recurrent episodes of dislocations
- Chronic hypermobility associated with severe pain
- Irreversible TMJ pain associated with clicking or grating.

Eminectomy Procedure

This procedure is relatively simple to perform. The main advantage is that the main joint cavity is not opened and avoids injury to meniscus and capsule. It can be performed under local anesthesia bilaterally with gratifying results **(Figs 22.20 to 22.22)**.

The basic step in this procedure consists of undermining and turning the skin and subcutaneous flap upward making small horizontal incision over the zygomatic arch in the region of articular eminence in front of the tragus. The articular eminence is located approximately 1.5 cm anterior to external auditory meatus. This distance is measured and the location of eminence is marked with marking ink prior to the incision. The eminence is next exposed by a T-shaped incision, the horizontal portion being over and parallel to the arch and vertical portion extending to the apex of the eminence. The periosteum is then reflected to expose the entire lateral portion of the eminence. A series of bur holes are drilled with a small round bur at the base of the eminence, in a line parallel to the arch. The bur is directed downward at approximately 10 degrees from horizontal plane. The bur holes are next connected with fissure bur, extending the cut as far inward as the shank of the bur will permit. After this, the eminence is sectioned and separated with broad osteotome. Base of the articular eminence is then smoothened with a sharp bone file (The foramen spinosum is located at the mesial aspect of the articular eminence. Injury to the middle meningeal artery

Table 22.5: Treatment for Chronic Recurrent or Habitual Dislocation or Subluxation
Conservative treatment • Prophylactic-prolonged rest of the TMJ for at least one month intraoral/extraoral bimanual relocation
Chemical Capsulorhaphy • Alcohol • Rivanol-aethedicaine • Sodium monoruate • Sodium psyliate-Sylnasol • Sodium tetradecyl sulfate • Autologous blood capsulorrhaphy • Platelet rich plasma capsulorrhaphy • Botulinium toxin muscle injection—into lateral pterygoid muscle
To restrict Condylar movement • Surgical capsuloraphy/restitution of ligaments • Use of mersilene tapes—dacron/Ethicon, or fascia lata around condylar neck • Internal lateral pterygoid myotomy • External lateral pterygoid myotomy
To recreate mechanical obstruction along condylar path- Mandibular condyle anchoring procedures. • Anterior/forward repositioning/placement of disc • Downward and inward fracture of zygomatic arch • Eminoplasty with screws or L-shaped miniplates • Eminoplasty with inlay bone grafts—Norman procedure • Eminoplasty with onlay bone grafts—Dautery procedure
To remove mechanical obstacle along condylar path • Eminectomy
To rehabilitate the joint function • Open condylotomy • Total joint replacement

may be a source of major hemorrhage after eminectomy). The irrigation of the area is then carried out. The tissues then carefully sutured. The application of an effective pressure dressing that is left in place for at least 48–72 hours **(Table 22.5).**

SURGICAL APPROACHES TO MANDIBULAR CONDYLE AND ITS NECK

Surgical access to the TMJ is an exacting procedure. It requires technical skill and a thorough knowledge of anatomy of the area. TMJ has got close proximity to the main trunk of the facial nerve with its branches in the temporal and facial areas. It has also got close proximity to the auriculotemporal nerve and the abundant vascular supply. Several approaches to the TMJ have been proposed and used clinically **(Figs 22.23, 22.24 and Table 22.6).**

Postauricular Approach

The incision is taken behind the external ear in the crease near the superior aspect of external pinna and extended to the tip of the mastoid process **(Figs 22.24A and B).**

This highly cosmetic incision has got several disadvantages. Main problems are small surgical exposure with poor access and visibility, stenosis of the external auditory canal, infection involving the external auditory canal or cartilaginous framework or both, paresthesia (temporary or permanent) of the external pinna and deformity of the auricle.

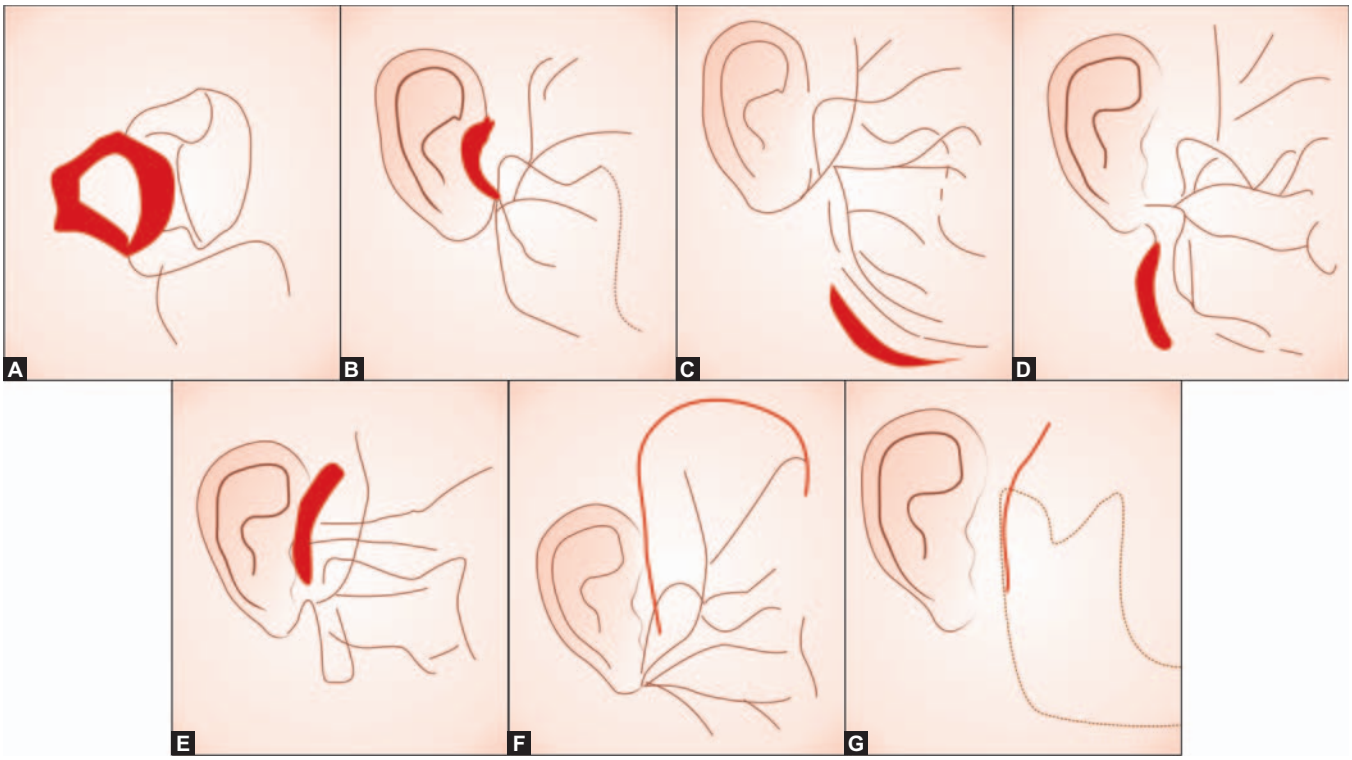
Endaural Approach

Short facial skin incision with extension into the external auditory meatus. The incision begins above the level of the zygomatic arch and extends downward and backward into the intercartilaginous cleft between the tragus and the helix and then extends inward along the roof of the auditory meatus for approximately 1 cm **(Fig. 22.25).**

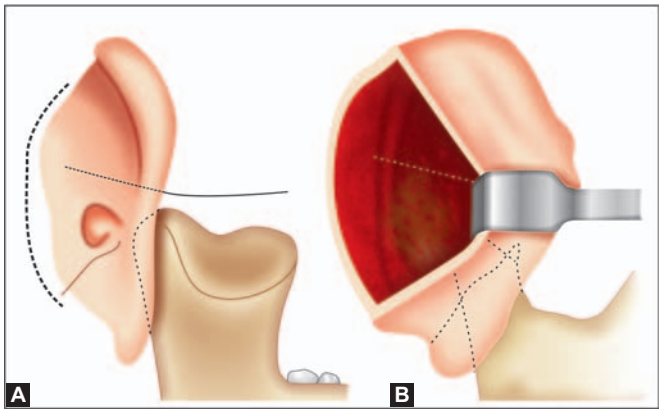
- **Advantages:** Excellent cosmetics.
- **Disadvantages:** The limited access and possibility of meatal stenosis or chondritis.

Submandibular (Risdon) Approach

Here the incision is taken about 1 cm below the angle of



Figs 22.23A to G: Surgical approaches to TMJ and associated structures: (A) Posterior auricular incision; (B) Endaural approach; (C) Risdon's incision; (D) Hind's incision; (E) Preauricular incision; (F) Popowich incision; and (G) Thoma's preauricular incision



Figs 22.24A and B: Post or retroauricular approach to TMJ: (A) Initial curved incision in the retroauricular crease; (B) Transection of external auditory meatus and retraction of the external ear anteriorly to expose the joint capsule

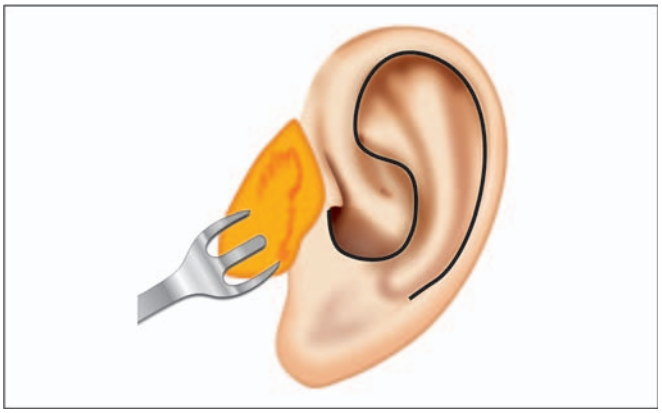


Fig. 22.25: Lamport's endaural approach to TMJ

the mandible. It extends forward, parallel to the lower border of the mandible and curves backward slightly behind the angle. Approach to the neck of the condyle and ramus is achieved by sharply incising through the pterygomasseteric sling and reflecting the masseter muscle laterally to expose the neck of the condyle and sigmoid notch **(Fig. 22.26).**

Poor access to the condylar head region. Procedures involving the articular portion of the head and the meniscus cannot be performed by this approach.

Table 22.6: Surgical approaches to TMJ	
Sl. No.	
1.	Submandibular (Risdon's) approach
2.	Postramal (Hind's) approach
3.	Postauricular approach
4.	Endaural approach
5.	Preauricular approach
	• Dingman's • Blair's • Thoma's • Popowich's modification of Al-Kayat and Bramley's
6.	Hemicoronal approach
7.	Coronal or bicoronal approach

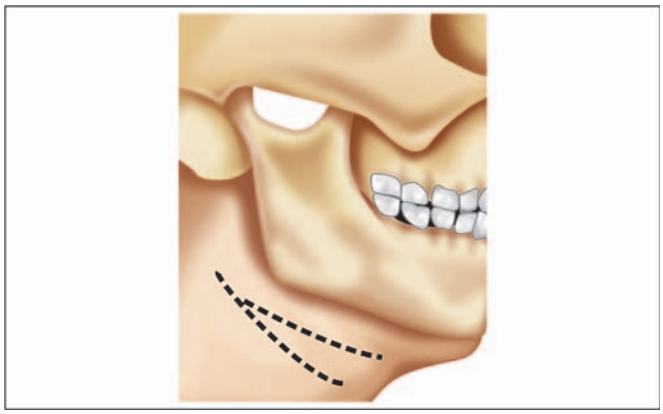


Fig. 22.26: Submandibular incision should be planned parallel to Langer's lines (Risdon's incision)

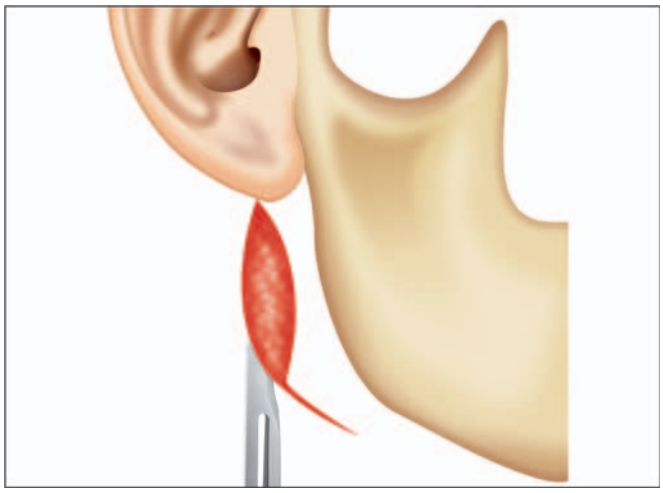


Fig. 22.27: Postramal (Hind's) incision

Postramal (Hind) Approach

Indicated for surgeries involving the condylar neck and ramus area. Highly cosmetic procedure. Excellent visibility and accessibility. A skin incision is placed 1 cm behind the ramus of the mandible and extends 1 cm below the lobe of the ear to the angle of the mandible. Communicating fascia between the sternomastoid muscle and the parotid gland and masseter muscle (parotidomasseteric fascia) is carefully separated, to expose the posterior border of the ramus. Perforation of the posterior facial vein and injury to the main trunk of the facial nerve is avoided. Once the posterior border of the ramus has been exposed, the pterygomasseteric sling is incised at the angle and the masseter muscle, parotid gland are reflected upward and laterally to expose the neck of the condyle. After completion of the surgical procedure, the pterygomasseteric sling is reapproximated and sutured and the wound is closed in layers **(Fig. 22.27).**

Preauricular Approach

This is the most basic and standard approach to the TMJ. Many clinicians have modified this basic incision for avoiding injury to the auriculotemporal nerve and for having better exposure to the TMJ. First, the standard preauricular approach is described. Later, variations are briefly presented. This basic incision is advocated and popularized by Dingman (1951) **(Figs 22.28 to 22.31).**

Preparation of the Surgical Site

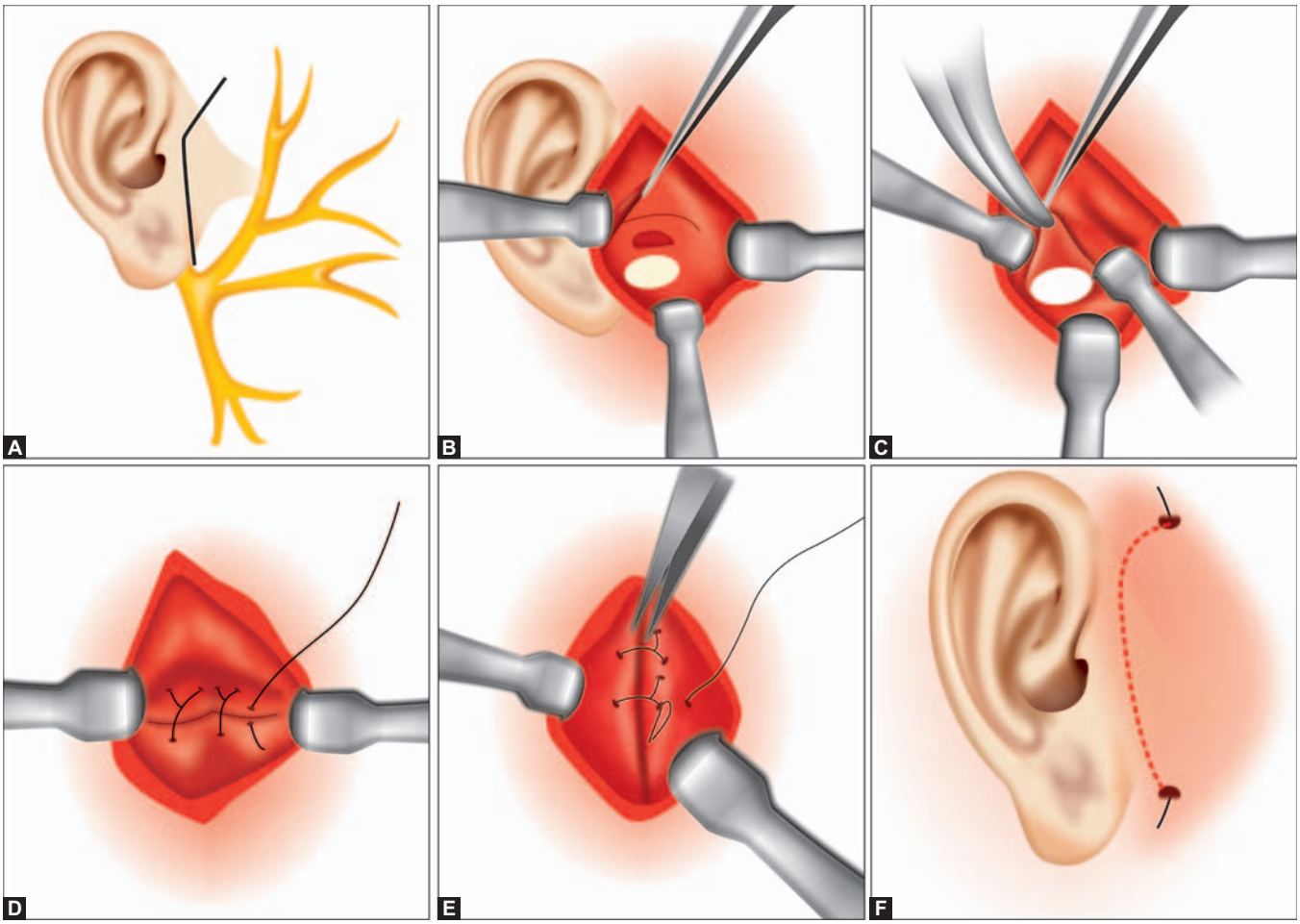
Preparation and draping should expose the entire ear and lateral canthus of the eye. Shaving of the preauricular hair is optional. Cotton soaked with antibiotic ointment may be placed into the external auditory canal.

Marking the Incision

The incision is outlined at the junction of the facial skin with the helix of the ear. A natural skin fold along the entire length of the incision from (the free margin of the attached ear to the scalp) the helix to the upper border of the tragus can be used.

Infiltration of Vasoconstrictor

The preauricular area is very vascular. A vasoconstrictor can be injected subcutaneously in the area of the incision to decrease the intraoperative bleeding.



Figs 22.28A to F: Preauricular incision: (A) Initial incision in the preauricular fold; (B) Oblique incision through the superficial layer of temporalis fascia. Periosteal elevator is then inserted below the temporalis muscle to expose the lateral portion of the zygomatic arch; (C) Cut in the capsule to enter the TMJ space and incision through the lateral attachment of the disk, entering the inferior joint space, (D) After surgery, suturing of the capsule; (E) Suturing the wound in layers; (F) Final skin subcuticular suturing

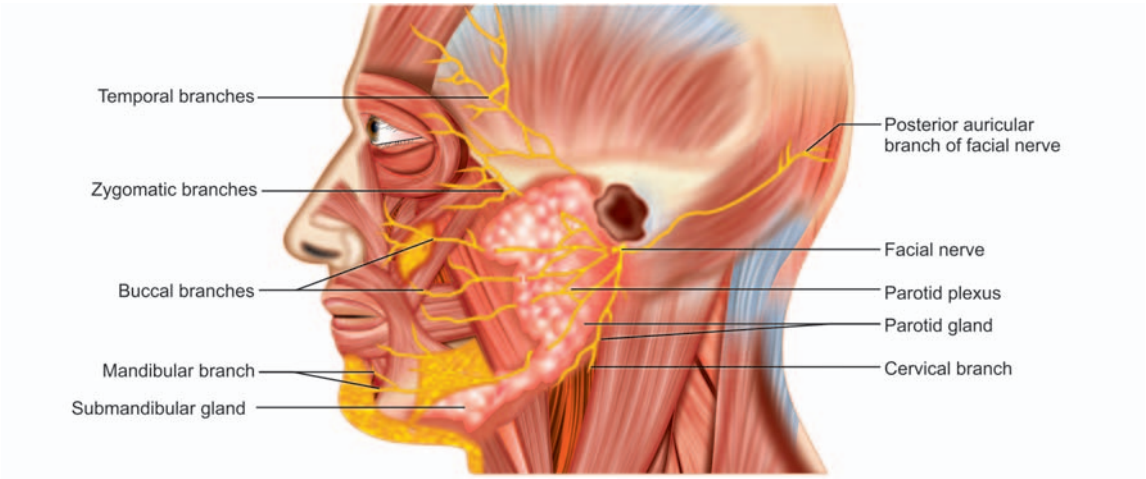


Fig. 22.29: Facial nerve and its branches

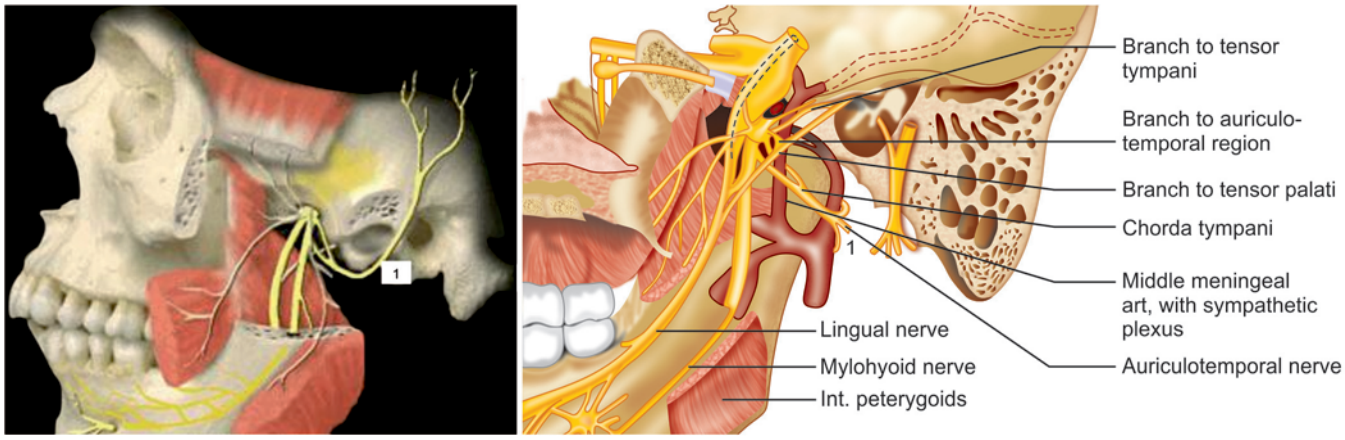
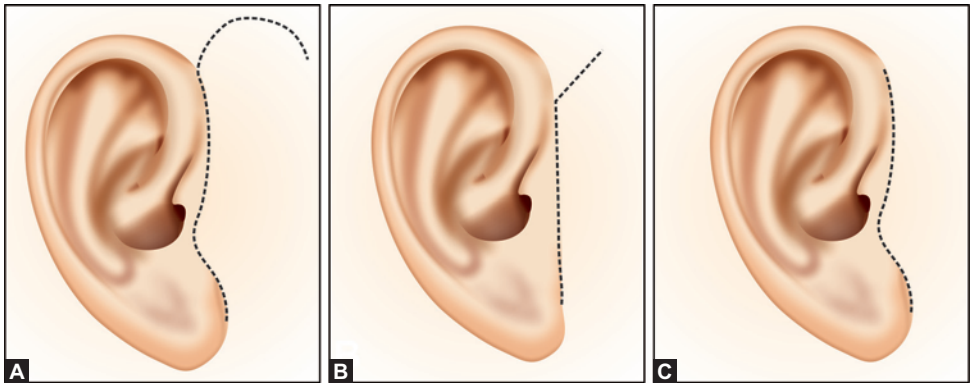


Fig. 22.30: (1) Auriculotemporal nerve and its relation



Figs 22.31A to C: Preauricular incisions: (A) Blair's inverted hockey stick incision; (B) Thoma's angulated incision; and (C) Dingman's incision

Skin Incision

The incision is made through the skin, subcutaneous connective tissue to the depth of superficial layer of temporalis fascia. Any bleeding superficial vessels are cauterized before deeper dissection proceeds.

Dissection to the TMJ Capsule

Blunt dissection with periosteal elevator undermining the superior portion of the incision (that above the zygomatic arch), so that a flap can be retracted anteriorly for approximately 1–1.5 cm. This flap is dissected anteriorly at the level of the superficial layer of temporalis fascia.

Below the zygomatic arch, dissection proceeds bluntly adjacent to the external auditory cartilage. Scissor dissection proceeds along the external auditory cartilage in an avascular plane between it and the glenoid lobe of the parotid gland **(Fig. 22.28)**.

With the flap retracted anteriorly, above the zygomatic arch, an oblique incision is made through the superficial layer of the temporalis fascia beginning from the root of the zygomatic arch, just in front of the tragus toward the upper corner of the retracted flap. The fat globules contained between the superficial and deep layers of temporalis fascia are then exposed. At the root of the zygoma, the incision can be through both the superficial layer of temporalis fascia and the periosteum of the zygomatic arch. The sharp end of the periosteal elevator is used to expose the lateral surface of the zygomatic arch, till the articular eminence is exposed. The entire TMJ capsule will be then revealed.

Exposing the Interarticular Spaces

Inverted L-shaped incision should be taken in the capsule and with the retraction of this developed flap, the joint spaces can be entered. The opening is extended

anteroposteriorly by cutting along the lateral aspect of the eminence and fossa. Vertical incision is taken in the capsule till condylar neck, allows the separation down the periosteal layer.

Closure

The surgical procedure planned for TMJ disorder is carried out. The joint space irrigated well and any hemorrhage is controlled before closure. The wound is closed in multiple layers.

Modifications of Basic Preauricular Incision

All these modifications of basic preauricular incision were made to have better access and visibility and wider exposure and to prevent injury to the auriculotemporal nerve and the branches of the facial nerve **(Figs 22.31 and 22.32).**

1. *Blair and Ivy in 1936, used an 'inverted hockey stick' incision over the zygomatic arch*, which gave easy access and better visibility and also facilitated exposure of the arch along with condylar area.
2. *Thoma in 1958,* recommended an 'angulated vertical incision' which is carried out across the zygomatic arch in the fold, directly in front of the ear, extending down slightly above the ear lobe, to avoid the main trunk of the facial nerve.
3. *Al-Kayat and Bramley in 1979, described a modified preauricular approach to TMJ and zygomatic arch* considering the main branches of the vessels and nerves in the vicinity.
   The facial nerve exits the skull through the stylomastoid foramen. It enters the parotid gland, where it usually divides into two main trunks—temporofacial and cervicofacial. The facial nerve divides at a point between 1.5 and 2.8 cm below the lowest concavity of the bony external auditory canal, according to Al-Kayat and Bramley. These measurements can be used to identify the main trunk (whenever required) and avoid it during TMJ surgery.
   The terminal branches of the facial nerve are classified as temporal, zygomatic, buccal, marginal mandibular and cervical. The location of the temporal branches is of particular importance during TMJ surgery. The temporal nerve branches lie within a dense fusion of periosteum, temporal

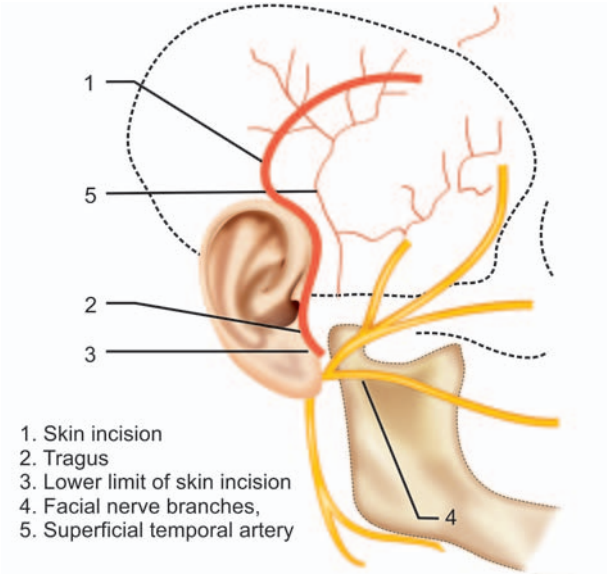
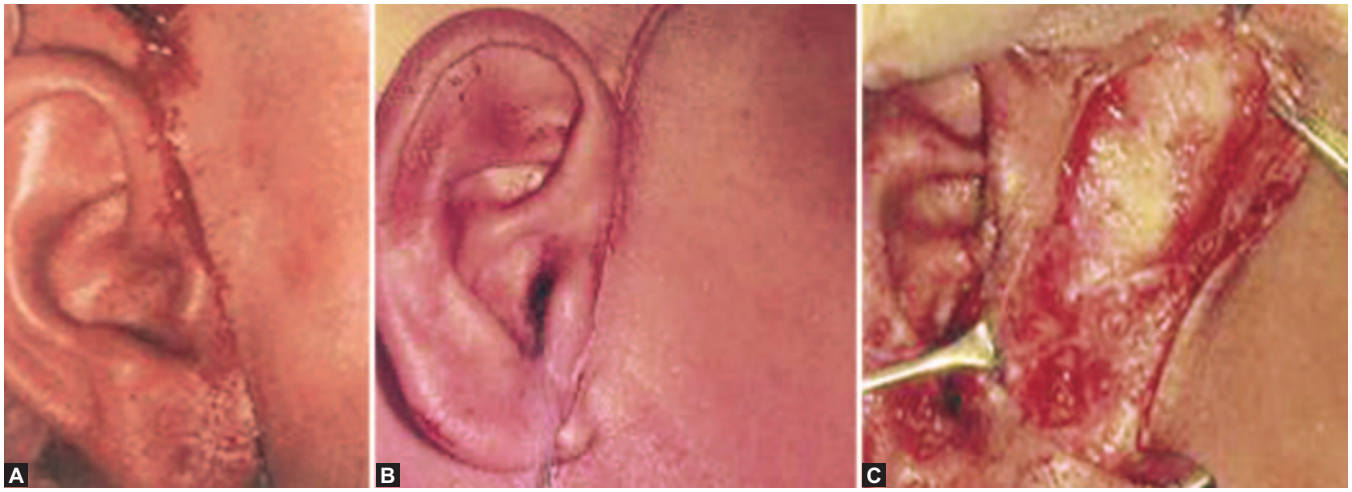


Fig. 22.32: Modified preauricular incision



Figs 22.33A to C: (A and B) Popowich and crane incision; and (C) Exposure of parotidomasseteric fascia

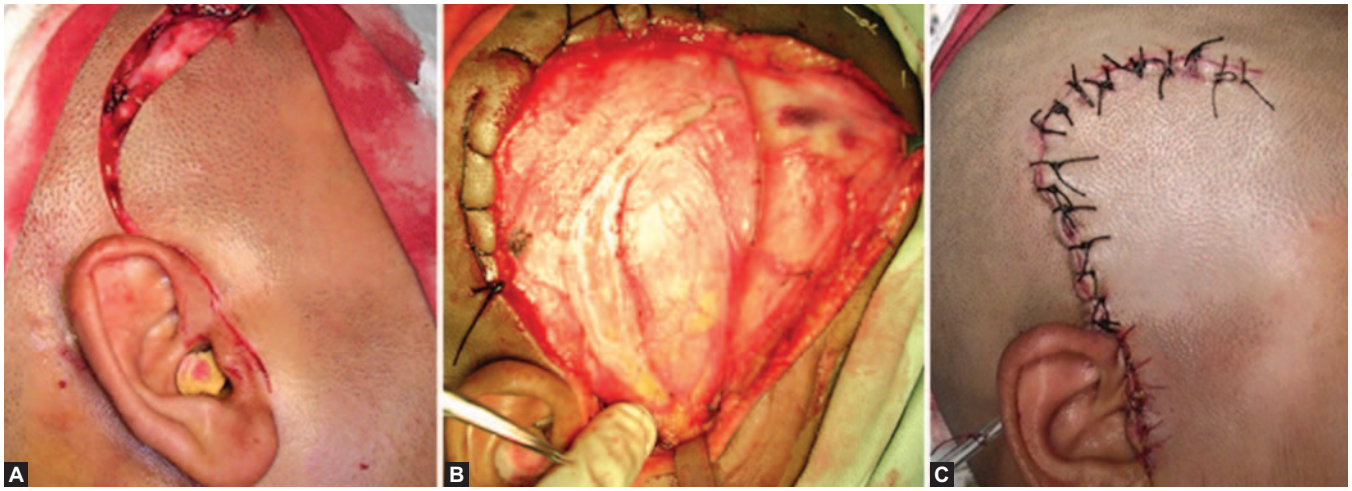
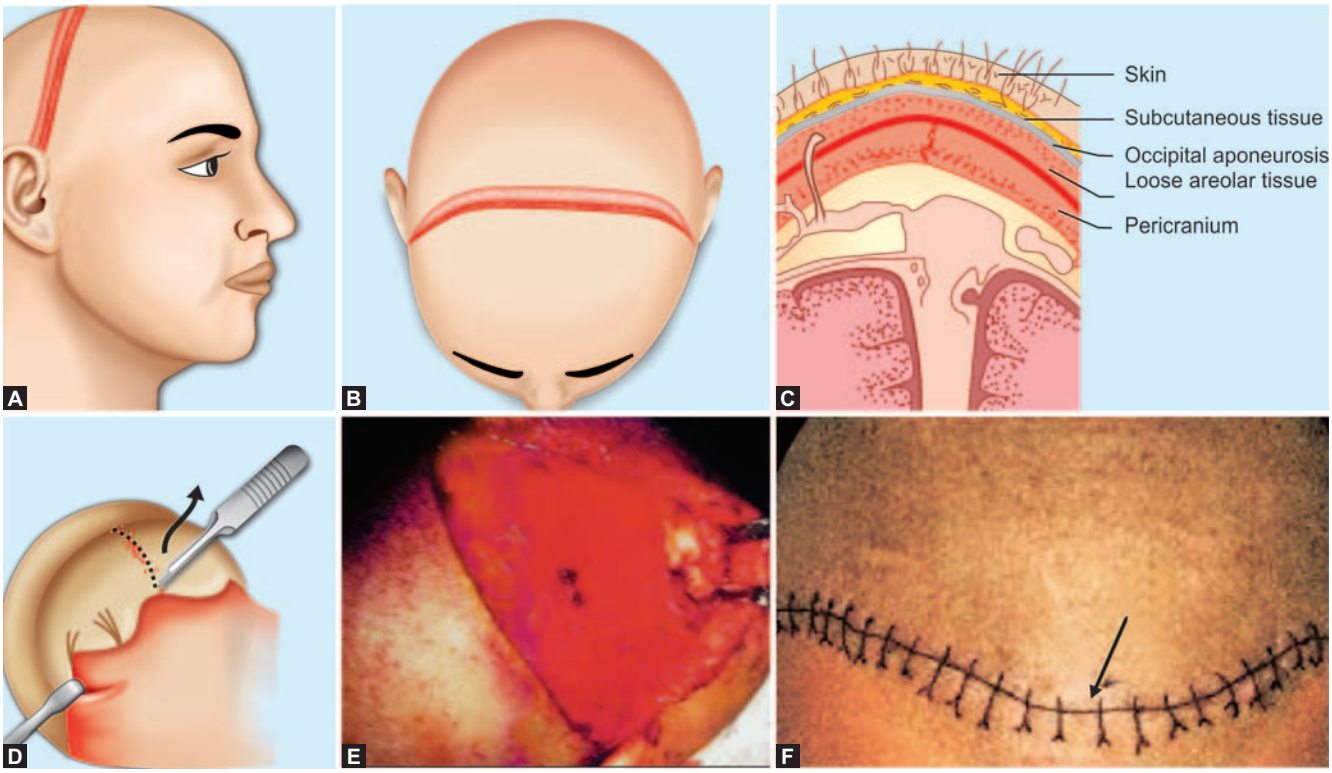


Fig.22.34A to C: (A and B) Modified Popowich and Crane incision; (B) Superior temporal dissection; and (C) Final suturing



Figs 22.35A to F: Coronal approach: (A) Hemicoronal incision; (B) Bicoronal or coronal incision; (C) Layers of the scalp; (D) Coronal flap reflection to expose the supraorbital rims, further incision can be taken in pericranium to expose the middle-third of the face; (E) Surgical exposure for malunited zygomaticomalar complex fracture; and (F) Final suturing

fascia and superficial fascia at the level of the zygomatic arch. Al-Kayat and Bramley found that the nerve averaged 2 cm from the anterior concavity of the external auditory canal. But in some cases, the nerve is found as near as 0.8 cm and as far anteriorly as 3.5 cm. Protection of the nerve can be achieved by making an incision through the temporal fascia and periosteum down to the arch, not more than 0.8 cm in front of the anterior border of the external auditory canal.

4. *Popowich and Crane in 1982, further modified basic Al-Kayat and Bramley's incision.* A large incision shaped like a question mark, was made in the temporal area and extended in the preauricular area **(Fig. 22.32 to 22.34).**

A Surgical Approach via Popowich Incision

This approach to the zygomatic arch and joint, gives excellent visibility with safety. The incision is longer and wider than the conventional. The skin incision is question mark shaped and begins about a pinna's length away from the ear, anteroposteriorly just within the hair line, curves backward and downward well posterior to the main branches of the temporal vessels, till it meets the upper attachment of the ear. The rest of the incision is same as the routine preauricular incision. The temporal incision is carried through the skin, superficial fascia to the level of temporal fascia. The facial nerve branches run in the superficial fascia and it is important that the full length of this fascia is reflected with the skin flap. Blunt dissection in this plane is carried out till about 2 cm above the zygomatic arch, where the temporalis fascia splits. Starting at the root of the zygomatic arch, an incision running at 45 degrees upward and forward is made through the superficial layer of the temporalis fascia. The zygomatic arch is exposed after reflecting periosteum, lateral layer of temporal fascia and superficial fascia as one layer. Downward dissection will expose the capsule and then the dissection is carried out as usual **(Figs 22.33A and B, and 22.34).**

Advantages of Popowich (1982) modification of Al-Kayat and Bramley's (1979) incision

- Reduction in incidence of facial nerve palsy
- Provision of donor site for temporalis fascia
- Decreased hemorrhage (dissection through avascular zone)
- Improved visibility and easier identification of fascial planes
- Reduction in postoperative edema and discomfort
- Potential complications of muscle herniation and fibrosis avoided
- Good cosmetic results
- Avoidance of auriculotemporal nerve anesthesia/paresthesia
- Reduction in total operating time.

Coronal Approach

Hemicoronal (unilateral incision) and bicoronal or coronal incision (bilateral incision) is more extensive, but versatile surgical approach to the upper and middle regions of the facial skeleton, including the zygomatic arch and the TMJ areas. It provides excellent access to these areas with minimum complications **(Figs 22.35A to F).**

A major advantage is that most of the scar is hidden within the hairline, when the incision is extended into the preauricular area, the surgical scar is inconspicuous. This incision can be utilized for more extensive bilateral involvement.

Points to Remember

- Anatomy of the temporomandibular joint
- Temporomandibular joint disorders classification
- Causes of TMJ dislocation and management
- Surgical approaches to mandibular condyle and its neck.

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CHAPTER 23

Ankylosis of the Temporomandibular Joint and its Management

INTRODUCTION

Ankylosis is a Greek terminology meaning "stiff joint or the joint which cannot move". In temporomandibular joint (TMJ) ankylosis, it is basically stiffening (immobility) or pathological intracapsular fusion/union (either of fibrous tissue adhesion or bony deposition) between the head of the condyle and glenoid fossa articular area. Here, because of immobility of the joint, the jaw function gets affected. Hypomobility to immobility of the joint can lead to inability to open the mouth from partial to complete. The incidence of intra-articular TMJ ankylosis is difficult to assess. But, in the western literature it is reported as decreasing, due to better understanding of management of condylar fractures and also to the decreased incidence of middle ear infection following the introduction of antibiotics. But in India, the incidence of TMJ ankylosis is still high. The reported age distribution ranges from 2 years to 63 years. Onset is usually seen before the age of 10.

CLASSIFICATION OF ANKYLOSIS

- False ankylosis or true ankylosis
- Extra-articular or intra-articular
- Fibrous or bony
- Unilateral or bilateral
- Partial or complete.

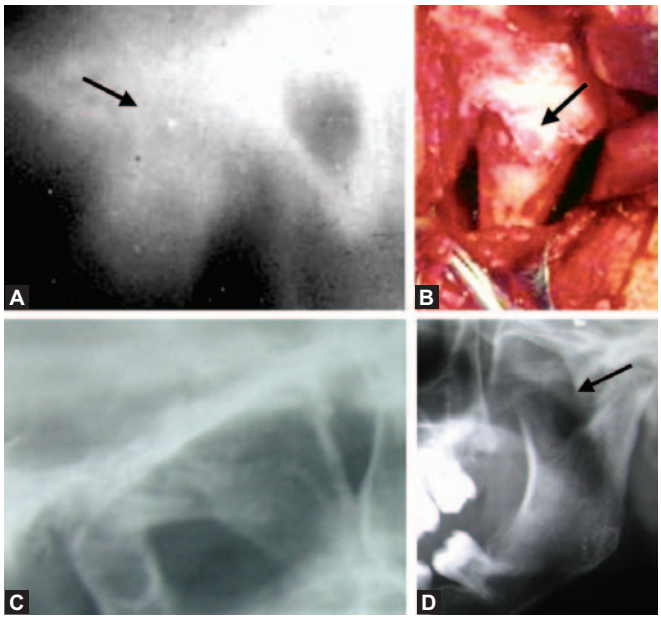
Extra-articular and intra-articular types of TMJ ankylosis have been described depending mainly on the anatomic site of the fusion or union. Intra-articular ankylosis indicates union between the articular surfaces of the TMJ, while extra-articular ankylosis results from lesions involving extra-articular structures.

The fusion or union of the articular surfaces of the head of the condyle with the glenoid fossa may be of fibrous or bony, depending on the nature of the tissue **(Figs 23.1 and 23.2).**

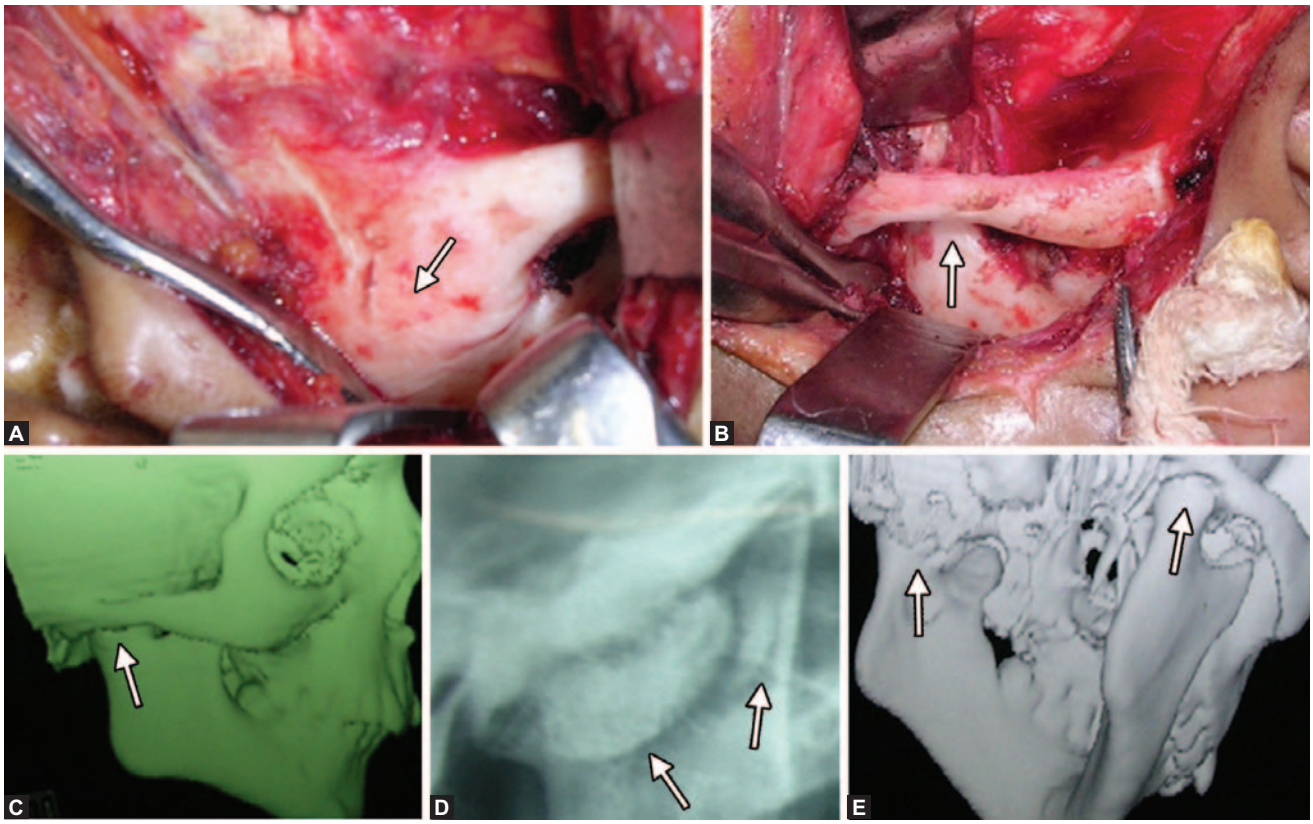
ETIOPATHOLOGY

The definite cause of ankylosis of TMJ is unknown. Two main factors predisposing to the ankylosis are trauma and infection in or around the joint region. In 1968, Topazian reported that 26–75% of cases of TMJ ankylosis are seen following trauma, while 44–68% are seen due to infection **(Table 23.1).**

- **Joint infection:** It may occur secondary to septicemia due to osteomyelitis, septic sore throat, scarlet fever, tuberculosis, meningitis, etc.



Figs 23.1A to D: Fibrous ankylosis of TMJ: (A) Tomogram of (L) TMJ showing fibrous fusion at the joint space; (B) Surgical exposure showing fibrous union of (L) TMJ. Note the condylar head is not deformed; (C and D) Right and left TMJs from OPG—Fibrous ankylosis



Figs 23.2A to E: Bony ankylosis: (A and B) Surgical exposure of (R) and (L) TMJs showing the bony ankylosed mass, with deformed head of the condyle; (C) 3D CT scan showing (R) TMJ bony ankylosis; (D) OPG—(R) Side bony ankylosis and deformed condylar head and elongated coronoid process; (E) Medial rotation 3 D view showing one side bony ankylosis and other side fibrous ankylosis of TMJ

Table 23.1: Etiopathology of ankylosis of TMJ

Trauma	*Congenital*
	• At birth, forceps delivery • Hemarthrosis (direct/indirect trauma) • Condylar fractures ▪ Intracapsular ▪ Extracapsular • Glenoid fossa fracture (rare)
• Infections	• Otitis media • Parotitis • Tonsilitis • Furuncle • Abscess around the joint • Osteomyelitis of the jaw • Actinomycosis
• Inflammation	• Rheumatoid arthritis • Osteoarthritis • Septic arthritis—hematogenous spread
• Rare causes	• Polyarthritis • Measles
• Systemic diseases	• Smallpox • Scarlet fever • Typhoid • Gonoccocal arthritis • Scleroderma • Beriberi • Marie-Strümpell disease • Ankylosing spondylitis
• Other causes	• Bifid condyle • Prolonged trismus • Prolonged immobilization • Unknown • Burns

Contd...

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- **Direct spread of infection** from adjacent areas may occur in cases of otitis media (infection of middle ear), mastoiditis, osteomyelitis of temporal bone or parotid abscess, soft tissue abscess, skin infections, or severe odontogenic submasseteric, infratemporal abscesses, etc.
- **Diseases affecting the joints:** Such as rheumatoid arthritis, osteoarthritis and ankylosing spondylitis bring about degenerative changes, destruction of the disk followed by the repair process. This can lead to the ankylosis of TMJ.

  Any other degenerative disease will also lead towards the destruction of the meniscus along with the narrowing of the joint space, leading to bony contact between the condylar head and roof of the glenoid fossa.
- **Trauma:** A high percentage of TMJ ankylosis is seen following trauma. At birth, TMJ may receive trauma from a forceps delivery. Trauma during intrauterine life leads to congenital ankylosis.

  Ankylosis is also generally associated with some form of facial injury at later date involving fracture of the neck or head of the condyle. Direct blow over the joint or at the chin may also cause bleeding into the joint. Any injury with hemorrhage into the joint space will initiate a progression of undesirable changes (clot organization and deposition of bone). If mandibular movement is not encouraged over a prolonged period of time, fusion will result. Comatose patients with associated condylar fracture are prone to develop ankylosis. Prolonged immobilization of condylar fractures, especially in children, where abundant blood supply is more likely to increase the incidence of hemarthrosis following injury leading to ankylosis. Therefore, a maximum period of immobilization of 3 weeks in the adults and 2 weeks in the children following reduction of condylar fracture is recommended.

PATHOGENESIS

Trauma will bring about extravasation of blood into the joint space called hemarthrosis. This predisposes to calcification and obliteration of a joint space, where immobility of the joint is maintained over a prolonged period. Many times initial fibrous bands lead towards bony consolidation to ossification.

In intra-articular ankylosis, the meniscus undergoes progressive destruction with flattening of the glenoid fossa and the head of the condyle is deformed and thickened, resulting in narrowing or obliteration of the joint space. Many times bony fusion may extend well beyond the joint space to involve the cranial base and even the sigmoid notch, zygomatic arch, coronoid process. In the severest form, it may include the lateral pterygoid plate and even the spine of the sphenoid bone.

DIAGNOSIS

Diagnosis of TMJ ankylosis is relatively easy and is dependent more upon careful clinical examination, rather than the diagnostic tests. Restricted oral opening or nil oral opening is seen and patient will complain of difficulty in mastication. Protrusive movements are not possible on the involved side. Also partial mobility or complete immobility of the condyle is readily noticed, when one palpates the joint movements. Pain is totally absent. In addition, in a young patient, a nature of facial deformity will help to differentiate between unilateral and bilateral involvement.

CLINICAL MANIFESTATIONS

Clinical manifestations vary according to: (1) severity of ankylosis, (2) time of onset of ankylosis and (3) duration.

- **Early joint involvement—less than 15 years:** Severe facial deformity and loss of function.
- **Later joint involvement after the age of 15 years:** Facial deformity marginal or nil. But, functional loss severe.

Those patients in whom the ankylosis develops after full growth completion have no facial deformity.

Unilateral Ankylosis

Seen in a child or in a person where the onset was usually in the childhood **(Figs 23.3A to F)**.

- Obvious facial asymmetry.
- Deviation of the mandible and chin on the affected side.
- The chin is receded with hypoplastic mandible on the affected side.
- Roundness and fullness of the face on the affected side.
- The appearance of the flatness and elongation on the unaffected side.
- The lower border of the mandible on the affected side has a concavity that ends in a well-defined antegonial notch.
- In unilateral ankylosis, some amount of oral opening may be possible. Interincisal opening will



Figs 23.3A to F: Unilateral ankylosis: Facial and dental features—partial oral opening

vary depending on whether it is fibrous or bony ankylosis.
- Crossbite may be seen.
- Class II angles malocclusion on the affected side plus unilateral posterior crossbite on the ipsilateral side seen.
- Condylar movements are absent on the affected side

Bilateral Ankylosis

- Inability to open the mouth progresses by gradual decrease in interincisal opening. The mandible is symmetrical, but micrognathic. The patient develops typical "bird face" deformity with receding chin **(Figs. 23.4A to H)**.
- The neck-chin angle may be reduced or almost completely absent.
- Antegonial notch is well defined/accentuated bilaterally.
- Class II malocclusion can be noticed.
- Upper incisors are often protrusive with anterior open bite. Maxilla may be narrow.
- Oral opening will be less than 5 mm or many times there is nil oral opening.
- Multiple carious teeth with bad periodontal health can be seen.
- Severe malocclusion, crowding can be seen and many impacted teeth may be found on the X-rays.

Diagnosis

Diagnosis is based on the following:
- History of trauma, infection, etc.
- Clinical findings
- **Radiographic findings:** They are important in arriving at a final diagnosis **(Fig. 23.5)**.
  - **Orthopantomograph:** It will show both the joints picture which can be compared in unilateral cases. Presence of antegonial notch can be appreciated, which develops secondary to the contraction of the depressor muscles and their action against elevator group of muscles. The antegonial notch becomes more pronounced in severe cases.
  - **Lateral oblique view:** It will give anteroposterior dimension of the condylar mass. Elongation of coronoid process can be seen.
  - **Cephalometric radiograph:** It is taken to evaluate the associated skeletal deformities.



Figs 23.4A to H: (A to E) Bilateral ankylosis of TM joint showing typical "Bird Face" and Facial profile features, severe micrognathia in bilateral TM joint ankylosis case; (F and G) Dental features and nil oral opening in bilateral TMJ ankylosis; (H) Scintigraphy showing increased uptake in TMJ areas, indicating active reankylosis process

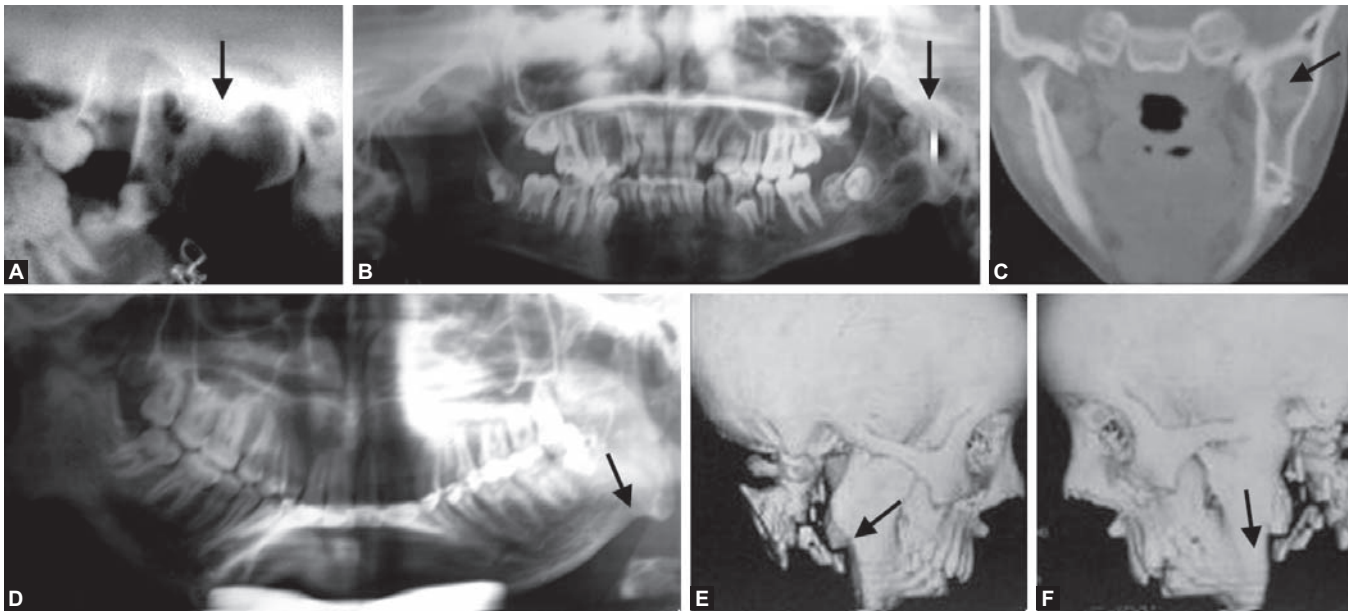
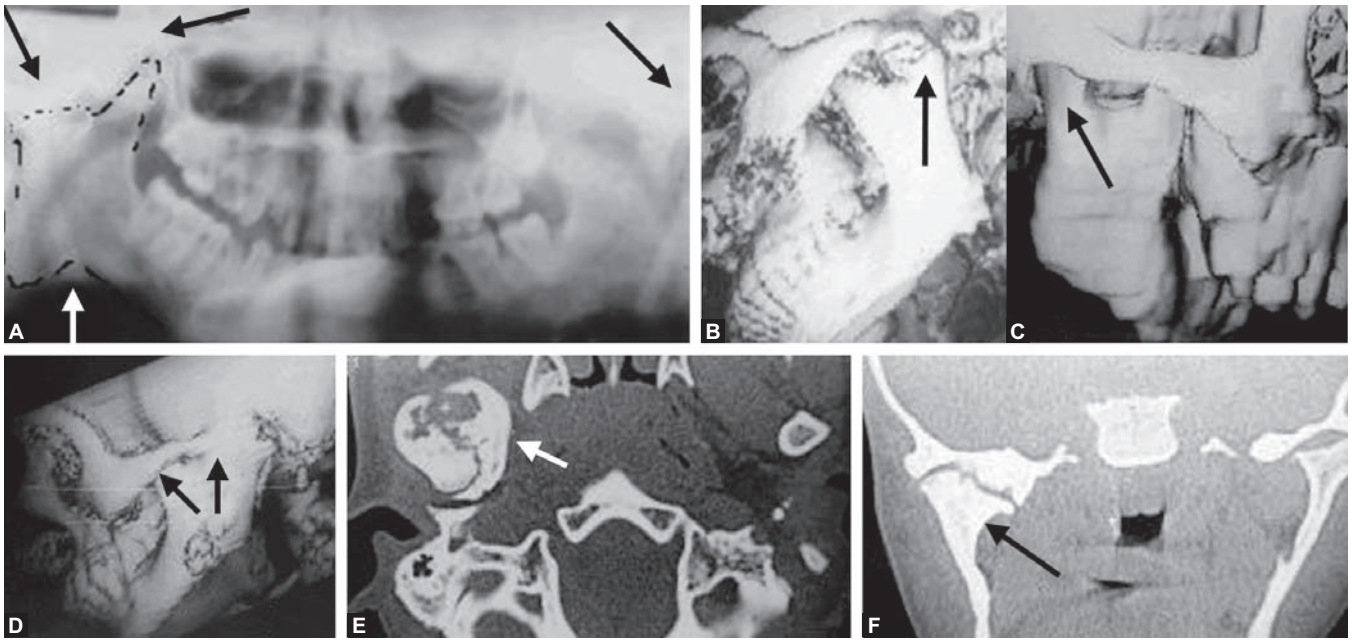
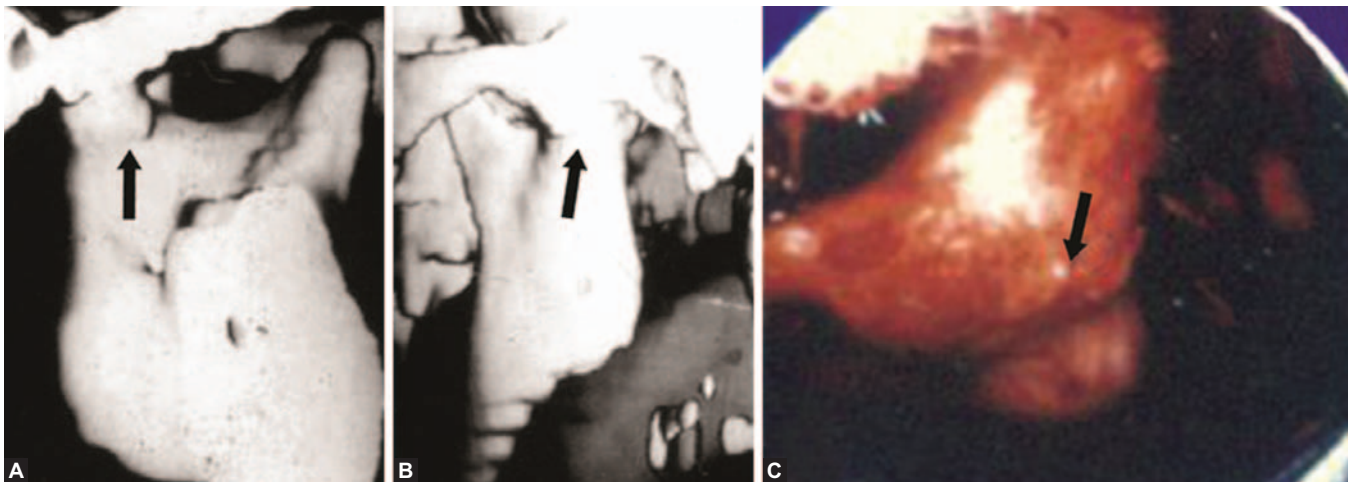


Fig. 23.5A to F: Various radiographs and a 3D CT scan for detecting TMJ ankylosis. Second row—arrows at inferior border of mandible indicating pronounced antegonial notch

- **Posteroanterior radiograph:** It will reveal the mediolateral extent of the bony mass. It will also highlight the facial asymmetry in unilateral cases.
- **CT scan:** It is very helpful guide for surgery. Relation to the medial cranial fossa, the antero-posterior width, mediolateral depth can be assessed. Any presence of fractured condylar head on the medial aspect of ramus can be located. In cases of reankylosis, the bony fusion can be seen. Three-dimensional (3D) CT scan will give life size picture of all aspects of the deformity **(Figs 23.6 and 23.7)**.



Figs 23.6A to F: (A) OPG bilateral ankylosis; (B) Unilateral ankylosis—3D scan; (C) Normal TMJ in 3D scan; (D) (L) TMJ ankylosis 3D scan showing bony fusion and elongated coronoid process; (E) Axial scan—bony ankylosis; (F) Coronal scan—bony ankylosis



Figs 23.7A to C: 3D CT scan for (L) TMJ ankylosis: (A) Medial rotation 3D scan with disarticulation; (B) Lateral rotation 3D scan with disarticulation; (C) Intraoperative picture of TMJ ankylosis of the same patient

Radiographic Findings

Fibrous Ankylosis

In fibrous ankylosis, reduced joint space and hazy appearance can be seen. But, still the normal anatomy of the head and glenoid fossa can be appreciated **(Figs 23.1A to D)**.

Bony Ankylosis

Complete obliteration of joint space. Normal TMJ anatomy is distorted. Deformed condylar head or complete bony consolidation replacing the joint space can be seen. Elongation of the coronoid process on the side of hypomobility will be seen **(Figs 23.2A to E)**.

Table 23.2: Grading of TMJ ankylosis by Sawhney (1986)	
Type I	The condylar head is present without much distortion. Fibrous adhesions make movement impossible
Type II	Bony fusion of the mis-shaped head and the articular surface. No involvement of sigmoid notch and coronoid process
Type III	A bony block bridging across the ramus and the zygomatic arch. Medially an atrophic dislocated fragment of the former head of the condyle is still found. Elongation of the coronoid process seen
Type IV	The normal anatomy of the TMJ is totally destroyed by complete bony block between the ramus and the skull base

Sawhney in 1986, graded TMJ ankylosis into following types **(Table 23.2)**. In 2002, Hakim and Metwalli proposed that ankylosed joints can be grouped as per the relation of their ankylosed mass to the surrounding vital structures, especially to the base of the skull, interpreted from CT scan, as follows:

Classification of TMJ Ankylosis as per CT Scan Interpretation (Hakim and Metawalli)

- **Class 1:** Unilateral/bilateral ankylosis, the condyle and glenoid fossa retain their original shape, and the maxillary artery is in normal anatomic relation to the ankylotic mass.
- **Class 2:** Unilateral/bilateral ankylosis, between the condyle and glenoid fossa/temporal bone, and the maxillary artery is in normal anatomic relation to the ankylotic mass.
- **Class 3:** The distance between the maxillary artery and the medial pole of the condyle is less on the ankylosed side than in the normal side or the maxillary artery runs within the ankylotic bony mass—best seen in coronal CT.
- **Class 4:** The ankylosed mass is fused to the base of the skull with extensive bone formation, especially from the medial aspect of the condyle. The ankylosed bony mass is in close relationship to the pterygoid plates, the carotid and jugular foramina, foramen spinosum. No normal joint anatomy can be seen. Best visualized on axial CT.

Sequelae of Untreated Ankylosis

- Normal facial growth and development affected.
- Speech impairment.
- Nutritional impairment.
- Respiratory distress (tongue fall in sleep), especially in bilateral involvement with severe micrognathia (obstructive sleep apnea syndrome).
- Malocclusion.
- Poor oral hygiene.
- Multiple carious and impacted teeth.

MANAGEMENT OF TMJ ANKYLOSIS

The treatment of TMJ ankylosis is always surgical. Early surgical correction of the ankylosed joint is highly desirable, if satisfactory function is to be regained.
Surgical strategy adopted depends on the following:

- Age of onset of ankylosis
- Extent of ankylosis
- Whether there is unilateral or bilateral involvement
- Associated facial deformity.

Aims and Objectives of Surgery

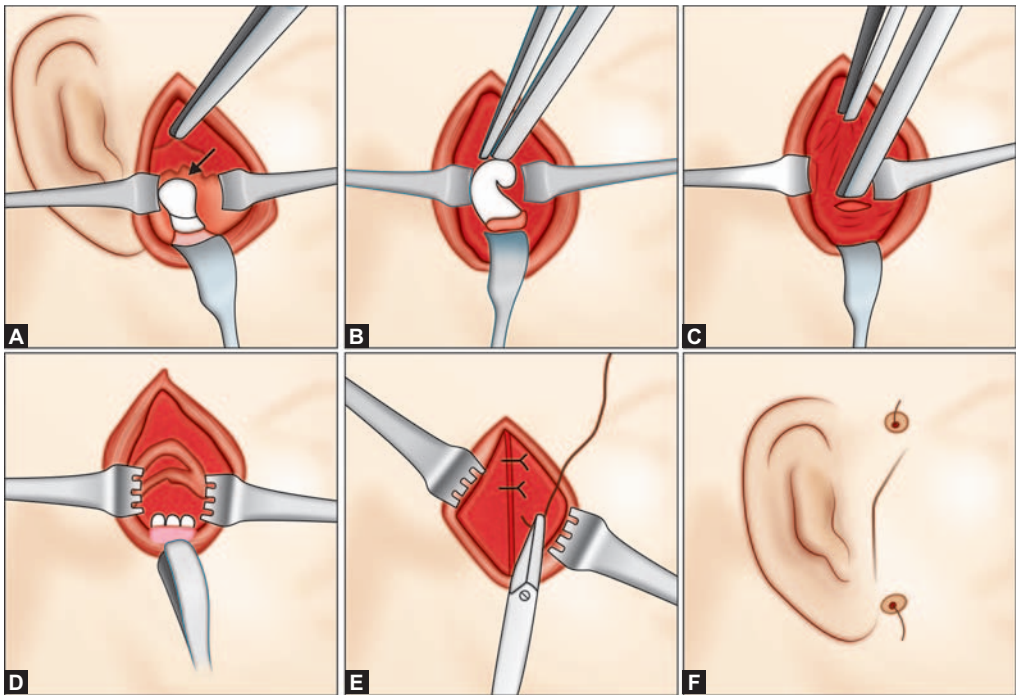
- Release of ankylosed mass and creation of a gap to mobilize the joint.
- Creation of a functional joint
  - To improve patient's nutrition
  - To improve patient's oral hygiene
  - To carry out necessary dental treatment.
- To reconstruct the joint and restore the lost vertical height of the ramus.
- To prevent recurrence—reankylosis.
- To restore normal facial growth pattern (based on functional matrix theory/adaptive growth center).
- To improve esthetics and rehabilitate the patient (cosmetic surgery may be carried out at a later date or at second phase).

Surgical Techniques

A number of techniques have been advocated by different surgeons. Critical analysis of all, filters only to three basic methods:

1. Condylectomy
2. Gap arthroplasty
3. Interpositional arthroplasty

Most surgical procedures can be done through a preauricular incision alone. The Popowich's incision is chosen for its obvious advantages. Whenever required, additional submandibular incision can be used for fixation of the graft, etc.



Figs 28.8A to F: Condylectomy—surgical procedure: (A) Exposure of condylar head via preauricular incision; (B) Sectioning of condylar head; (C) Breaking the fibrous adhesions; (D) Condylectomy complete; (E) Suturing the capsule; and (F) Final skin suturing

Condylectomy

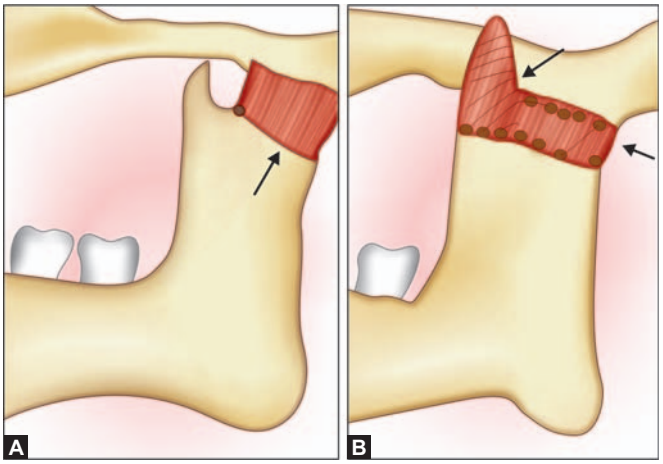
Condylectomy is advocated in cases of fibrous ankylosis, where the joint space is obliterated with deposition of fibrous bands, but there is not much deformity of the condylar head **(Figs 23.8A to F)**.

Radiologically and clinically after surgical exposure one can see the demarcation between the roof of the glenoid fossa and the head of the condyle. The condylectomy procedure can be carried out via preauricular incision. Horizontal osteotomy cut is carried out with the help of the surgical bur at the level of condylar neck. Vital structures on the medial surface of the condylar neck should be protected, by using special condylar retractor, inserted prior to the bony cut. The condylar head, which is sectioned from ramus, then should be separated from the superior fibrous attachments carefully and removed. The rest of the ramal stump should be smoothened out and wound closed in layers. Unilateral condylectomy tends to cause deviation of the mandible towards the operated side on oral opening and if bilateral, anterior open bite will be caused as a result of the loss of height in the vertical rami.

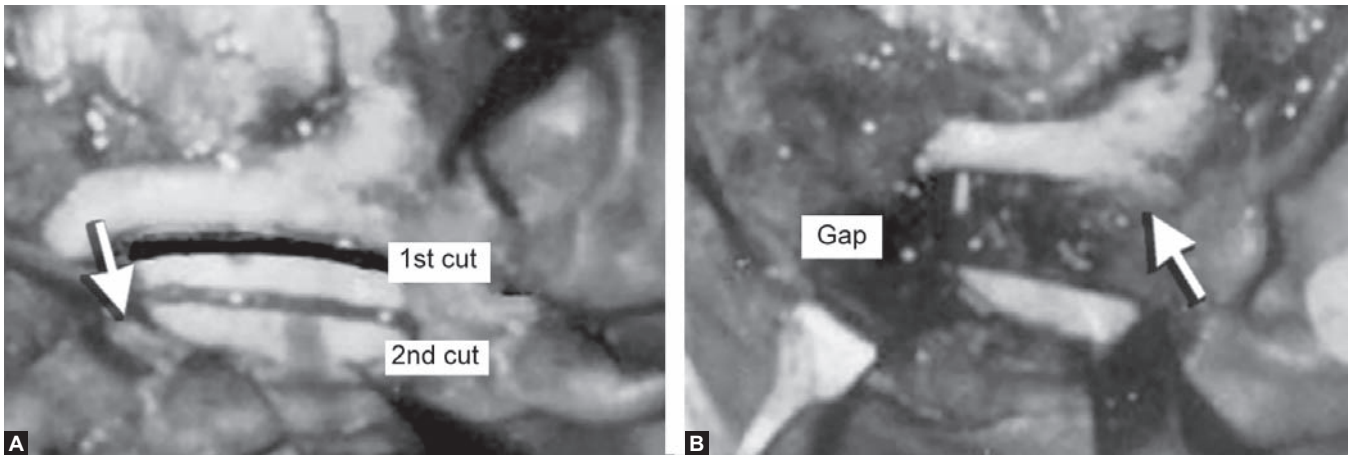
Therefore, when the site of the fused joint is mobilized via condylectomy, then after recontouring by arthroplasty, an alloplastic material can be used to maintain the joint space, satisfactory occlusion and joint movements.

Gap Arthroplasty

In the extensive bony ankylosis, a broad, thick area of bone deposition obliterates the entire joint, sigmoid notch and coronoid process. Identification of the previous joint structure is impossible and mobilization at the level of the joint becomes difficult, if not impossible (one cannot identify the roof of the glenoid fossa, which forms the floor of the middle cranial fossa) **(Figs 23.9 to 23.11)**.



Figs 23.9A and B: Diagrammatic representation: (A) Gap arthroplasty; (B) Gap arthroplasty with coronoidectomy



Figs 23.10A and B: Gap arthroplasty surgery: intraoperative pictures: (A) Surgical exposure of left ankylosed TMJ. 1st and 2nd bony cuts are seen. The wedge of bone between the two cuts is removed to create a gap and release the ankylosis; (B) Gap arthroplasty completed to achieve the mobility of the joint

The term gap arthroplasty is therefore used to describe the operation, in which the level of section is below that of the previous joint space and in which, no substance is interposed between the two cut bony surfaces. Section consists of two horizontal osteotomy cuts and removal of a bony wedge for creation of a gap between the roof of the glenoid fossa and ramus. Here, it is recommended to create a minimum gap of at least 1 cm to prevent reankylosis. The width of the bone removed is considered crucial. It is not usually possible to remove the entire block in toto, particularly from the medial aspect, which is in close proximity to the internal maxillary artery. Hence, bone is removed carefully by using a large round bur, until the medial bone is thinned out enough to be readily removed by using hand chisel or osteotome. It is important to create a gap of equal dimension both laterally and medially, so that the possibility of medial reankylosis due to bone contact is avoided.

Interpositional Arthroplasty

Most authorities agree that recurrence of ankylosis is less likely when something is interposed between the two cut raw bony surfaces. Topazian compared gap and interpositional arthroplasties and reported a 53% incidence of recurrence, when the gap arthroplasty method was used **(Figs 23.12 and 23.13)**.

So, interpositional arthroplasty involves the creation of a gap, but in addition a barrier (autogenous or alloplastic) is inserted between the cut bony surfaces to minimize the risk of recurrence/fusion again and to maintain the vertical height of the ramus **(Table 23.3)**.

Table 23.3: Interpositional materials used

Autogenous	*Heterogeneous*	*Alloplasts*
1. Cartilaginous grafts ▪ Costochondral ▪ Metatarsal ▪ Sternoclavicular ▪ Auricular cartilage 2. Temporal muscle 3. Temporal fascia 4. Fascia lata 5. Dermis	1. Chromatized submucosa of pig bladder 2. Lyophilized bovine cartilage (still under research)	1. Metallic ▪ Tantalum foil/plate ▪ Tantalum foil/plate ▪ 316L stainless steel ▪ Titanium ▪ Gold 2. Nonmetallic ▪ Silastic ▪ Teflon ▪ Acrylic ▪ Nylon ▪ Proplast ▪ Ceramic implants

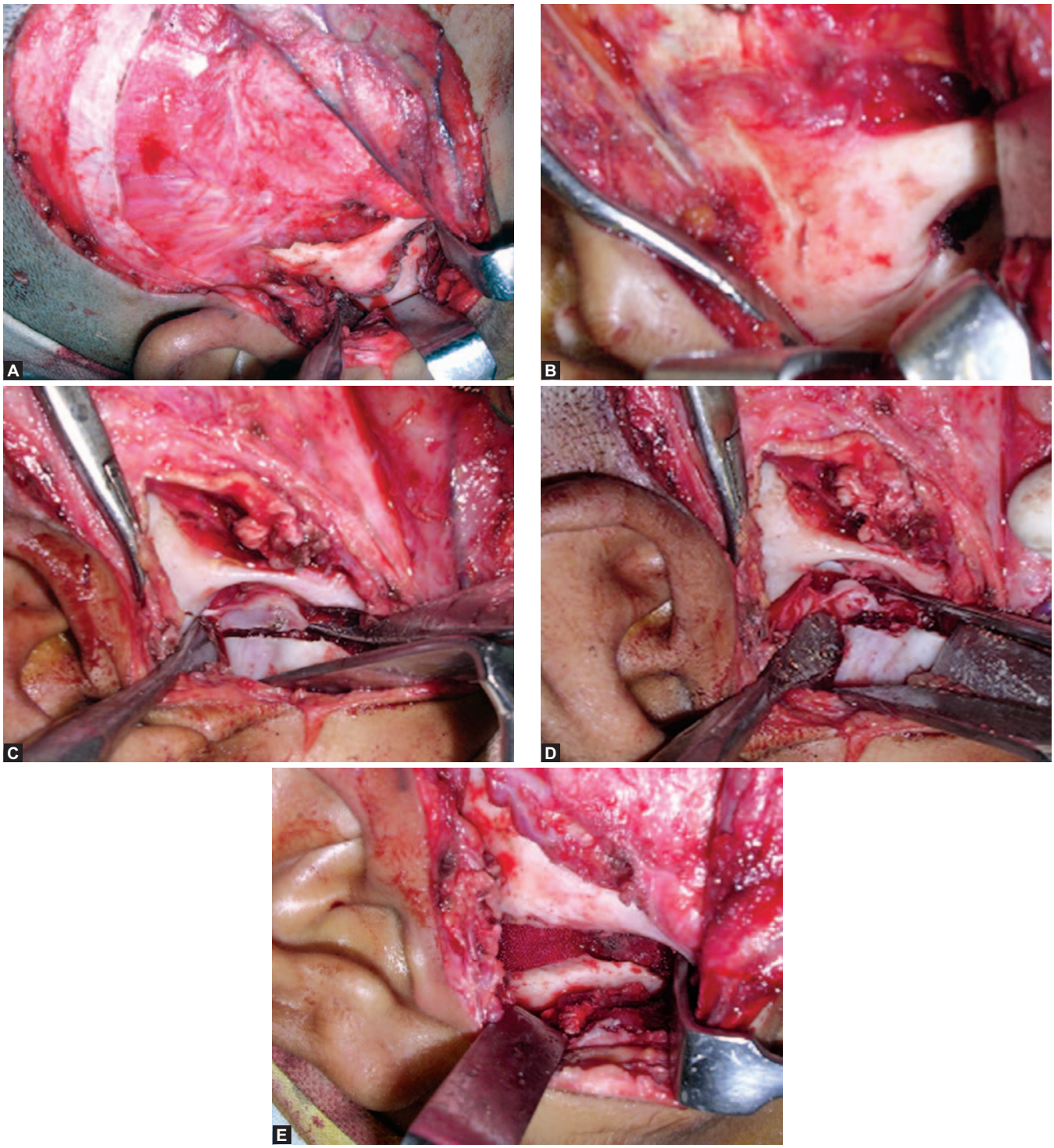
Artificial Replacement of the Joint

Prefabricated condylar prosthesis made of steel, vitallium or titanium, proplast, teflon, etc. have been also used extensively. Fossa liners along with especially constructed TMJ prosthesis reconstruct the entire joint. These are commercially available or custom fabricated **(Fig. 23.12B)**.

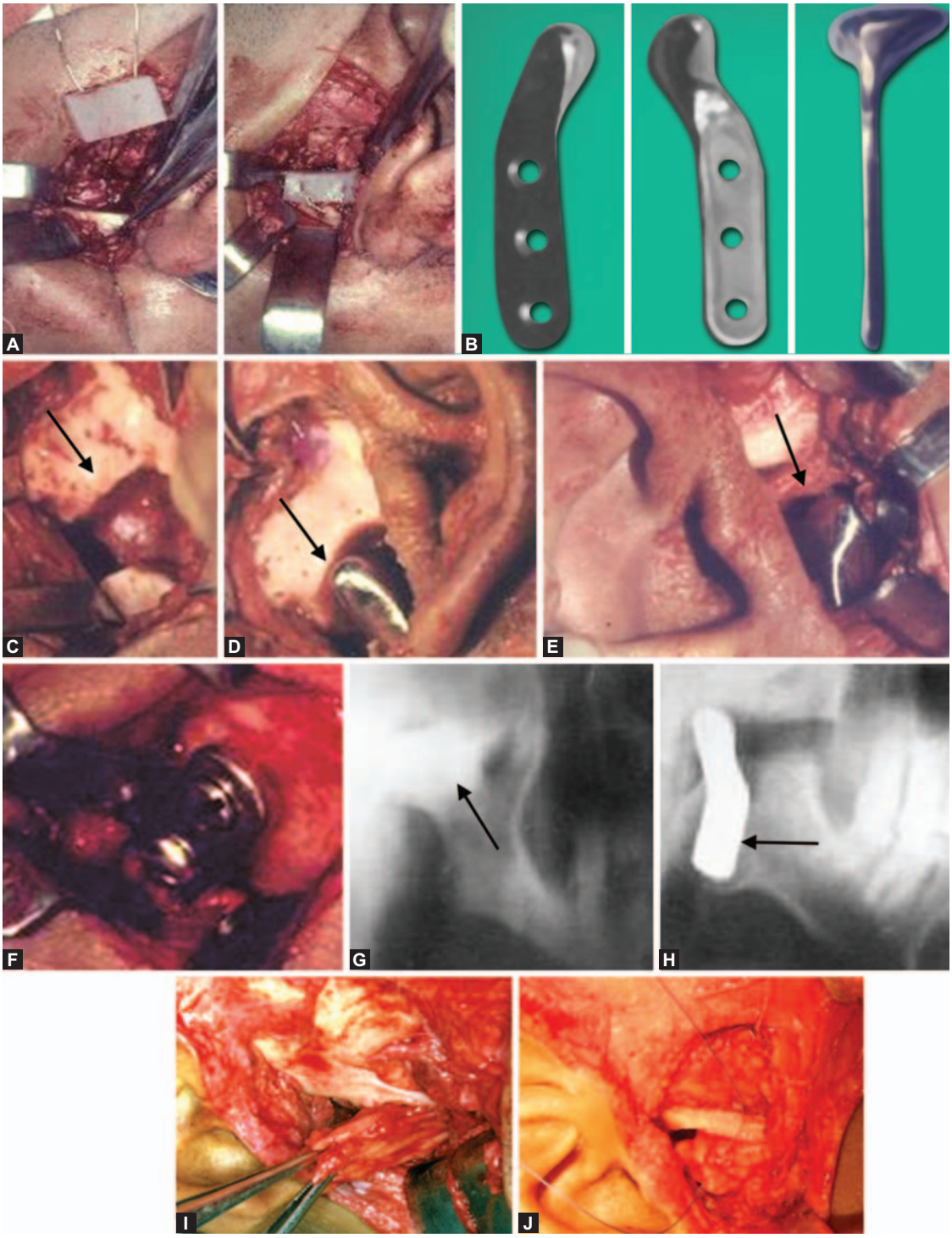
Internationally Accepted Sequential Protocols for the Management of TMJ Ankylosis

Put forward by Kaban, Perrott and Fisher in 1990:

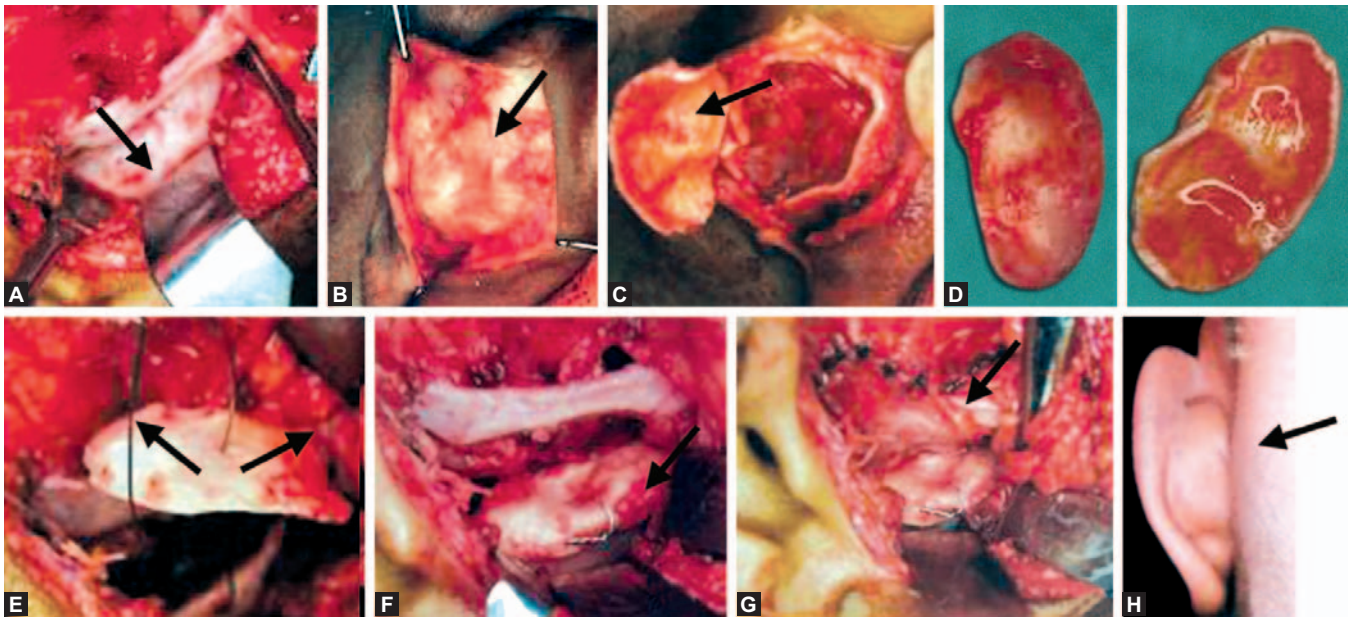
- Early surgical intervention.



Figs 23.11A to E: Intraoperative photographs: (A and B) Bony fusion; (C) Cut is completed for creating gap arthroplasty; (D) After completion of gap arthroplasty, old medially displaced condylar head is located and excised; and (E) Gap arthroplasty completed



Figs 23.12A to J: Interpositional arthroplasty: (A) Silastic block interposition; (B) Condylar metallic prosthesis; (C) Gap arthroplasty; (D) Metallic prosthesis at glenoid fossa; (E) Temporalis muscle interposition between glenoid fossa and metallic prosthesis; (F) Fixation of prosthesis at angle of the mandible, via submandibular incision; (G) Preoperative X-ray showing ankylosis; (H) Postoperative X-ray of prosthesis in situ; and (I and J) Dr Vidya Rattan's method—Buccal pad of fat brought to fill up the dead space, which prevents heterotopic bone formation and eliminates reankylosis



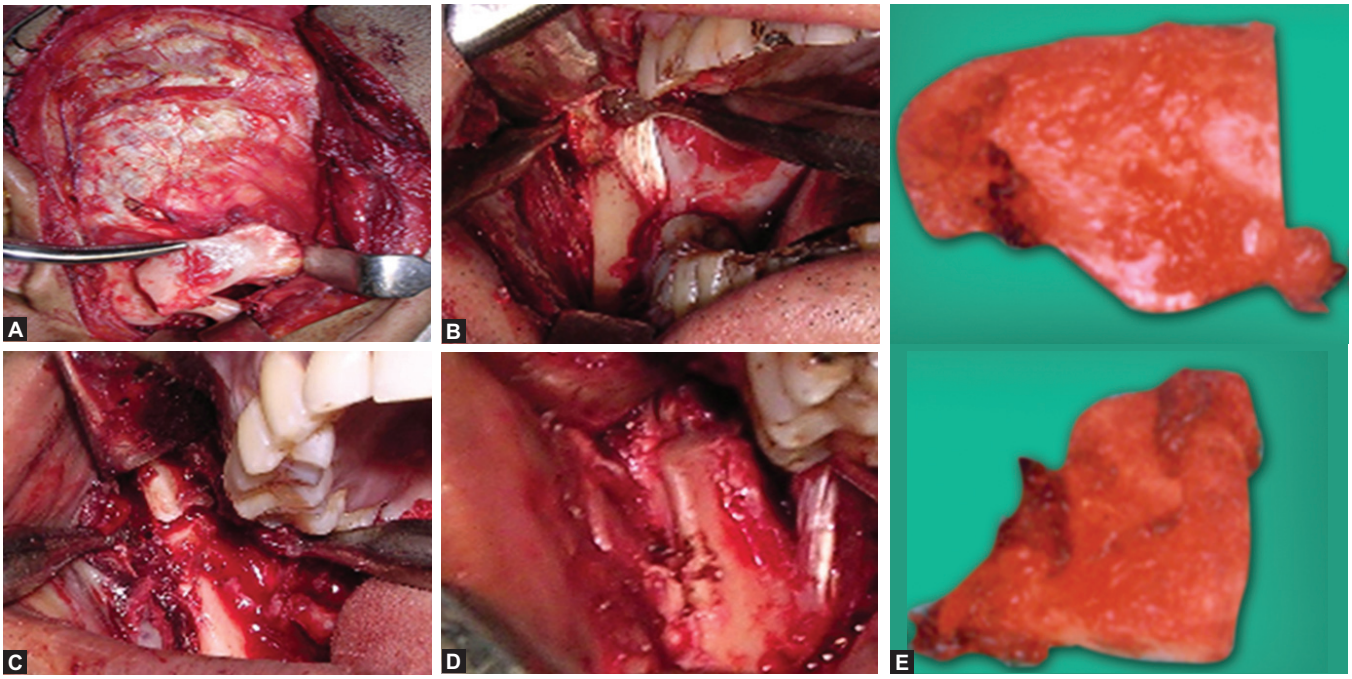
Figs 23.13A to H: Use of auricular cartilage graft as an interpositional material: (A) TM joint ankylosis in 8 years old boy, surgical exposure; (B and C) Harvesting of auricular Conchal) cartilage graft; (D) Auricular graft obtained via postauricular approach; (E) Fixation of auricular cartilage graft on to the ramus stump with wire; (F) Auricular graft final fixation; (G) Raw surface at glenoid fossa side, covered with temporalis muscle; and (H) Contour of the external ear is not changed

- **Aggressive resection:** A gap of at least 1–1.5 cm should be created. Special attention should be given to the fusion on the medial aspect of the ramus. Old malunited condylar fractured piece can be seen attached on the medial side.
- **Ipsilateral coronoidectomy and temporalis myotomy:** In most of these cases, there is always association of elongated coronoid process. After carrying out gap arthroplasty, the coronoidectomy on the same side should be carried out either separately or in combination with the gap arthroplasty cut from the same extraoral incision. yThe coronoid process is cut from the level of sigmoid notch till the anterior border of the ramus. The temporalis muscle attachments are severed by carrying out temporalis myotomy. The oral opening is checked after this procedure by the assistant. If maximum interincisal opening is greater than 35 mm is obtained, then there is no need to carry out contralateral coronoidectomy.
- Contralateral coronoidectomy and temporalis myotomy is necessary if maximum incisal opening is less than 35 mm. Then uninvolved side coronoidectomy and temporalis myotomy can be carried out through intraoral incision **(Figs 23.14 and 23.15)**.
- Lining of the glenoid fossa region with temporalis fascia.
- Reconstruction of the ramus with a costochondral graft.
- Early mobilization and aggressive physiotherapy for the period of at least 6 months postoperatively.
- Regular long-term follow-up.
- To carry out cosmetic surgery at the later date, when the growth of the patient is completed.

Release of the jaw movements is quite dramatic, upon completion of coronoidectomy. It is also desirable to excise the coronoid rather than release it and allow it to be pulled up superiorly by the temporalis muscle. Unless the coronoid process is removed, there is potential for reankylosis after reattachment **(Fig. 23.14A to E)**.

Lining of the Glenoid Fossa Side by Temporalis Myofascial Flap

Temporalis fascia along with a varying thickness of temporalis muscle may be harvested as an axial flap based on the middle and deep temporal arteries and veins. The dependable blood supply, the proximity to the TMJ and the ability to alter the arc of rotation by basing the flap inferiorly or posteriorly, makes this a versatile flap for lining the glenoid fossa. It is used as an interpositional material after release ankylosis of TMJ **(Figs 23.16A to E)**.



Figs 23.14A to E: (A) Extraoral coronoidectomy carried out after the release of TMJ ankylosis by gap osteoarthroplasty; (B) Intraoral coronoidectomy surgical procedure, exposure of coronoid process through intraoral incision; (C) Coronoid tip is released from temporalis muscle by myotomy and coronoidectomy cut is done; (D) Remaining ramus portion; and (E) Bilateral coronoid processes excised

Interposition Arthroplasty Using Autogenous Costochondral Graft

Basic three goals:

1. To replicate structurally normal joint anatomy
2. To provide functional articulation



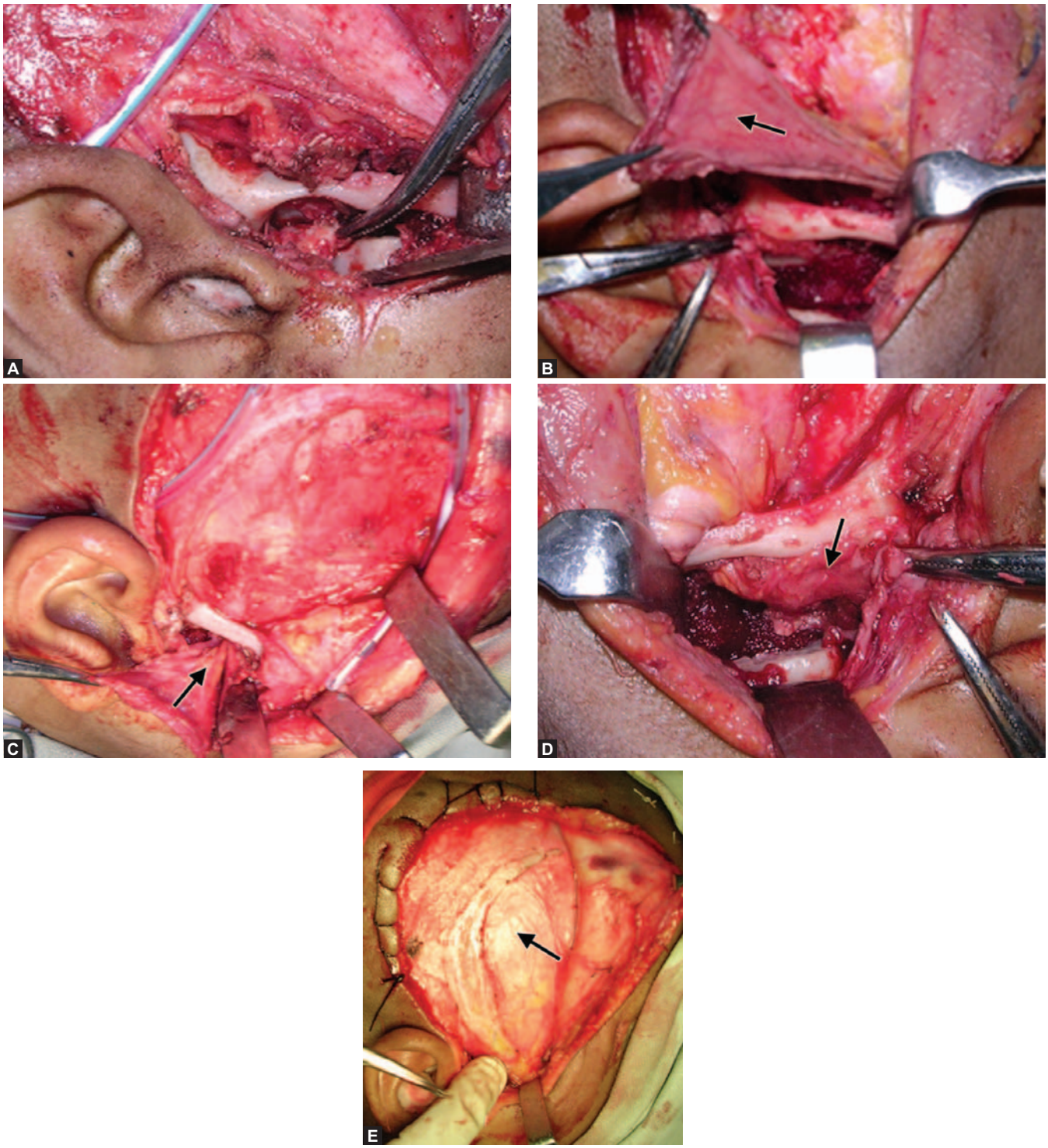
Fig. 23.15: Checking oral opening with jaw stretcher after gap arthroplasty

3. To establish an area, where adaptive growth can occur (in children).

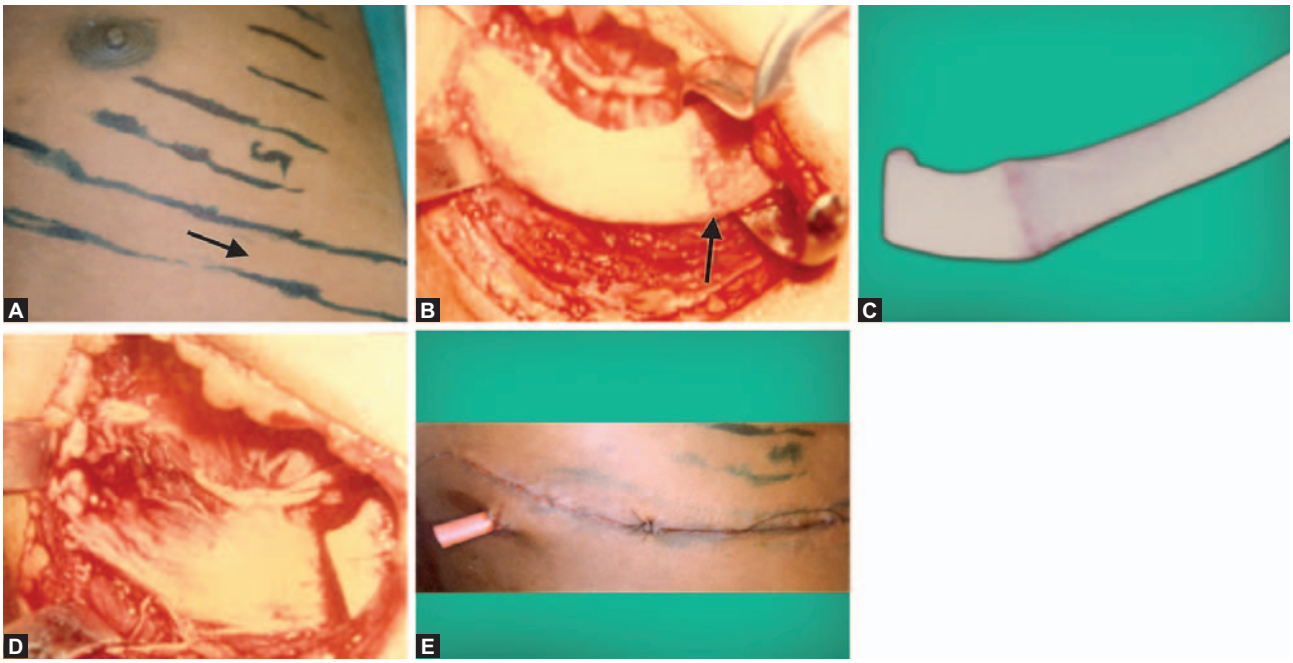
Costochondral graft is harvested through the inframammary incision. Either 5th, 6th or 7th rib is harvested. If two ribs are required, some surgeons advocate that an intervening rib should be left. And costochondral junction of the rib is chosen along with some amount of length of the rib. The length of the total graft will depend on the height of the ramus to be restored. A minimum of 1.5 cm of costochondral junction should be included in the graft. This should be carved to simulate the shape of condylar head. The graft should be fixed on the lateral aspect of the ramus with the screws or transosseous wires. A minimum gap of 0.5–1 cm should be kept between the graft and glenoid fossa side, so that free movement is possible without any friction **(Figs 23.17 and 23.18)**.

Disadvantages

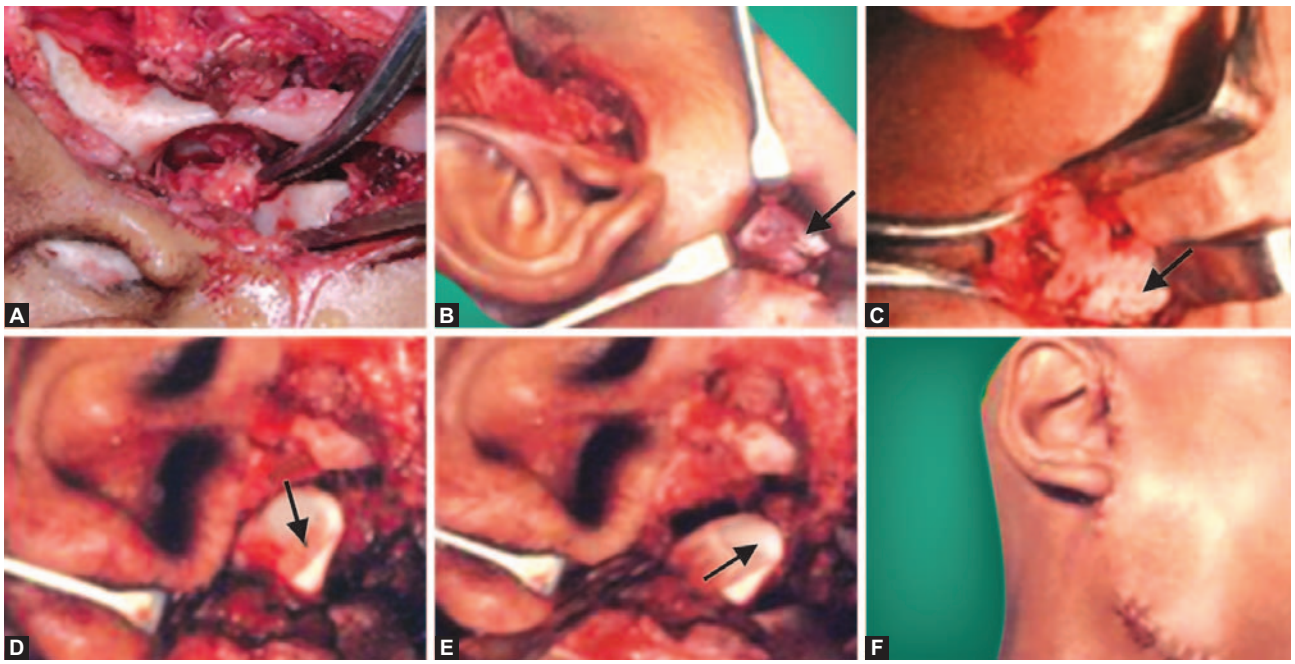
- Increased operating time.
- Additional surgical site.
- Donor site morbidity—such as pneumothorax, pleural tear and pleuritic pain.
- Graft overgrowth.



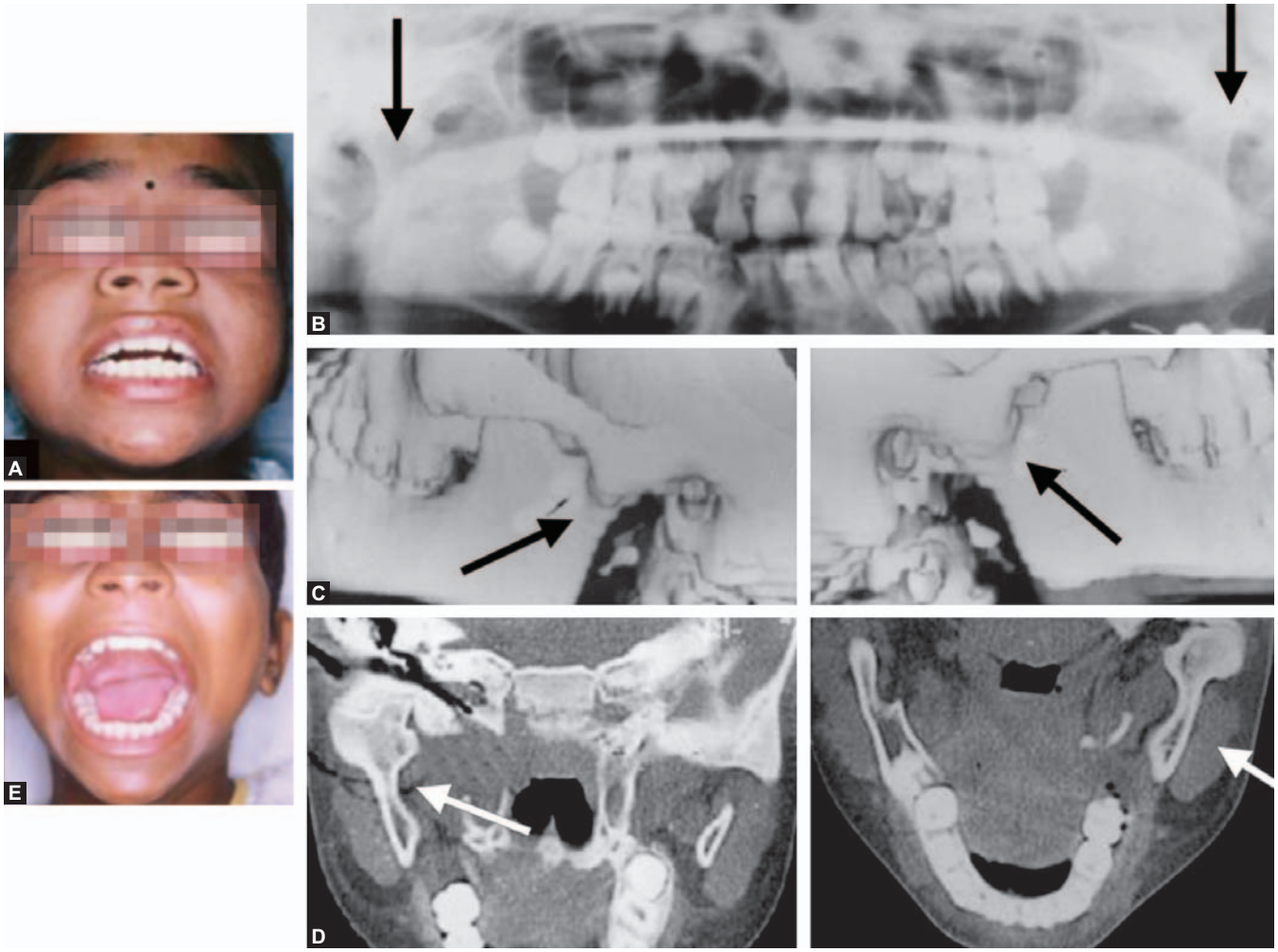
Figs 23.16A to E: (A) Gap arthroplasty performed; (B and C) Temporalis myofascial flap is used for lining the glenoid fossa; (D) Flap lining the raw area over glenoid fossa; (E) Only temporalis fascia also can be mobilized to cover the glenoid fossa and used as an interpositional autogenous graft



Figs 23.17A to E: (A) Inframammary markings for incision at the 7th rib; (B) Harvesting of the 7th rib. Costochondral junction exposed; (C) Adequate length of costochondral graft, (Rib graft); (D) Rib graft harvested from donor bed; (E) Inframammary incision closed in multiple layers. Skin subcuticular suturing done. Drain is secured



Figs 23.18A to F: (A) Gap osteoarthroplasty; (B) CC graft pushed through small submandibular incision over the lateral aspect of the ramus; (C) Fixation of the CC graft at the angle of the mandible; (D) CC graft carved simulating condylar head, which was placed in the gap; (E) Checking the CC graft movement in open mouth position; and (F) Final suturing



Figs 23.19A to E: An 8-year-old girl reported with complaint of inability to open the mouth since 3 years. She gave history of trauma 4 years back: (A) Preoperative interincisal opening was 2 mm; (B) OPG; (C) 3D CT scan; (D) Coronal CT scan—all showing bilateral TMJ ankylosis. Bilateral TMJ surgery with CC graft interpositioning was done; (E) Postoperative oral opening

- Possible potential for reankylosis.
- **Figures 23.19 and 23.20** show the results of surgery for TMJ ankylosis.

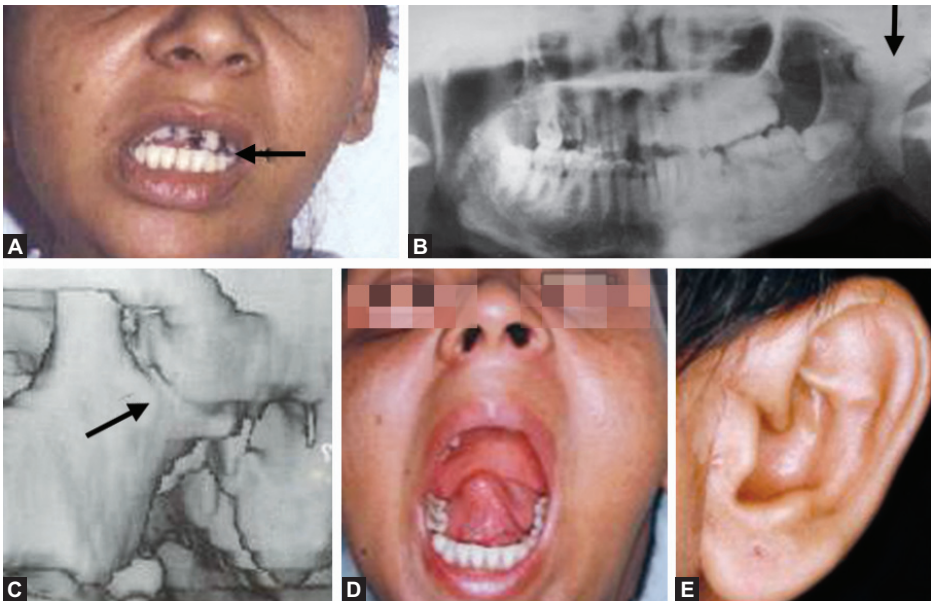
Complications during TMJ Ankylosis Surgery

During Anesthesia

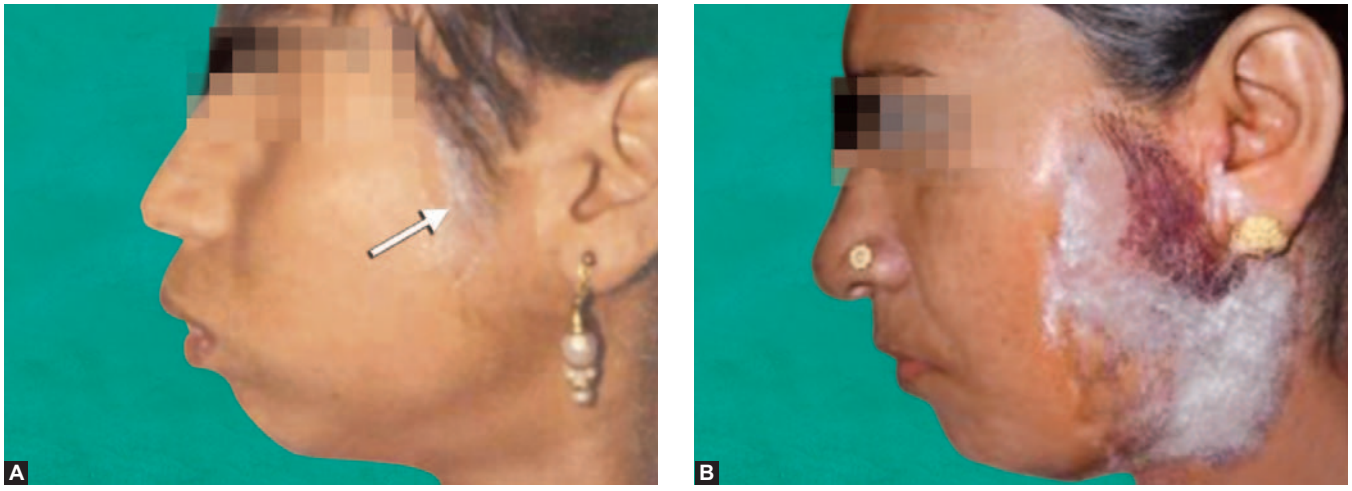
- As the patient cannot open the mouth, awake blind intubation has to be done, where patients cooperation is required, which is very difficult to obtain from younger group of patients.
- Because of small mandible and altered position of the larynx, intubation poses a problem.
- Aspiration of blood clot, tooth or foreign body during extubation, as throat cannot be packed prior to surgery.
- Danger of falling back of tongue and obstructing airway is always there, after extubation.

During Surgery

- Hemorrhage due to damage to any of the superficial temporal vessels, transverse facial artery, inferior alveolar vessel and internal maxillary vessels, pterygoid plexus of veins.
- Damage to external auditory meatus.
- Damage to zygomatic and temporal branch of facial nerve.
- Damage to glenoid fossa and thus leading entry into middle cranial fossa.
- Damage to auriculotemporal nerve.



Figs 23.20A to E: A 23-year-old female complaint of inability to open the mouth since 6 years. She gave history of abscess in preauricular area 6 years ago. Gradual decrease in oral opening was noticed by her: (A) Interincisal oral opening—4 mm; (B and C) OPG and 3D CT scan showed (L) TMJ ankylosis. (L) side TMJ gap arthroplasty with bilateral coronoidectomy was done. Auricular cartilage and temporalis myofascial flap was used as interpositional autogenous material; (D) Postoperative oral opening—5 cm; and (E) No auricular deformity seen postoperatively



Figs 23.21A and B: Frey's syndrome: Patient complaint of severe sweating and burning sensation in (L) preauricular region since last 10 years. Patient gave history of some surgery in L parotid region 10 years back. A minor starch iodine test is positive

- Damage to parotid gland.
- Damage to the teeth during opening of the jaws with jaw stretcher.

During Postoperative Follow-up

- Infection.
- Open bite.
- Recurrence of ankylosis.

Frey's Syndrome/Auriculotemporal Nerve Syndrome

Frey's syndrome was described by Frey. He reported the incidence of localized gustatory sweating and flushing following a gunshot wound and suppurative parotitis. This auriculotemporal nerve syndrome may follow the surgery of the parotid gland and TMJ, a facial wound or parotid abscess **(Figs 23.21A and B)**.

- It is characterized by pain in the auriculotemporal nerve distribution.
- Associated gustatory sweating and occasionally erythema is seen.
- There is flushing on the affected side of the face accompanied by sweating within the hairline, the periauricular region and beneath the pinna.
- A minor starch iodine test is positive in these patients (The skin is painted with a solution of iodine, castor oil and absolute alcohol. Corn starch is dusted onto the dried, painted area. A positive test will be evoked after the patient chewed a lemon wedge for 5 minutes).

Treatment Options for Frey's Syndrome

- Topical agents
  - Commercial antiperspirants—effective only for milder symptoms
  - Anticholinergic preparations—topical glycopyrrolate should be used with caution. It should not be applied on cut or infected skin. Contraindicated in diabetic patient, cardiovascular, central nervous system, renal or hepatic diseases.
- Radiation therapy—dose of 50 Gy is needed. Used only in very symptomatic patients, where other treatments have failed or contraindicated.
- Surgical procedures
  - Skin excision—for localized and relatively small areas.
  - Auriculotemporal nerve section—results may not be permanent.
  - Tympanic neurectomy—safe procedure can be done on outpatient basis.

Recurrence of TMJ Ankylosis

Recurrence of TMJ ankylosis is distressing both to the patient and surgeon. Several factors have been said to be responsible for reankylosis:

- An inadequate gap created between the fragments
- Missing on the medial condylar stump and leaving it behind
- Fracture of the costochondral graft
- Loosening of the costochondral graft due to inadequate fixation to the ramus
- Inadequate coverage of the glenoid fossa surface
- Inadequate postoperative physiotherapy
- Higher osteogenic potential and periosteal osteogenic power may be responsible for high rate of recurrence in children.

Points to Remember

Classification of ankylosis:

- Etiopathology
- Pathogenesis
- Diagnosis
- Clinical manifestations
- Management of temporomandibular joint ankylosis.

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CHAPTER 24 Myofascial Pain Dysfunction Syndrome

INTRODUCTION

Temporomandibular joint (TMJ) disorders are among the most misdiagnosed and mistreated maladies in medicine. Though, a lot of research is constantly being carried out, TMJ problems raise many questions, some of which remain unanswered or debatable, because of the complex nature of this joint.

It has got multifactorial origin or etiology and part of the misunderstanding stems from the inability to point at exact etiological factors. Further confusion is created due to different terms used for the various TMJ symptoms, such as Costen's syndrome, TMJ syndrome, TMJ pain dysfunction syndrome and myofascial pain dysfunction syndrome (MPDS).

It is very important for the clinician to learn to distinguish the many types of TMJ dysfunction, as so many other etiological factors mimic the same symptoms. For example, organic diseases, certain dental conditions, periodontal disease may cause similar symptoms and need to be evaluated.

HISTORY

Historically, TMJ disorders have been described as having their etiologies in either malocclusion, or the patient's psychological status or as being secondary to an intrinsic joint pathology.

Costen (1934), was the first one to indicate an "occlusal etiology" in TMJ pain. He reported association of bite overclosure (due to loss of posterior teeth) with symptoms like ear pain, sinus pain, decreased hearing, tinnitus, dizziness, burning and vertigo and occipital headaches (Bite raising era).

Schwartz (1956), coined the term TMJ "pain dysfunction syndrome" and blamed the "spasm of the masticatory and perimasticatory musculature" leading towards the symptoms. He also noted that many TMJ pain sufferers had an altered psychologic make up as well. He advocated the use of muscle relaxants, restriction of oral opening for resting the muscles.

Laskin (1969), put forward a provocative paper on "myofascial pain dysfunction syndrome". He implicated psychophysiologic theory stating that the psychological stress leads to myospasm (tranquilizers, muscle relaxants).

Mackenzie and Banks and Toller and Poswillo (1975), stressed on the diagnosis and treatment of "intrinsic joint disorders" (different disk surgeries).

Dentists have a historic role in resolving acute pain and restoring oral function. But, when confronted with patients, who appear to be suffering from obscure facial pain and functional jaw problems, they are less comfortable handling these situations. These TMJ disorders are not life-threatening, but their treatment relates to improvement in the quality of life. Faulty or painful function disturbs day-to-day activities and body image. These problems sometimes become so significant, that they impair person's emotional stability. Usually, these patients run from pillar to post for the want of relief. Most of the dentists and physicians dismiss their problem as illegitimate, as it is not demonstrable on radiographs or by visual examination.

Epidemiologic study has shown that at least 30% of the population suffer from this problem and the ratio of females to male patients is 3 : 1. The target group for therapy appears to be women between the ages of 15 years and 40 years.

The MPDS is a pain disorder, in which unilateral pain is referred from the trigger points in myofascial structures, to the muscles of the head and neck. Pain is constant, dull in nature, in contrast to the sudden sharp, shooting, intermittent pain of neuralgias (chronic pain). But the pain may range from mild to intolerable.

CLINICAL CHARACTERISTICS

- A zone of reference
- Trigger points in muscles
- Occasional associated symptoms
- Presence of contributing factors.

Trigger Points

Trigger points exist as a localized tender area within taut bands of skeletal muscles and when stimulated by macro- and microtraumatic episodes, they refer a characteristic pain pattern to a distant group of muscles, i.e. zone of reference.

Palpation of trigger points will give rise to a positive "jump sign".

PATHOPHYSIOLOGY (ETIOLOGY)

The MPDS can be visualized as a vicious cycle of several contributing factors such as:

- Muscular hyperfunction
- Physical disorders
- Injuries to the tissues
- Parafunctional habits.
- Disuse
- Nutritional problems
- Physiological stress
- Sleep disturbances.

It is difficult to know the initiating point, since it arises from the multifactorial origin. There are many different groups with various ideas about the disorders. They can be put into following major groups:

- Psychologic or central etiology
- Occlusal or peripheral etiology
- The third group is recently considered is due to intrinsic joint disorder etiology.

Psychogenic Cause

It is possible that certain psychologically unbalanced individuals, due to unusual habits, perpetuate muscular disturbance leading to occlusal disharmony and thereby affecting the TM joints.

There is muscle fatigue seen in these individuals brought about by muscle spasm. This fatigue is believed to be related to psychologically motivated, persistent, tension relieving oral habits. Under emotional stress, the skeletal musculature exhibits general and sustained hyperfunction, which leads to the susceptibility to neurotic muscular contraction leading to muscle fatigue.

Persistent Tension Relieving Oral Habits

Pipe smoking, sleeping on stomach with the mandible supported by the forearm, teeth clenching, teeth grinding (bruxism), lip licking, jaw thrusting, nail-biting, tongue thrusting, pencil/pen biting, constant chewing of tobacco and chewing gum, etc.

Sleep disturbances in these individuals undergoing stress also aggravate the problem and the habits, because of increased irritability.

Occlusal Disharmony

Occlusal disharmony can be either inherent or acquired or iatrogenic.

- *Inherent malocclusion* is due to developmental deformities. Gross-occlusal discrepancy can lead to TMJ disorder due to constant microtrauma.
- *Acquired malocclusion*—failure to replace the loss of any tooth or teeth for a prolonged period causes drifting of the teeth leading to occlusal imbalance.
- *Iatrogenic occlusal disharmony*—faulty restorations, with high points and unbalanced vertical dimensions in dentures are the causative factors.

Faulty occlusion also leads to muscle spasm and changes the physiodynamics of TMJ leading to pain. Loss of vertical dimension or deep bite causes the shift of condyles posteriorly, impinging on the sensitive bilaminar zone—causing constant pain.

All the above factors lead towards either micro- or macrotraumatic episodes leading towards muscle spasm.

- Pain in MPDS is due to muscle spasm which follows the micro- or macrotrauma injury to musculoskeletal system.
- Sensory input from the injured area, results in increased tone of musculature, in order to stabilize the affected part.
- This hypertonicity may lead to muscle fatigue and the accumulation of metabolic byproducts such as lactic acid, prostaglandins, bradykinins, histamine and leukotrienes. The accumulation of these chemical pain mediators, lower the threshold of pain receptors to mechanical and chemical stimuli leading to MPDS.
- In addition, chronic pain often involves a psychogenic component, which modifies the reaction to pain and complicates the treatment.

SYMPTOMS

The MPDS exhibits varied symptoms. One particular patient may complain of all the various symptoms,

Table 24.1: Various symptoms of myofascial pain dysfunction syndrome (MPDS)

Cardinal symptoms of MPDS			
• Pain or discomfort (unexplained nature), anywhere about the head or neck • Limitation of motion of the jaw • Joint noises—grating, clicking, snapping, etc. • Tenderness to palpation of the muscles of mastication [Negative recent history of trauma, infection, ear or joint or maxillary sinus pathosis]			
Associated symptoms in MPDS			
Neurologic	*Gastrointestinal tract*	*Musculoskeletal*	*Otologic*
• Tingling • Numbness • Blurred vision • Twitches • Trembling • Lacrimation	• Nausea • Vomiting • Diarrhea • Constipation • Indigestion • Dry mouth	• Fatigue • Tension • Shift joint pains • Tiredness • Weakness	• Tinnitus • Ear pain • Dizziness • Vertigo • Diminished hearing

whereas in another patient only a single symptom may be present **(Table 24.1)**.

HISTORY OF THE PATIENT

It is important that the patient should be allowed to describe his symptomatology in detail. Intelligent and effective treatment cannot be instituted without an accurate diagnosis. Probably the most beneficial aid (in this disorder) to diagnosis is a complete and standardized history and examination. The history should include questions concerned with:

- Mode of onset, duration, frequency and quality of pain. Site and reference point of pain.
- Time of the day, at which pain is most pronounced
- Occupation
- Sleeping habits
- Parafunctional habits
- History of previous trauma, prolonged dental work, etc.
- Family or emotional problems
- Associated symptoms
- How the pain is lessened or relieved? How the pain is aggravated?

While taking the history, following questions regarding three components should be asked or looked for and the significant points should be noted down **(Table 24.2)**.

Follow-7 R's for occlusal rehabilitation

1. Remove—extract; 2. Reshape—grind; 3. Reposition—orthodontia/orthognathic surgery; 4. Restore—conservative dentistry; 5. Replace—prosthesis; 6. Reconstruct—TMJ surgery; 7. Regulate—control habit and symptoms.

Table 24.2: History of the patient: three components

Physical component	***Psychologic component***	***Dental component***
General health	Ethnic background	Supracontacts
Nutrition	Social customs	Incorrect dynamics
Age	Behavior	Improper vertical dimension
Occupation	Emotional health	
Lifestyle	Personal annoyances	
	Parafunctional stress relieving habits	

Physical Examination

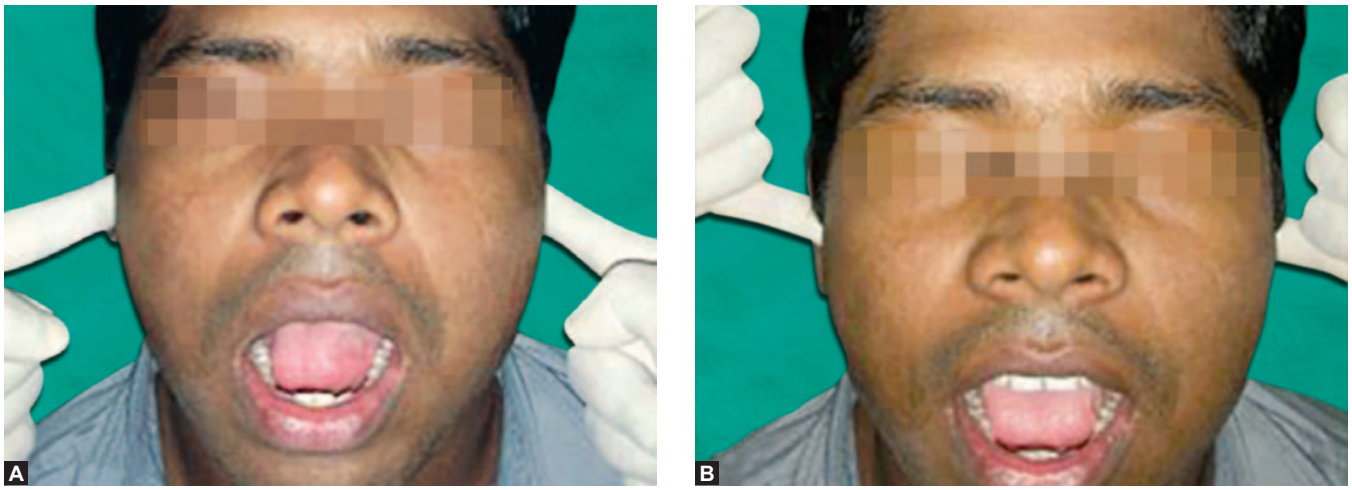
Physical examination consists of an evaluation of entire masticatory system along with head and neck region.

- Articular (joint)
- Muscular
- Dental
- Cervical

Articular or TMJ Function and Range of Motion

- Amount of oral opening and the excursions
- Extent of movement
  - ROM ——— Range of motion
  - AROM ——— Active range of motion
  - PROM ——— Passive range of motion
- Palpation for tenderness
- Grading of click or crepitation—noises evaluation
- Auscultation (stethoscopic evaluation), if needed.

Palpation: Simultaneous palpation of both the joints, with index finger laterally over the joint and through the external auditory canal in open and closed movements is done **(Figs 24.1A and B)**.



Figs 24.1A and B: (A) Simultaneous palpation of both the joints with index finger laterally over the joints; (B) Palpation of both the joints through the external auditory canal in open and closed position

Range of Motion

- It should be inspected for hypomobility or hypermobility and associated pain, if present. Normal vertical range of motion (ROM) in adults is between 40 mm and 50 mm. Hypomobility without pain gives early indication of pathology. Measurement of maximum pain free movement is noted. The AROM and PROM tests should be carried out to delineate the source of restriction, whether articular or muscular or both. The AROM tests all anatomic structures. "Limited AROM with pain indicates structural restriction, but PROM tests all inert structures. Restricted movements suggest all contractile elements, i.e. muscle problems".
- Direction of opening—opening path and amount of deviation should be noted. Early opening deviation is due to spasm of lateral pterygoid muscle on the side towards which the deviation is seen. Gradual deviation is due to muscle imbalance. Stronger opening muscles on one side overpower the weaker muscles on the opposite side **(Fig. 24.2)**.
- Protrusive deviation and movement—normal range of protrusive movement is 10 mm.
- Lateral excursions—normal left and right lateral excursion should be around 10 mm. Pain or restriction may indicate one or more of the following conditions—joint inflammation, muscle dysfunction, anteriorly displaced disk, etc.

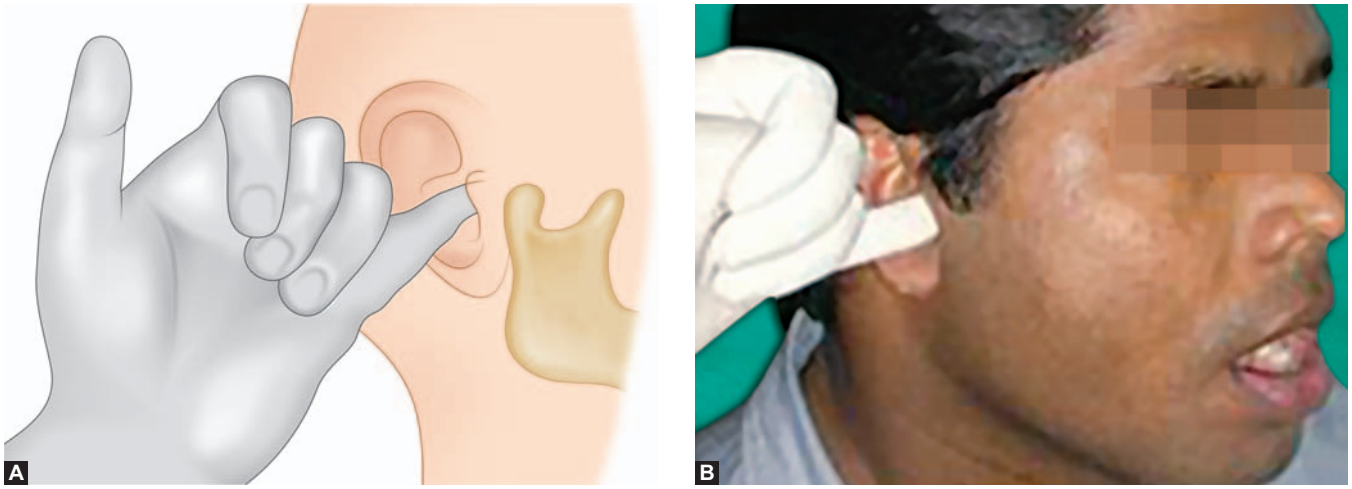
Areas of tenderness on palpation: It should be noted. In posterior joint palpation, pain unrelated to closure or straight lateral palpation may indicate ear problem or inflammation **(Figs 24.3A and B)**.

Timing of the click: Early, intermediate or wide open zones of condylar excursions are noted and whether it comes during opening, closing or both should be ascertained. Whether a distinct sound-click is felt or audible or whether only crepitus or multiple scraping, grating noises are felt is also noticed.

The joint noises can be heard with a stethoscope: Posterior joint palpation is also made to appreciate the opening and closing cycles of the click.



Fig. 24.2: Deviation of the mandible towards right side on oral opening with pain



Figs 24.3A and B: Posterior joint palpation

Muscular Examination

Systemic palpation of the muscles and their tendons is the best way to ascertain both subclinical and clinical existing levels of dysfunction. The areas responsive to palpation have been called "trigger points". The muscles are palpated bilaterally and simultaneously with firm but gentle pressure lasting for 1 minute or 2 minutes. The main pressure is exerted with the middle finger of each hand. The adjacent fingers may be used when the area being palpated is large enough **(Fig. 24.4).**

Muscle palpation: It is helpful for the following:

- Location of muscle pathology
- Evaluation of muscle tone
- Location of trigger points
- Evaluation of temperature change
- Location of swelling
- Identification of anatomic landmarks.

Sequence and sites of muscle palpation: The muscular structures are palpated using the sequence shown in **Figures 24.5A to D**. The subjective pain pattern should be precisely mapped. During muscle palpation, patient is asked questions regarding unilateral or bilateral pain, tenderness, whether it is mild, moderate or severe. During palpation eye wincing or palpation associated with bodily withdrawal should be noted. Reference zone of the pain also should be located.

Resistance tests (Figs 24.6A to D): Primary muscle disorders are likely to be responsive to maximal resistance. With the head supported and the mouth open a finger breadth, a gradual build-up of force is generated by the hand of the examiner. The patient is instructed to resist the examiner's initiative to move the jaw. The test is interrupted, if pain is produced. A positive response will include pain that is similar to the original complaint. Biting tests are another method of putting the muscles and TMJs under load.

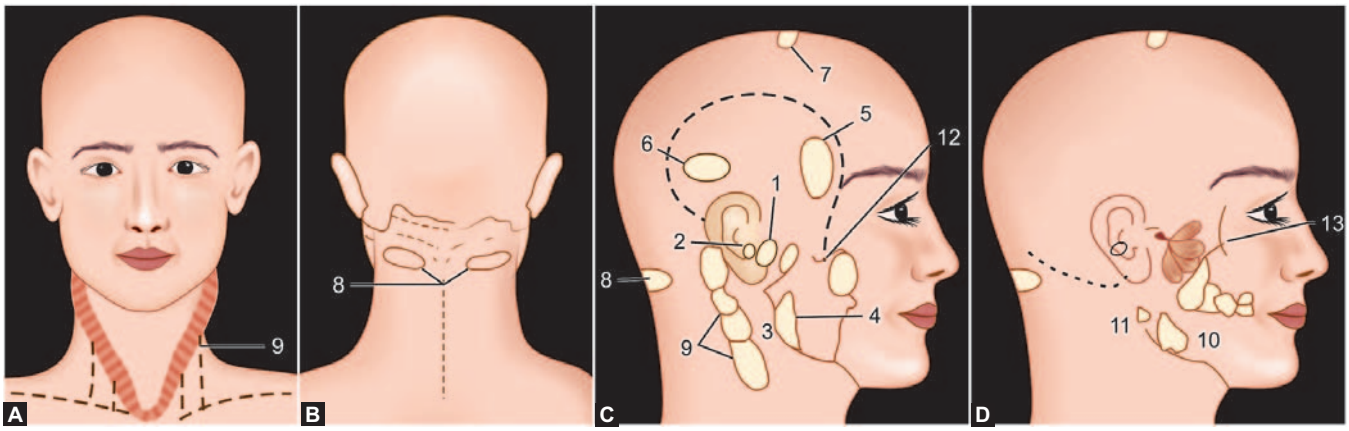


Fig. 24.4: Masseter muscle palpation

Dental/Occlusal Evaluation

Gross occlusal discrepancies, prematurities or interferences should be noted.

Anterior open bite, collapsed bite, cross bite, reduced vertical dimension, etc. should also be noted. Attrition, wear facets, mobility of teeth, missing teeth should be checked. Type of malocclusion, skeletal, dentofacial deformities should be looked for.



Figs 24.5A to D: Sequence and sites for muscles and joints palpation: (1) Lateral palpation; (2) Posterior joint palpation via ear. Extraoral muscles (3 and 4) Masseter; (5) Anterior temporalis; (6) Posterior temporalis; (7) Vertex; (8) Neck; (9) ternocleidomastoid; (10) Medial pterygoid; (11) Posterior digastric. Intraoral muscle palpation; (12) Temporalis tendon; (13) Lateral pterygoid



Figs 24.6A to D: Resistance test with a gradual build up of force, in open, protrusive and lateral excursion movements

Cervical Examination

Here, the neck group of muscles are palpated and neck ROM should also be checked.

Temporomandibular joint is in close proximity to the upper part of the cervical spine. Functionally, the cervical spine and the TMJ occlusion are interrelated. Any change in one of these can affect the function or position of the other. Patient's posture should be noticed **(Figs 24.7A and B).**

Shoulder and neck muscles are palpated, as they control anteroposterior and lateral position of the head. Incline the patient's head forward for shoulder and neck examination. Look for tender points.

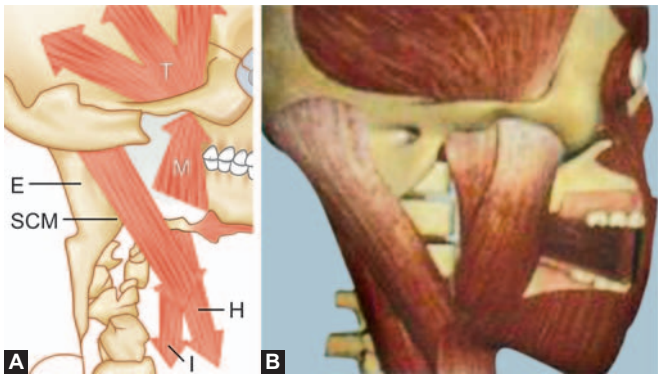
Hyoid bone palpation: Ask the patient to swallow. Irregular contraction can be noted while breathing, speaking or swallowing (digastric is a link between supra- and infrahyoid group of muscles). Neck ROM should also be checked.

Radiographic evaluation: It is helpful in diagnosis of the following:

- Intra-articular pathologies
- Osseous pathological process
- Soft tissue pathologies.

The use of radiographs should be done judiciously in MPDS patients depending on the patient's signs and symptoms instead of ordering routine set of radiographs.

- **Panoramic radiography**
  - For overall screening of TMJ on both sides simultaneously.

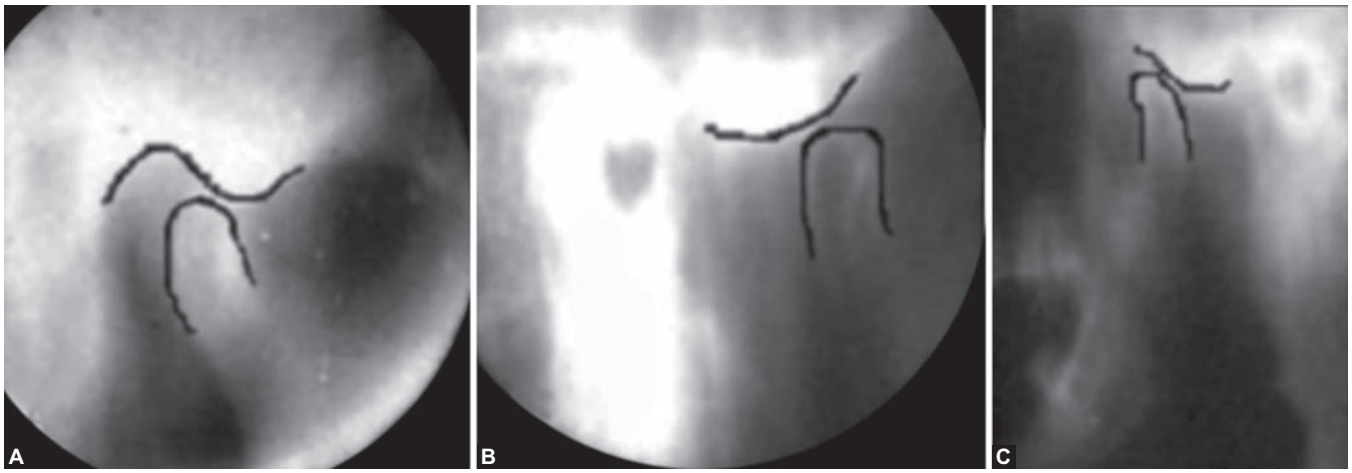


Figs 24.7A and B: Relationship of cervical and masticatory muscles ***Abbreviations***: M, masseter; T, temporalis; SCM, sternocleidomastoid; E, neck extensors; I and H, infrahyoid muscles

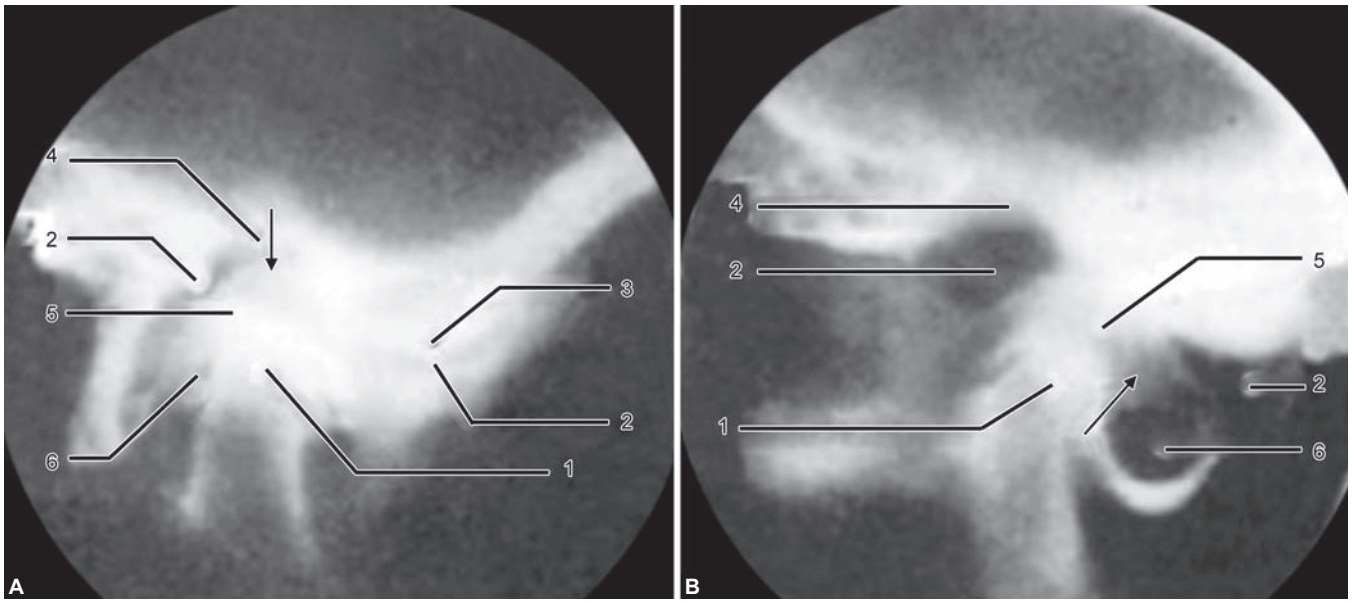
  - For assessment of articular surfaces of condylar head and glenoid fossa.
  - For any other osseous deformities.
  - For evaluation of both the joint spaces.
- ***Tomograms:*** For elimination of superimposition and to have clear detailed picture of TMJ **(Figs 24.8A to C)**.
- ***Transcranial radiographs:*** Comparison of both joints in open and closed position is helpful in detecting internal joint pathology. Also shows ROM of condylar head.

Recent Diagnostic Methods (Figs 24.9A and B)

- **TMJ arthrography**—double contrast arthrography is more useful than single contrast method. Invasive and uncomfortable for patient. It is used in order to examine soft tissue components of the TMJ, especially, the disk. In this newer technique, 0.3–0.6 mL of contrast medium is injected into the upper and lower joint spaces to coat the internal surfaces. The contrast medium is subsequently withdrawn and in turn 1.0–1.5 mL of air is reinjected. These steps result in a thin contrast medium coating of the TMJ components, allowing good visualization of the shape and position of the disk.
- **Computed radiography (CR)**—it uses an "imaging plate" instead of the conventional X-ray film. Information from the "imaging plate" is then fed into a computer for storing and processing into graphic images. Here the assessment of soft and hard tissue can be done.
- **CT scan and MRI**—noninvasive methods of obtaining superior image of dense soft tissue disk as well as of the hard tissue. Magnetic resonance imaging (MRI) does not use ionizing radiation. The principles of MRI involve taking advantage of the weak resonance energy emitted by the spinning actions of hydrogen nuclei when placed in a strong magnetic field. The signals emitted are then fed into computer for sorting and processing into graphic images.
  - CT scan provides the most accurate radiographic assessment of the bony components of the joint. Here, the image is obtained in one plane of space, but allows the reconstructions in different views.
- **Bone scintigram**—*nuclear imaging*—the technique involves injection of ^{99}Tc, (Technicium-99), a gamma-emitting isotope that is concentrated in areas of active bone metabolism. Approximately after 3 hours of injection of this radioactive isotope, images are obtained using gamma camera.



Figs 24.8A to C: (A) Tomogram showing normal relation of the condylar head to the eminence in open position; (B) Tomogram showing hypermobility of the TM joint; and (C) Tomogram showing acute dislocation of the condylar head



Figs 24.9A and B: Double contrast arthrography of the TM joint. (A) Normal TMJ image in closed position; (B) Open jaw position image indicating anterior displacement of the disk (arrow); 1. condylar head; 2. upper joint space; 3. articular eminence; 4. mandibular fossa; 5. disk; 6. lower joint space

Single photon emission computerized tomography (SPECT) images can then be obtained to determine active areas of bone metabolism known as "hot spots" or uptake areas. Very sensitive technique. Changes in the bone can be detected much earlier than the radiographs, but difficult to interpret. Interpretation is always based on history and clinical findings.

Psychological Evaluation of a Patient

If the patient is apparently depressed, then the clinical symptoms may be exaggerated. Psychiatrist should be involved, if patient is giving definitive history of stressful living environment or having emotional personality.

Psychological Symptoms

- Frustration
- Maladaptive behavior
- Anxiety
- Pain verbalization
- Depression
- Poor sleep
- Hypochondriasis
- Poor dietary habits
- Anger
- Clenching/bruxism
- Fear
- Medication dependencies.

Internal Derangement of the Temporomandibular Joint

Definition: Internal derangement (ID) is a disruption of the internal aspects of the TMJ, in which an abnormal relationship exists between the disk and the condyle, fossa and articular eminence.

Associated changes: Synovitis, there can be intracapsular scarring or adhesions within the joint, hemorrhage, fibrocartilaginous metaplasia, dystrophic calcifications and osteoarthritis.

Etiology of internal derangement (ID): Multifactorial

- Microtrauma—overloading from bruxism and other parafunctional habits, hypermobility of the joint.
- Macrotrauma—obvious history of trauma and osseous morphologic changes.

A result of disk displacement may be stretching or tearing of the retrodiscal tissues. Degenerative changes may occur in these attached tissues.

Symptoms

- Pain during function
- Limited oral opening
- Masticatory and cervical tenderness.

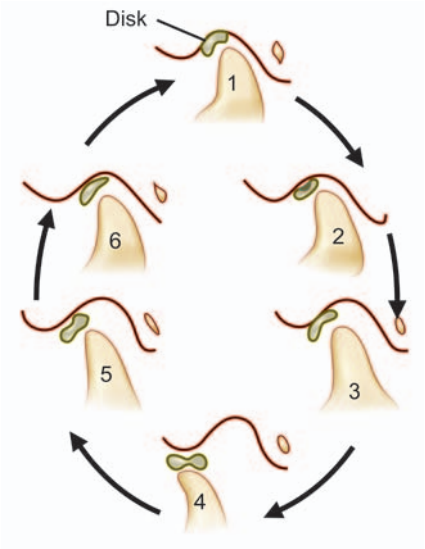


Fig. 24.10: Normal disk movement

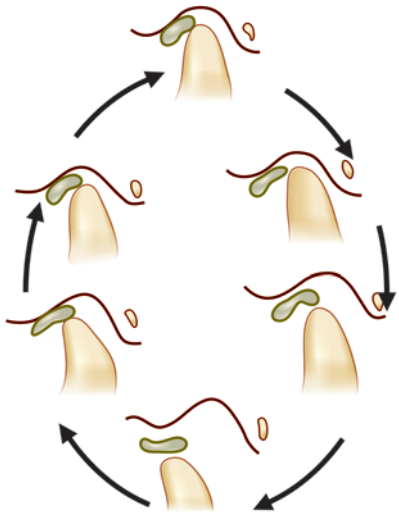


Fig. 24.11: Anterior disk displacement with reduction

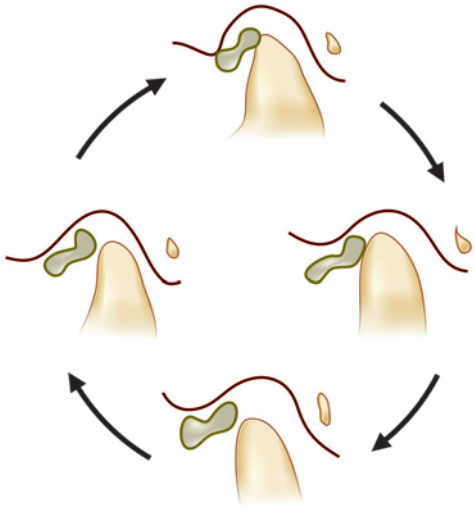


Fig. 24.12: Anterior disk displacement without reduction

Internal Derangements

A.

- Disk displacement
- Disk displacement with reduction
- Disk displacement without reduction

B. Structural incompatibility of the articular surfaces

- Adhesions
- Alterations in the form
- Due to systemic joint disorders such as rheumatoid arthritis, etc.

Anteromedial displacement of disk is more common. The prevalence of disk displacement appears to increase with age.

Figure 24.10 shows normal physiomechanical disk to condyle relationship during translation. When there is no internal derangement, the relationships of the mid-disk to condyle remain consistent throughout opening and closing.

Anterior Disk Displacement with Reduction

Here, the disk is dislocated anterior to the condylar head, resulting in pain during translation. There is reciprocal clicking in anterior dislocation with reduction, the patient demonstrates a click on opening and a click, usually less noticeable, on closing. The clicks are not always audible, but the dentist can feel them during posterior joint palpation, as the disk slips on and off the condyle during functional movements.

- **During opening:** Due to disk reduction, a clicking or popping sound ensues as the posterior part of the disk interferes with the condylar translation.
- **During closing:** Reciprocal click occurs again, as the condyle returns to the original position, gliding over the posterior part of the disk **(Fig. 24.11)**.

Anterior Disk Displacement without Reduction

Here, there is a closed lock form, where the disk interferes with condylar translation. Patient will not be able to open the mouth fully. Here, if patient attempts to open the mouth further, pain in the affected joint will be exhibited and deviation of the mandible towards the painful side will be noticed. This is because of the painful side remaining locked and it brings about translatory opening of the opposite side **(Fig. 24.12)**.

If this chronic condition continues, then it will progress towards perforation of the disk.

Following five "clinical findings" will be seen in "disk dislocation without reduction":

Positive history—sudden change in condylar movements

1. Limited mandibular opening
2. Unilateral condition, one side condyle cannot translate fully
3. Unrestricted ipsilateral eccentric movement, checked by moving the mandible on the affected side. 10–12 mm normal range.
4. Restricted contralateral eccentric movement—less than 8 mm.
5. Loss of joint sounds—earlier history of clicking.

Systemic Joint Diseases causing Internal Derangement

- Degenerative type—pathology in the articular surface—osteoarthritis
- Inflammatory—rheumatoid arthritis, juvenile rheumatoid arthritis, ankylosing spondylitis, Reiter's syndrome, lupus erythematosus. Disorders of immune system, hereditary factors.
- Infective arthritis—bacterial and viral.

OBJECTIVES OF TREATMENT IN MYOFASCIAL PAIN DYSFUNCTION SYNDROME

All the proposed theories revolve around myospasm caused either from the central or the peripheral origin. The treatment of this myospasm involves many different modalities. Definitive therapy always involves elimination of underlying cause (occlusal discrepancies, stress, etc.).

In MPDS, pain is provoked by manual palpation or functional manipulation. It is therefore appropriate to consider diagnostic injection with local anesthetic agent. Diagnostic blocking of a muscle trigger point is extremely helpful, when myofascial trigger point pain is suspected. It is also helpful to anesthetize the TMJ, so true joint pain can be separated from other pains.

Whenever muscle injections are given, a use of vasoconstrictor is contraindicated. Use lignocaine without adrenaline or use bupivacaine.

For TMJ pain, auriculotemporal nerve block is given. The advantage of this nerve block is that, entry into the joint structures can be avoided by blocking the auriculotemporal nerve, before its fibers reach the joint **(Figs 24.13A and B).**

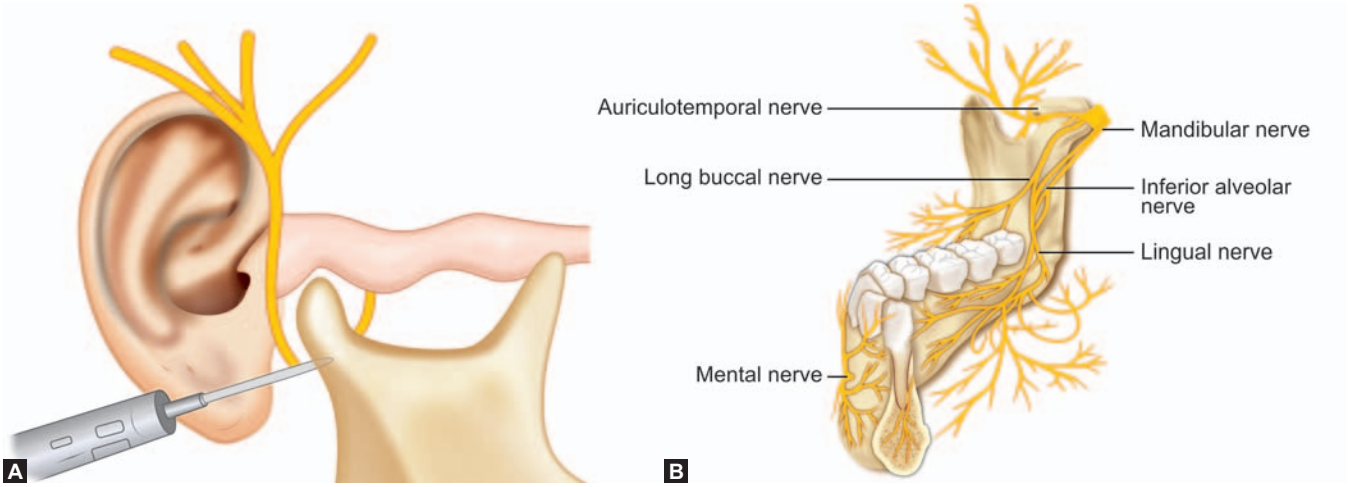
Technique for Auriculotemporal Nerve Block

Preauricular area is prepared taking routine aseptic measures. Usually, 27- or 26-G needle is inserted through the skin just anterior to the junction of the tragus and the ear lobe. The needle is then advanced behind the posterior aspect of the condyle in an anteromedial direction to a depth of 1 cm where the 1.5 mL of anesthetic solution is deposited after aspiration. If the true source of pain is the joint, then the pain should be eliminated or decreased within 5 minutes.

Treatment of MPDS

In the literature, there is no universal agreement for the treatment of MPDS. Various treatment modalities have been suggested.

First important task is counseling of the patient and giving the assurance regarding prognosis and planning for symptomatic pain relief. Once the pain is relieved, then the patient's acceptance for further treatment modalities is achieved. Nature of the myofascial pain resulting from parafunctional habits secondary to stress and anxiety should be explained to the patient in detail and patient should be encouraged for behavior modification. Modification of diet and home exercises should be suggested. Initially soft diet should be prescribed along with the medication.



Figs 24.13A and B: **(A)** Auriculotemporal nerve block; **(B)** Mandibular nerve and its distributions

Medications

- Aspirin : 2 tabs 0.3–0.6 g/4 hourly
- Piroxicam : 10–20 mg/3–4 times a day
- Ibuprofen : 200–600 mg/3 times a day
- Pentazocine : 50 mg/2–3 times a day
- Valium/Librium : 5–10 mg/2–3 times a day
- Methocarbamol : 500 mg/2–3 times a day
- Amitriptyline : 10–25 mg/3 times a day or at bedtime
- *Nonsteroidal anti-inflammatory drugs*—to reduce inflammation and to provide pain relief, both in the muscles as well as in the joints (for 14–21 days).
- *Muscle relaxants*—are recommended only for short duration, as they produce sedation and addiction. Diazepam 2–5 mg or cyclobenzapine 10 mg at bedtime can be given for 10 days or meprobamate 400 mg TDS x 7 days.
- *Ethyl chloride spray* or intramuscular local anesthetic injections in the affected muscles can also give relief. The patient is asked to follow the stretch exercises subsequently. 2% lignocaine or 0.05% bupivacaine can be used.

Physiotherapeutic Modalities

Heat application: It increases local circulation, acts as a sedative, lowers muscle tension. It also increases permeability of membranes and metabolic activity. Heat application can be given superficial or deep. Heating lamps, moist or dry heating pads or packs, hot moist application of towels can be given for 15–20 minutes, 4 times a day.

Ultrasound: It is an effective way to produce heat, deep in the tissues, with the use of ultrasonic waves. It alters blood flow and metabolic activity.

Application to the muscles and joints can be given. 0.7–1.0 watt/cm^2 for 10 minutes every alternate day given by physiotherapist.

Cryotherapy: Ice packs application to the painful area 4 times a day for 20 minutes. Cold compressions lower the thermal gradient in the skin, interrupting massive concentration of histamines, thus lowering pain threshold in the skin.

Spread of pain is interrupted by sudden cold stimulus, it also raises cutaneous pain threshold by counter-irritation.

Massage with counter-irritants and vibrators: Firm friction massage produces temporary ischemia followed by hyperemia. It inactivates trigger points.

Use of vapocoolent spray: Fluoromethane or ethyl chloride spray is applied to painful area for 5 seconds. The muscle is gently stretched after that. The eyes, nose and ears are protected from the spray.

Tetanizing and sinusoidal currents: Fatiguing the muscle helps to recover gradual rhythmic movement.

Electrogalvanic stimulation: Delivers a wide range of intensity (voltage) to activate the injured muscle. It stimulates local circulation, achieves excitability and conductivity without painful heating. Pulse at 80 cycles/second for 10 minutes followed by exercise for 5 minutes is used.

Transcutaneous electronic nerve stimulator (TENS): It interferes with the sensation of pain in the brain and increases blood flow to the site.

Active stretch exercises: It includes opening and closing of mouth 10 times as a warm up against resistance. It can help to restore the normal ROM, by flexibility and strengthening the muscles. Each of these physiotherapy modalities can be very helpful to reduce the pain and increase the ROM along with the medication.

Stress Management

Managing daily stress is one of the best ways to help restore harmony between the muscles and TMJ. Biofeedback technique teaches the patient how to relax. Other methods such as acupressure, acupuncture, Yoga, hypnosis, zen therapy, transcendental meditation, deep breathing relaxation, etc. also can help to relieve the stress.

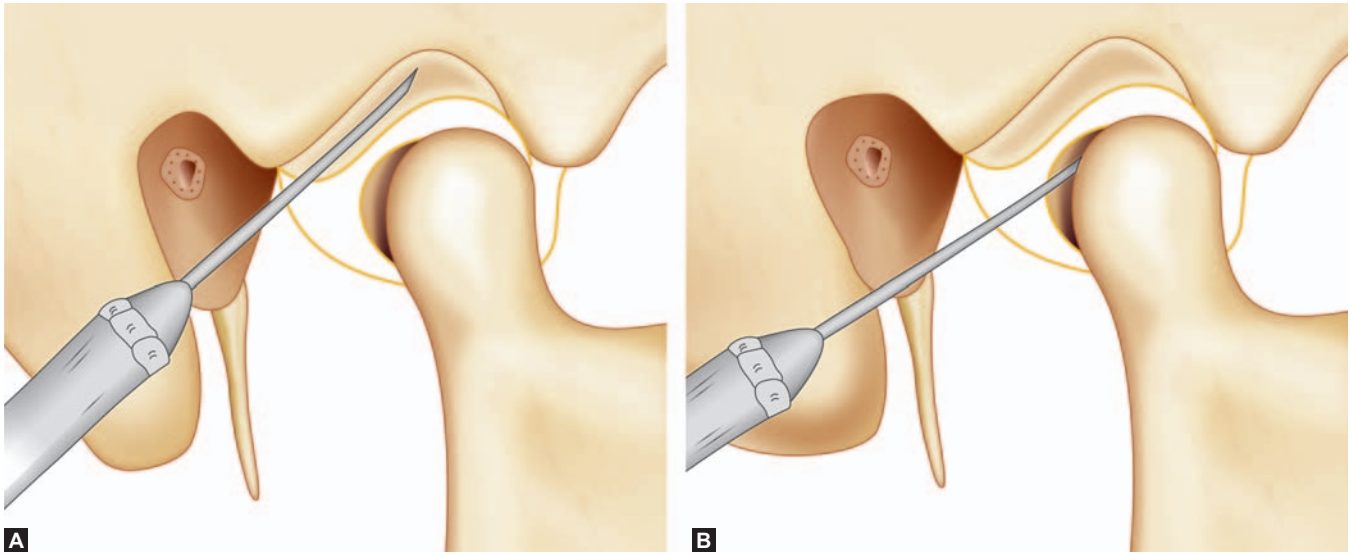
Biofeedback instrument provides audio as well as visual output allowing the patient to hear and see increased muscle activity and then relax.

Intra-articular Injections

Hydrocortisone intra-articular injections can be used to treat the inflammation within the joint. 2% lignocaine 0.5 cc can be mixed with hydrocortisone for relieving the pain.

These injections should not be used routinely. But the injections can be used selectively, once in a month with other supportive and corrective treatments.

The technique of TMJ intra-articular injection (Figs 24.14A and B): The preauricular area must be prepared in routine aseptic manner. Patient is asked to carry out opening and closing movements. Joint movements are palpated by the operator and a mouth prop should be kept between the last posterior teeth to keep the mouth



Figs 24.14A and B: Intra-articular injection technique for temporomandibular joint

wide open. This makes the joint cavity more accessible for the injection. A 2 mL Luer-lok syringe is fitted with 1 mL solution of hydrocortisone + 0.5 mL of 2% lignocaine and is fitted with a 25-G 1.5" long needle. When the mouth is fully opened and the condyle is placed anteriorly, the pathway of the needle in the joint cavity is easy. The direction of insertion of the needle is inward, forward and upward till it strikes the roof of the glenoid fossa at a depth of 2–3 cm. The needle is withdrawn about half a centimeter and 1 mL solution is injected after aspiration, slowly in the upper joint cavity. After changing the direction further downward rest of the solution is injected in the lower joint cavity. Patient should be covered with routine antibiotic/anti-inflammatory regime.

Occlusal Splints (Fig. 24.15)

They can be used for the following:

- To temporarily disengage the teeth
- To create a balanced joint-tooth stabilization of the mandible
- To reduce spasm, contracture and hyperactivity of musculature
- To improve/restore the vertical dimension
- To serve as safety or protective appliance.

  In majority of cases, two types of occlusal splints are used. The splints should be removed while eating.
- **Stabilization splint:** Twelve to eighteen hours use is advocated up to 4–6 months. These are fabricated over the maxillary teeth, covering the occlusal and incisal surface. Similar to Hawley's plate, but occlusal coverage is added. The splint is made up of acrylic. A flat platform is added perpendicular to the mandibular incisors, so that the splint will disengage the teeth and relax the muscles. The splint should be worn as instructed and patient should be recalled for check-up at 2 weeks interval. Follow-up is done until the occlusion is stabilized and muscles are free of tenderness. If patient does not have relief at the end of 3 months, re-evaluation of the original diagnosis should be done.

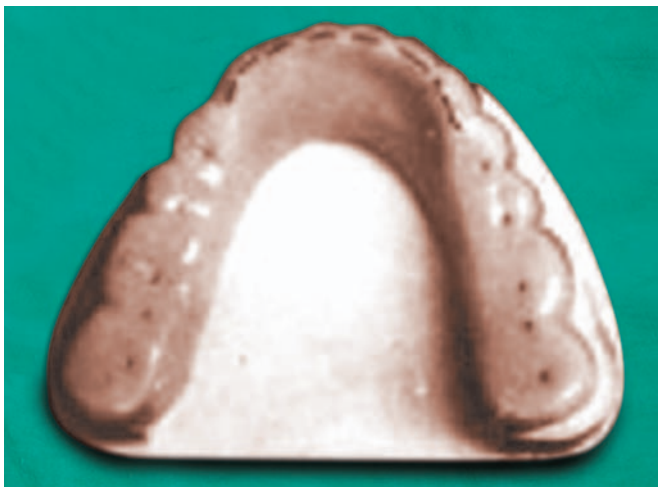


Fig. 24.15: Occlusal splint

This splint reduces the load on the retrodiscal area and thereby relieves the pain. It can be also used to eliminate occlusal interferences associated with bruxism.

Instead of acrylic material, prefabricated commercially available resilient splints are also available for protection of teeth from trauma or from forces of bruxism **(Figs 24.16 and 24.17).**

- **Relaxation splints:** Relaxation splints are used for disengagement of teeth and for only short period (up to 4 weeks). They are fabricated over the maxillary incisor teeth. A platform is added to disengage mandibular anteriors.

Temporomandibular Joint Arthrocentesis

This is a simple treatment for limited mouth opening accompanied by severe pain.

Progress of internal derangement of TMJ is as follows:

- First stage—clicking is accompanied by normal maximal mouth opening (MMO).
- Next stage—progression of the first stage to this stage. Here clicking will gradually stop with varying degrees of restriction in oral opening (closed lock). This stage is attributed to a nonreducible, anteriorly displaced disk acting as an obstacle for the translation of the condyle **(Fig. 24.12).**

Literature shows that the treatment options for closed lock were initially, conservative treatment and if it failed, then surgical contouring and repositioning of the disk. Later on, arthroscopic lysis and lavage and use of hydraulic pressure in the upper joint compartment were applied for ID and found effective in closed lock cases in establishing normal MMO.

Simple arthrocentesis does not require arthroscope.



Figs 24.16A to C: (A) Prefabricated TMJ appliance. The TMJ appliance • Immediate application • No fitting required • One size for all adults • Shorten base for children • Joint decompression • Limits bruxing • Treats myofunctional habits • Double mouthguard • Zero chair time; (B and C) TMD appliance—it is made up of thermoplastic material, which allows custom fitting to the lower teeth and the correct bite. Low profile design allows for easy speech when in place. Aerofoil-shaped splint over the lower back teeth reduces TM joint symptoms by decompressing the temporomandibular joints

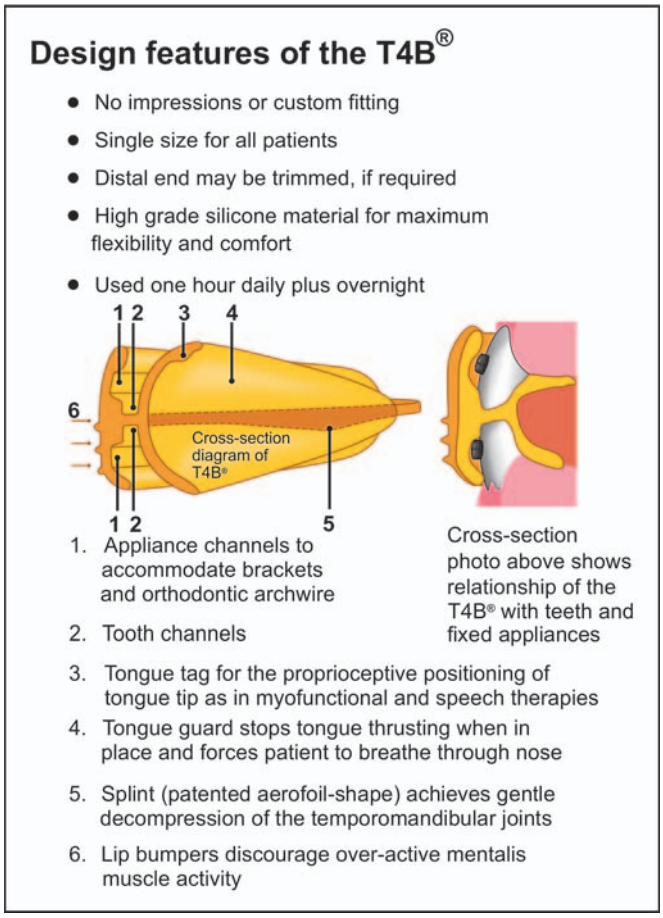


Fig. 24.17: Special features of the temporomandibular joint appliance

Arthrocentesis (Lavage or Irrigation of the Upper Joint Cavity)

Objectives

- Improve the disk mobility
- Eliminate joint inflammation
- Remove the resistance to condyle translation. Return to normal function.
- Early physiotherapy
- Eliminate pain.

Indications for arthrocentesis: All patients who had proved refractory to conservative treatment (medication, bite appliance, physiotherapy and manipulation of the joint).

Arthrocentesis technique (Figs 24.18A to C): Patient is made to lie supine with the head turned. Preauricular area is prepared as usual. With palpating index finger on the affected side, the TMJ movements are palpated. Two points are marked over the skin indicating the articular fossa and eminence. Auriculotemporal nerve block injection is given using 0.5 mL of 2% lignocaine solution.

A 19 or 18 G, 1.5" long needle is then inserted into the superior joint compartment corresponding to the posterior mark. This first needle is inserted about 1" in depth and stabilized. Then another 19 or 18 G 1.5" long needle is inserted at the second mark corresponding to articular eminence. A 10 cc syringe is filled up with Ringer lactate solution and connected to the first needle. The solution is pushed to distend the joint space. This solution should flow freely out of the second needle like a fountain. The position of both needles is manipulated till such free flow is established. Before injection, it is made sure that patient's mouth is fully stretched open and mouth prop is inserted to maintain it, during the entire procedure.

Initially, the solution which will flow out of second needle will be blood tinged or turbid, but as more solution is pushed through the first needle, (up to 200 mL), the flow of clear solution will be noticed. On termination of procedure, 1 mL of hydrocortisone is injected into the joint space, followed by removal of the needle.

Hypothesis

Due to lavage, the pain mediators prostaglandin E_2 and leukotriene B get washed out, reducing the inflammation



Figs 24.18A to C: Arthrocentesis procedure for TM joint: (A) Insertion of first and second needles at posterior aspect of superior joint compartment and articular eminence respectively; (B) Ringer lactate solution is pushed in the first needle to distend the joint space; and (C) Fountain such as flow from the second needle during lavage

and pain. Speculation is that because of synovitis the sliding of the disc is prevented by its adherence to the fossa. This persistent inability of the disk to slide can be readily reversed by simple lavage. This nonreducing disk might result from adhesive forces originating from an increase in synovial fluid viscosity or from a vacuum effect created between the disk and fossa. The injected fluid distends hydraulically, the joint space and enables the disk to slide and thereby re-establishes normal MMO.

Postarthrocentesis Medication

Tablet naproxen sodium 275 mg 3 times daily and diazepam 2.5–5 mg at bedtime to be taken for 2 weeks in association with the use of a bite appliance at night. Patient should be kept on soft diet. Patient should start physiotherapy program on the following day to establish normal MMO. The procedure can be repeated after a gap of 1 week at least 3–4 times with 1 week's interval. 80% of the patients show improvement in pain, MMO and clicking or grating disappears in at least 50% of cases.

Advantages

- Simple technique
- Minimum armamentarium
- Less invasive
- Inexpensive
- Highly effective
- Therapeutic benefit.

Temporomandibular Joint Arthroscopy

Temporomandibular joint arthroscopy consists of the insertion of a especially designed fiberoptic endoscope into a joint compartment for observation (diagnostic) and therapeutic purpose. The TMJ arthroscopy was made popular by Ohnishi in 1975, with the development of a 1.7 mm diameter needle type arthroscope.

Techniques

- Basic single puncture diagnostic technique.
- Double puncture technique for therapeutic as well as surgical purpose.

Patient selection: After all conservative methods have failed.

- Disk dysfunction
- Osteoarthrosis
- Synovial disease
- Hypomobility due to disk problems
- Hypermobility associated with severe pain.

Contraindications

- Regional infection
- Presence of tumor
- Usual medical contraindications to surgery.

Instrumentation (Figs 24.19 to 24.21)

- Arthroscope 1.7–2 mm diameter
- Fiberoptic light source and cables
- Videocamera and cable
- Monitor
- Videorecorder.

Percutaneous Puncture Instruments

- Two cannulas
- Sharp trocar
- Blunt obturator.

Hand Instruments (Fig. 24.22)

- Biopsy forceps—for synovial membrane or fibrocartilage
- Biopsy scissors—for adhesions
- Probe—curved, blunt.

Irrigation System

- Ringer lactate solution
- IV delivery systemTwo connecting tubing
- Two 3-way stop cocks
- Luer-Lok syringe

Sterilization: The arthroscope may be sterilized with ethylene oxide gas or formalin chamber or chemical sterilization can be done. Nonoptical parts and all other accessories should be autoclaved.

Arthroscopic Techniques

Anesthesia: For diagnostic arthroscopy, local anesthesia with or without sedation is sufficient. For therapeutic or surgical purpose, general anesthesia is indicated.

Position of the patient and instrumentations: Patient is placed in a dorsal supine position on the operation table. Head is rotated so that the affected side is superior. Patient is prepared and draped in usual surgical aseptic manner.

A TV monitor along with power instruments, camera control and light source are all positioned in such a way that operator will have direct view of the monitor. Mandibular movements palpated and the mandible must be distracted by the assistant's padded thumb on the occlusal surfaces of lower molars and the index,



Fig. 24.19


Fig. 24.20

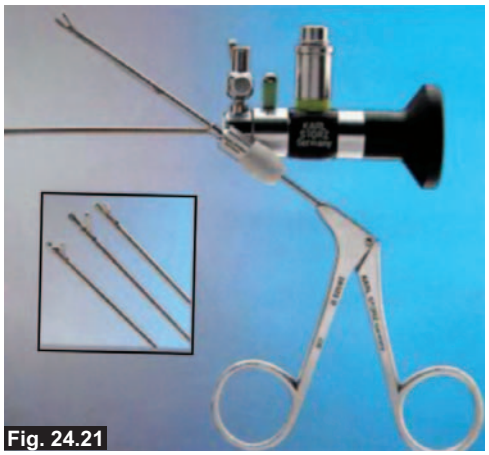

Fig. 24.21

Fig. 24.19: Equipment for arthroscopy. (A) Monitor; (B) Xenon light source; **Fig. 24.20:** Temporomandibular joint arthroscopy in progress.
Fig. 24.21: Instrumentation for arthroscopy (Arthroscope camera

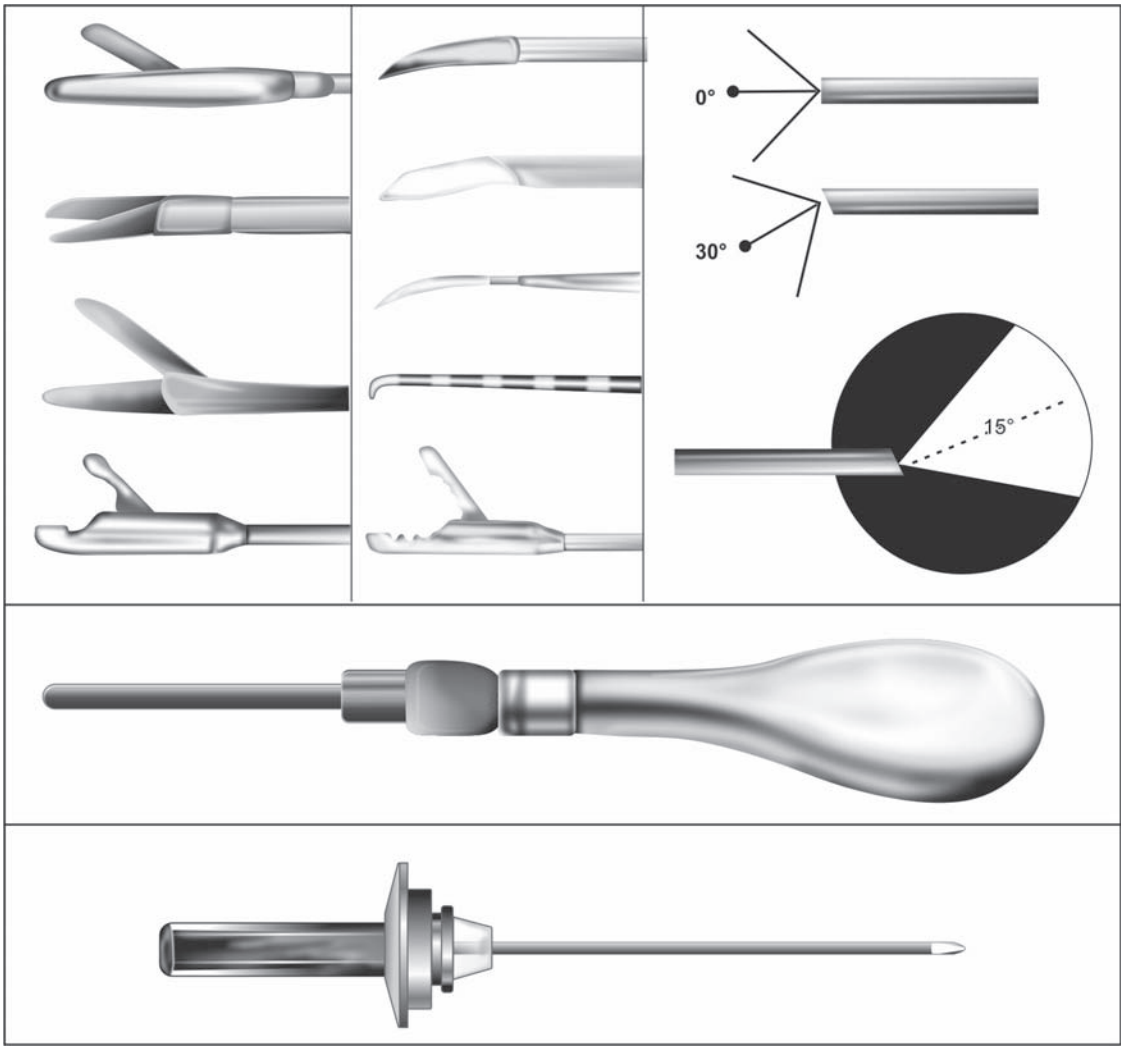


Fig. 24.22: Instrumentation for arthroscopy (Trocar, cannula, biopsy forceps, scissors, probes, blades, etc.)

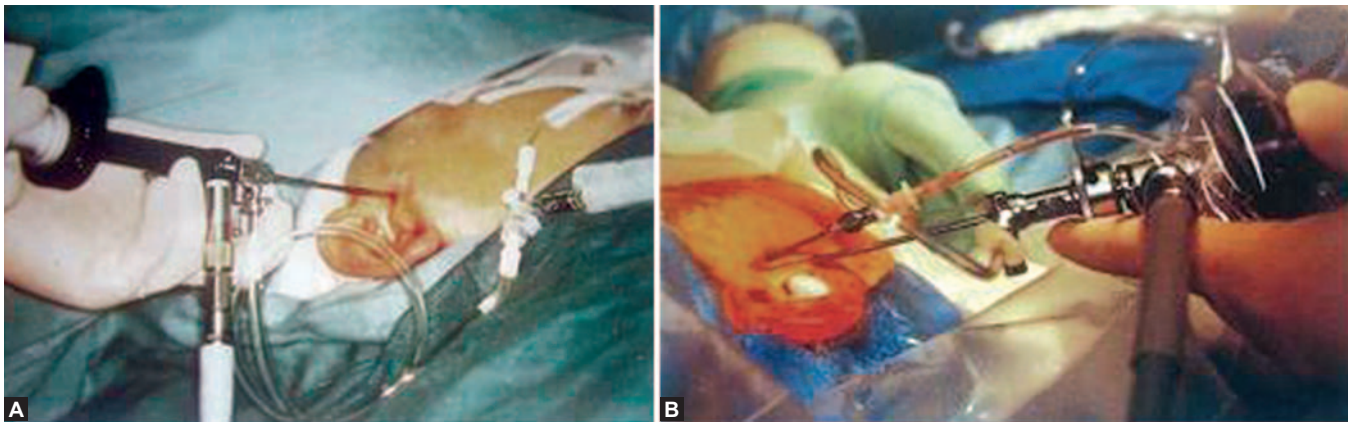
middle and ring finger along the inferior border of the mandible and then maintained in the distracted position by inserting a mouth prop.

Marking: A line is drawn from the mid-tragus of the ear to the lateral canthus of the eye. First point is marked 10 mm anterior to the tragus and 2 mm inferior to the canthus tragus line. This corresponds to the maximum concavity of the glenoid fossa, the target for the first puncture (while marking and palpating this point, superficial temporal artery pulsations also to be checked).

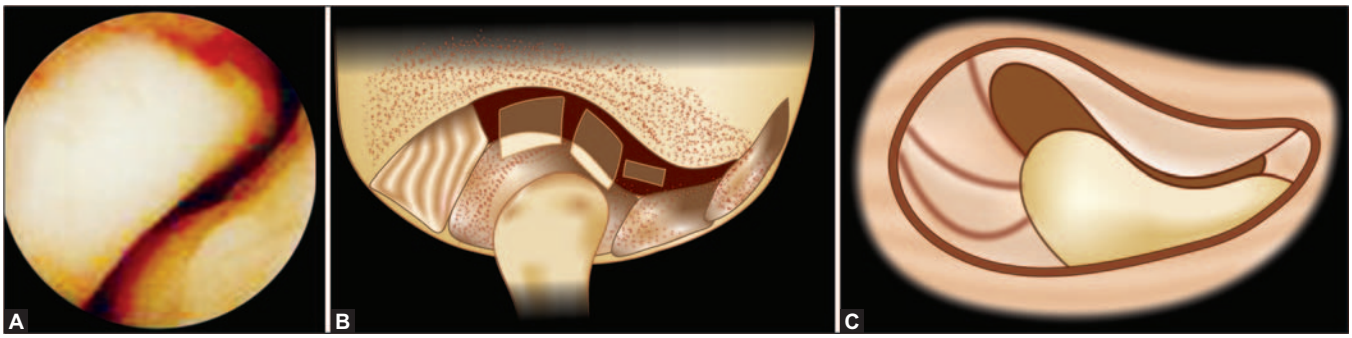
Another point is marked 20 mm anterior to the midportion of the tragus and 10 mm below the canthus tragus line. This corresponds to the peak of the eminence. This second marking is made for the second puncture in double puncture technique.

Anesthesia: Around 1–3 cc of local anesthetic solution with adrenaline is injected into the superior joint space by using 18- or 19-G 1.5" inch long needle. The needle should be inserted from an inferior, posterior and lateral approach aiming for the midportion of the posterior slope of the articular eminence. Local anesthetic is used for anesthesia and hemostasis, plus it distends the upper joint space, for easier introduction of the arthroscope and for clearer observation.

Single puncture technique (Figs 24.23 and 24.24): Mainly used for examination of the joint. The sharp trocar is inserted into the cannula and inserted at first marking point to create a puncture wound. The trocar and cannula should be kept perpendicular to the skin surface and directed anterosuperiorly (10° angle to the horizontal plane) aiming at the roof of the glenoid fossa. The depth of cannula can vary from 5 to 10 mm. Then the trocar can be withdrawn as soon as the resistance felt is ceased, blunt obturator is inserted and the cannula is advanced to the center of the joint. The average depth for insertion ranges from 25 to 45 mm. The blunt obturator is then removed and the backflow of the fluid will be noticed. Then the joint lavage is carried out to remove blood or any puncture debris by flushing 20–25 cc of Ringer lactate solution. After



Figs 24.23A and B: Arthroscopic technique. (A) Single puncture technique; (B) Lavage by injecting lactated Ringer's solution into the inflow system



Figs 24.24A to C: (A) TMJ diagnostic arthroscopy; (B) Normal condyle disk relation; and (C) Arthroscopic view of condyle and disk

the adequate lavage, the cannula is held in position and the arthroscope is inserted. Once the scope is in position, the joint is systematically examined.

Arthroscopy is proceeded from the known to unknown. Thus, first the structure should be identified for orientation and then the scope can be moved to obtain an entire view of the joint. Rotation or forward and backward movements or side-to-side movements of the scope can be carried out for complete visualization of the joint cavity.

Double puncture technique (Figs 24.25 to 24.27): The arthroscope or operative instruments or an outflow cannula can be introduced via a second marking point entry. This puncture facilitates examination of the anterior space and joint lavage can be carried out without much extravasation of the fluid.

After initial examination and diagnosis is done through the arthroscope, lavage is carried out. If proper instruments are available, then arthroscopic surgery like incision, shaving or resection of tissue can be done. Operating arthroscope consists of a double channel sheath for introduction of operating instruments to be used under direct vision.

Surgical Hand Instruments

- Probe—used for palpation and hooking the disk, wall of the cavity and loose bodies.
- Knives—for cutting the adhesions.
- Yag-Laser—to burn, coagulate or vaporize the tissue.
- Forceps—used to grasp the loose bodies, tissues to be sent for biopsy of the synovial membrane/fibrocartilage.
- Intra-articular shaver system—electrically driven, rotating cutting, suction device.
- Suturing needle—for disk, synovial membrane.

Uses of Arthroscopic Technique

- Lavage—arthrocentesis
- Lysis of adhesion
- Disk mobility improvement
- Sclerotherapy or disk suturing for hypermobility
- Retrodiscal cauterization
- Shaving of the articular surfaces
- Biopsy
- Documentation by still or cine photography or video recording.

Complications: Drawbacks and Possible Complications

- Inadequate findings
- Costly equipment
- Otologic findings—complete or sensory hearing loss and severe vertigo
- Facial paralysis
- Instrument breakage
- Iatrogenic damage to the disk.

Arthroscopic Anatomy (Fig. 24.24)

To visualize the joint structures into clear focus, the arthroscope is first placed at the maximum depth permissible, and then gradually withdrawn. Sweeping motion along the horizontal plane allows the visualization

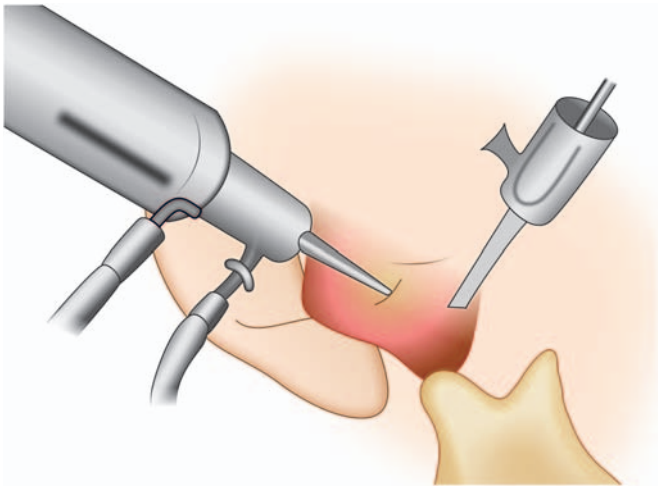


Fig. 24.25: Double puncture arthroscopy

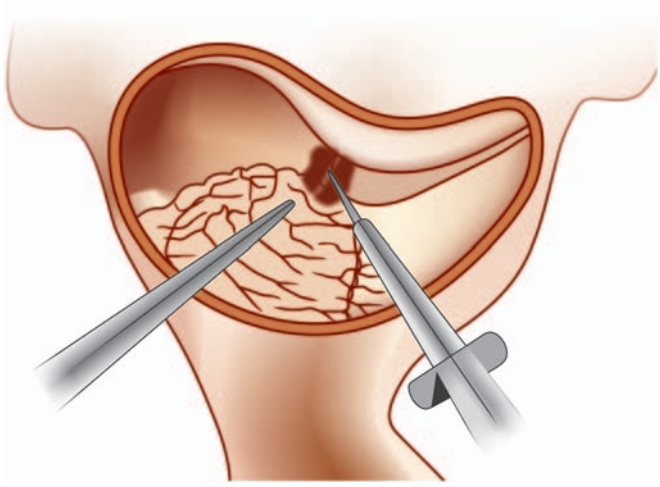


Fig. 24.26: The lysis, lavage and manipulation technique as performed in the superior joint space. An arthroscopic knife is used to incise the adhesion between the posterior slope of the eminence and the remodeled retrodiskal tissue. The lysis is carried out under direct vision

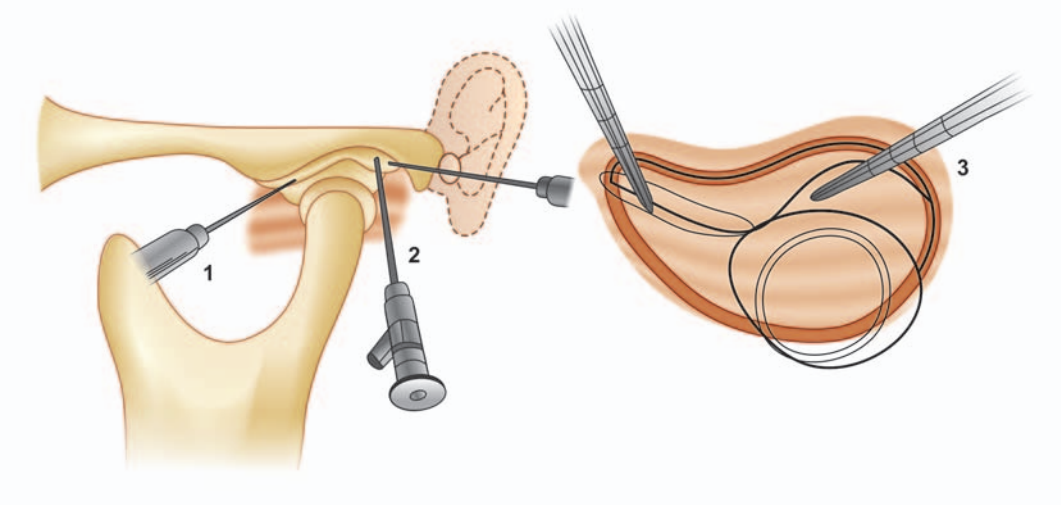


Fig. 24.27: Double puncture arthroscopy (1–2) cannulae in position; and (3) surgical lysis in progress

of the disk. The angle viewing scope can be rotated through 360° arc.

Synovium: It appears as soft, folded, translucent material. In a normal joint, the synovial capillaries have a spider web appearance. A red/white line demarcates the junction between the synovium and the disk.

Disk: It is a milky white structure with a smooth surface.

Articular eminence: It is seen as a rounded protuberance covered with fibrocartilage. It is a highly reflective white surface, but color and texture will vary in the degenerated joint.

Glenoid fossa: It has a round concave shape and covered with the same type of fibrocartilage on the articular eminence. Bone is not seen in the healthy TMJ. The appearance of gray or brown denuded bony surface indicates pathology.

Arthroscopic examination: It is divided into these zones.

1. **Anterior zone:** It comprises of synovial tissue, the anterior slope of the eminence with its fibrocartilage and anterior portion of the disk.
2. **Intermediate zone (avascular zone)** comprised of articular cartilage covering the articular eminence and meniscus.
3. **Posterior zone** comprised of synovial tissue and glenoid fossa. Examination always begins in the posterior zone with the condyle in the forward position. Operator can detect synovial inflammation, adhesions, edema, perforation or prolapse of disk.

Postoperative Care

The puncture wound dressing is done with topical application of antibiotic ointment and covered with small adhesive tape. Analgesics, anti-inflammatory, muscle relaxants can be prescribed. After 24 hours, dressing can be removed and physiotherapy can be instituted.

Surgical Treatment of Temporomandibular Joint Dysfunction Disorders

First introduced by Humphrey in 1956. Since then, numerous philosophies of treatment and surgical modalities have evolved. But, the surgery should be undertaken only after all noninvasive conservative therapies have failed. Some of these surgical techniques, such as high condylectomy (excision of the condyle), aim at bypassing the obstacle, whereas others, such as partial or total discectomy or disk recontouring and repositioning, eminectomy are designed to eliminate the obstacle by removing it or correcting the displacement. All these methods have met with considerably high success rates. The procedures on condyle included condylotomy, osteoplasty (condylar shave or high condylectomy). Eminectomy can also be done. Theoretically, these procedures reduce the

intra-articular pressure by increasing the joint space, which in turn reduces load on the rich neurovascular retrodiscal tissues.

Condylar shave and arthroplasty: It consists of removing several millimeters of the articular surface. Recontouring should be done.

Condylectomy is the excision of the condyle. This procedure had mixed results and multiple complications, particularly an open bite, malocclusion and deviation of the mandible on opening.

Eminectomy: It may be performed to increase an access to the joint space for reconstruction of the disk, as well as to diminish the obstacle in the pathway of translocation.

Disk surgery: Autogenous grafts like dermis, temporalis fascia, myofascial flaps, auricular cartilage or homologous tissues like lyophilized cartilage, dura or collagen have been used after removal of the disk. Alloplastic materials like silastic, proplast and teflon have also been used after discectomy. Fragmentation of alloplastic material may result in foreign body giant cell reactions and lymphadenopathy. Subsequent resultant bone degeneration with pain dysfunction is often noticed.

Success rate of open joint surgery is generally 70–80% better than disk surgery.

Points to Remember

Clinical characteristics of MPDS :

- Pathophysiology (Etiology) of MPDS
- Symptoms of MPDS
- History of the patient suffering from MPDS
- Objectives of treatment in myofascial pain dysfunction syndrome
- Various treatment modalities for MPDS.

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Section 6

Orthognathic Surgery

25. Introduction to Orthognathic Surgery, Diagnosis and Treatment Planning
26. Presurgical Orthodontic Phase
27. Orthognathic Surgery: Osteotomy Procedures
28. Distraction Osteogenesis in Oral and Maxillofacial Surgery

CHAPTER 25 Introduction to Orthognathic Surgery, Diagnosis and Treatment Planning

INTRODUCTION

Variety is a spice of life and the human face is certainly no exception to this adage. Variations in facial proportions within normal limits make a human face interesting. Various facial patterns lend a unique identity to the person. It is the harmony and symmetry of each segment, which contributes towards the total beauty of the face. Any deviation from the normal facial development definitely brings about an unpleasant facial appearance, with a disturbance in both esthetics as well as function.

Dentofacial deformity is defined as "the deviation from normal facial proportions and dental relationships that are severe enough to bring about esthetic and functional as well as psychological problems". Dentofacial deformities can be a part of some syndromes or associated with cleft lip and palate deformity or an isolated problem.

These dentofacial deformities can induce severe psychological problems in the affected individuals. A study conducted by the National Research Council of USA reveals that dentofacial deformities affect 20% of the population, out of which 5% of the population have major severe skeletal deformities. In our day to day practice, we come across various developmental dentofacial deformities and these should be considered/studied in relation to all three planes of space to have proper understanding of the deformity **(Fig. 25.1)**.

- Anteroposterior plane

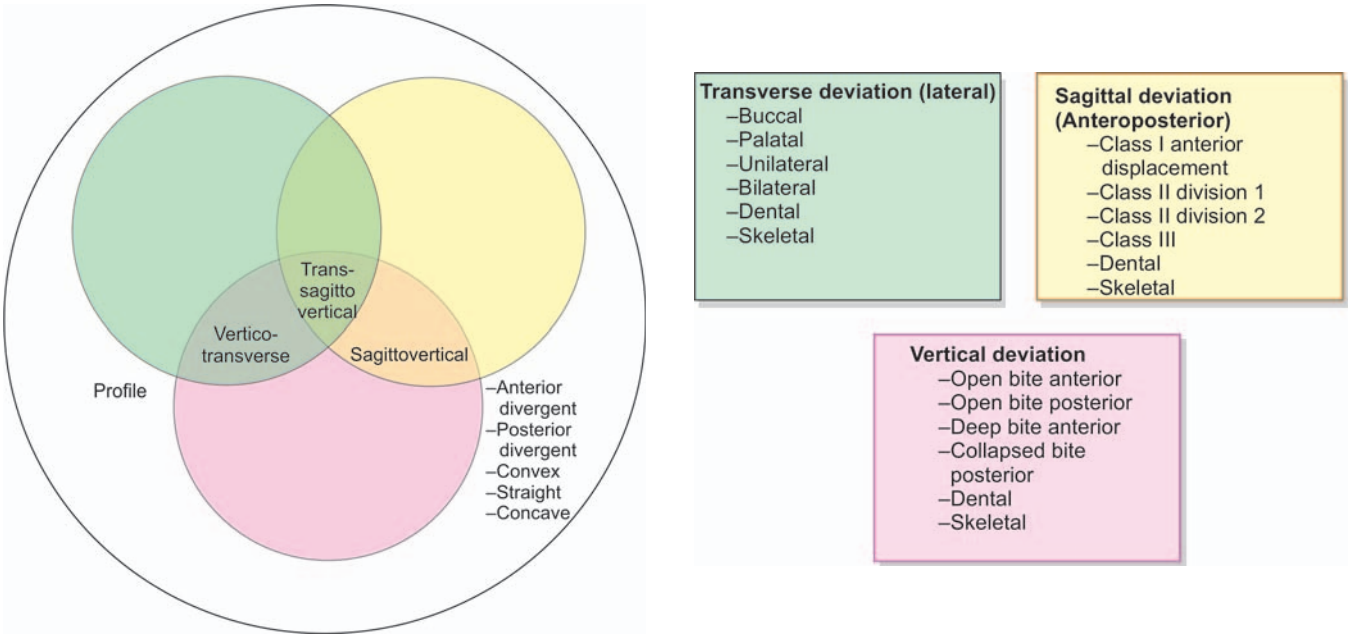


Fig. 25.1: Ackerman and Proffit's representation of five major characteristics of malocclusion via a Venn diagram. This is a convenient way of organizing the diagnostic information to be sure that no important criteria are overlooked

Table 25.1: Mandibular excess: prognathic mandible (prognathism) (Figs 25.2A to C)

Facial features	*Dental features*
1. Prominent chin is the dominant feature (prominent lower-third of the face)	1. Angle's class III molar malocclusion will be seen
2. A concave profile	2. Reverse horizontal overjet in the incisor area
3. Severe cases show lip incompetence	3. Posterior cross bite
4. Steep mandibular plane which may be parallel to high palatal plane (angle over 35°,– Normal 25°)	4. Mandibular anterior teeth may be inclined lingually (Nature's dental compensation) or they may be upright
5. Obtuse gonial angle	5. Maxillary teeth may be protrusive (Nature's dental compensation)
6. Middle-third of the face appears relatively deficient	6. An anterior open bite may be seen
7. Labiomental fold may be diminished or absent	
8. Nasolabial angle may be acute	
9. Anterior facial height may be increased	

Table 25.2: Mandibular deficiency/mandibular retrognathism/micrognathism (Figs 25.3A to C)

Facial features	*Dental features*
1. A convex profile	1. Angle's Class II molar malocclusion
2. Retruded "weak" chin. "Bird face deformity"— in extreme severe cases	2. Increased overjet
3. Short upper lip, curled and protrusive at rest	3. Accentuated curve of spee of lower anteriors
4. An everted lower lip, curled under the protrusive upper incisors with deep mentolabial fold	4. Lower anterior teeth may be tipped forwards (fanning) or crowded
5. Acute gonial angle	5. Skeletal deep bite may be present
6. The lip strain will be evident if closure of the mouth is attempted	

Table 25.3: Maxillary excess (long face syndrome): vertical maxillary excess (VME) (Figs 25.4 and 25.5)

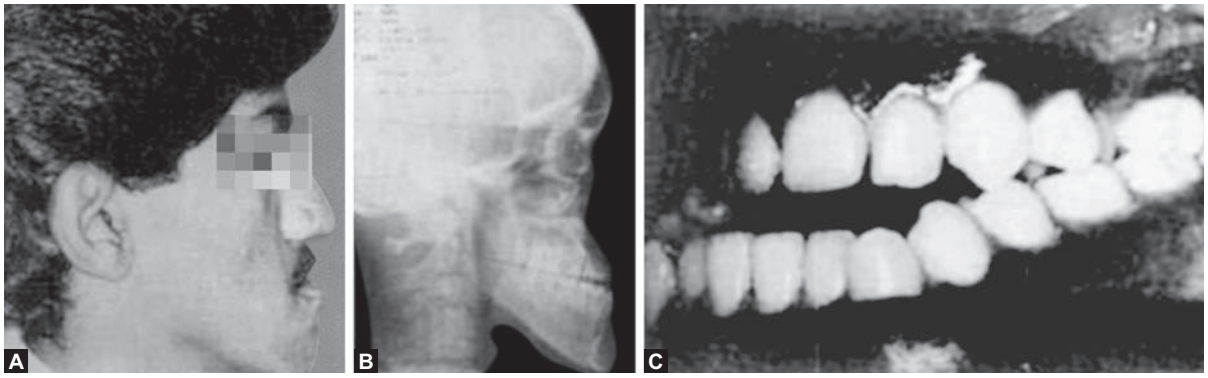
Facial features	*Dental features*
1. Increased height of lower-third of the face	1. An Angle's class II molar occlusion
2. Recessive paranasal areas	2. A high arched palate
3. Narrow alar base	3. V-shaped maxillary dental arch
4. Prominence of infraorbital rims, cheek bones, prominent nose	4. Accentuated curve of spee
5. Large interlabial gap (more than 4 mm) with the lips in repose (incompetent lips) 6. Excessive incisor display—typical gummy smile 7. Retropositioned or recessive chin 8. Steep mandibular plane	5. Two variants **(Figs 25.4 and 25.5):** A. With anterior open bite—excessive posterior maxillary vertical growth. A short or normal ramus. Two-thirds of the patients have anterior open bite. B. Without anterior open bite—Dental compensation with over eruption of incisors (an increased ramus height)

- Vertical plane
- Transverse plane.

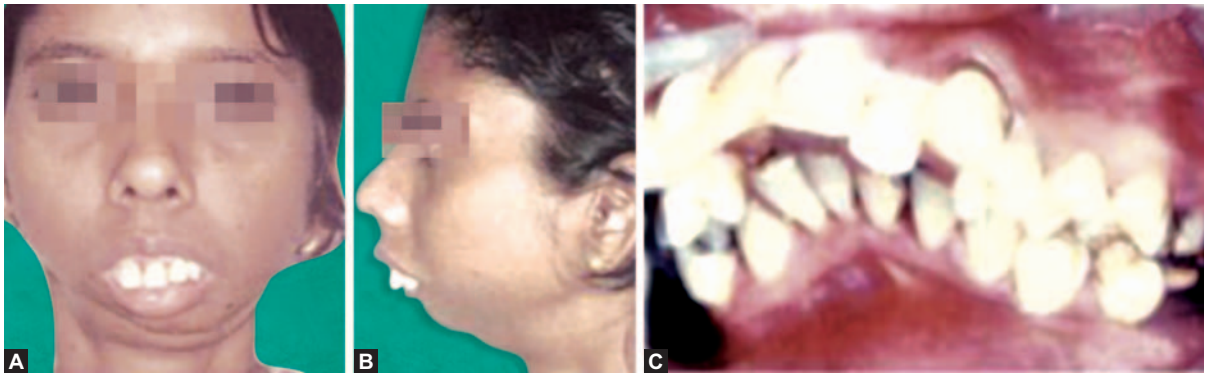
TYPES OF SKELETAL DENTOFACIAL DEFORMITIES

Types of severe skeletal dentofacial deformities can be broadly grouped into following categories **(Tables 25.1 to 25.8)**:

- Mandible Excess : *Mandibular prognathism*
  deficiency : *Mandibular retrognathism*
- Maxilla Excess : *Vertical maxillary excess—VME*
  deficiency : *Vertical maxillary deficiency—VMD*
- Combination
  - Bimaxillary protrusion
  - Nasomaxillary hypoplasia associated with prognathic mandible



Figs 25.2A to C: Mandibular prognathism. (A) Facial profile view; (B) Lateral cephalogram; (C) Intraoral features



Figs 25.3A to C: Mandibular deficiency. (A and B) Front and profile view; (C) Dental occlusion

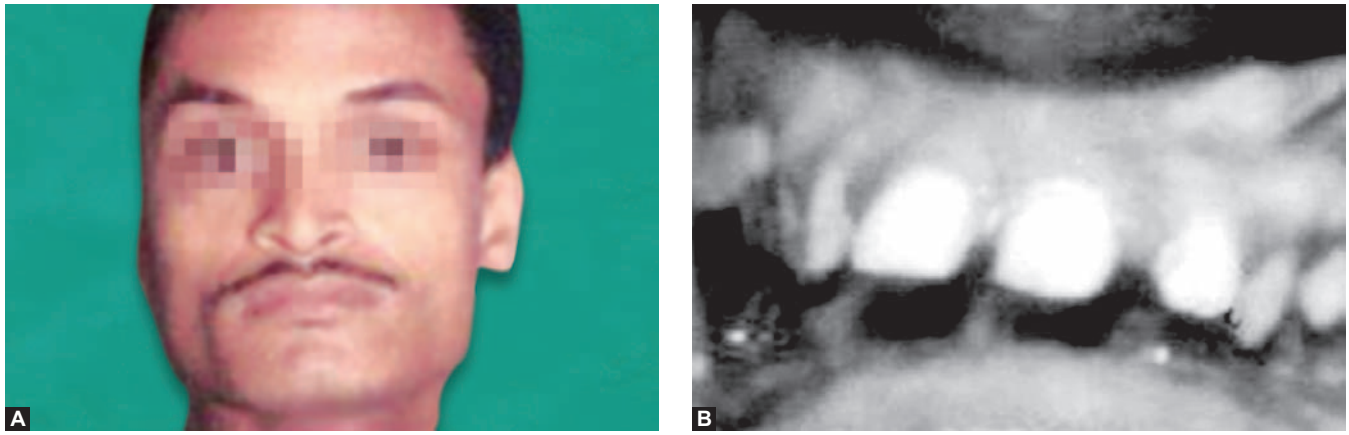


Figs 25.4A to C: Vertical maxillary excess (VME) with anterior open bite. (A and B) Profile view of VME patients; (C) Intraoral features



Figs 25.5A to C: Vertical maxillary excess without open bite. (A and B) Front and profile facial features; (C) Dental features

Table 25.4: Maxillary deficiency/vertical maxillary deficiency (VMD) (Figs 25.6A and B)	
Facial features	***Dental features***
1. A short square-shaped face with edentulous appearance	1. Angle's class I or class II molar occlusion
2. Decreased lower facial height	2. Deep overbite
3. The mandible appears square and prominent due to overclosure	3. Mandibular incisors frequently occlude with the palatal gingiva
4. Deep mentolabial fold "Knobby" appearance of the chin (prominent chin button)	4. Severe attrition of the teeth may be seen
5. Overclosure of the lips	

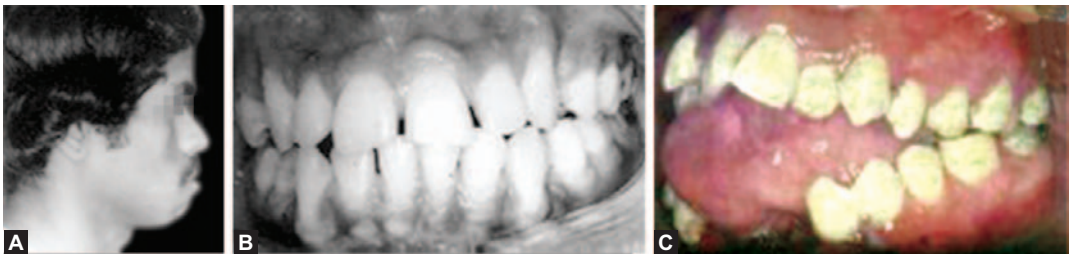


Figs 25.6A and B: Vertical maxillary deficiency (VMD) facial and dental features

Table 25.5: Skeletal bimaxillary protrusion with or without anterior open bite (Figs 25.7 and 25.8)	
Facial features	***Dental features***
1. Convex profile	1. Anterior open bite or edge to edge bite may be present
2. Extreme protrusion of maxillary and mandibular incisors	2. Mild to severe crowding or spaces may be seen
3. Anterior teeth prominent and visible in the frontal and profile views	3. May be associated with a severe tongue thrusting habit
4. Lip strain is evident, if the mouth is closed 5. Lip incompetence 6. Thick looking lips, with an everted vermilion border and a rolled appearance	4. When severe protrusion of maxillary incisors is seen, accentuated curve of spee with mandibular incisors crowding and deep bite may be seen
7. Apparent chin deficiency	



Figs 25.7A to C: Bimaxillary protrusion with anterior open bite (A) Frontal view; (B) Profile view; and (C) Dental features



Figs 25.8A to C: Bimaxillary protrusion without anterior open bite: (A) Profile view, (B) Dental features, and (C) Another bimaxillary protrusion patient's dental occlusion. Note the severe tongue thrust habit

Table 25.6: Nasomaxillary hypoplasia associated with a prognathic mandible (Figs 25.9A to C)

Facial Features	*Dental Features*
1. Flattening	1. Anterior and posterior cross bites
2. Sunken appearance	2. Maxillary incisors tend to be protrusive in relation to the hypoplastic maxilla
3. Prognathic mandible	3. Mandibular incisors upright to the mandibular basal bone
4. Relatively flat & short Upper lip	4. Mandibular posterior teeth have an exaggerated lingual inclination
5. No display of upper incisors	5. Maxillary posterior teeth tend to lean outwards
6. Deepened nasolabial fold	

Table 25.7: Nasomaxillary hypoplasia associated with cleft lip-palate deformities (Figs 25.10A to E)

Facial Features	*Dental Features*
• Severe mid-face hypoplasia	• Angle's class III molar
• Short, distorted upper lip	Malocclusion
• Asymmetry of the nose (Typical speech "Nasal Twang")	• Constricted maxillary arch
• Mandible appears relatively prognathic (pseudoprognathism)	• Anterior cross bite • Crowding of maxillary teeth



Figs 25.9A to C: Nasomaxillary hypoplasia associated with a prognathic mandible: (A and B) Frontal and profile view; (C) Dental occlusion

  - Nasomaxillary hypoplasia associated with cleft lip and palate
- Facial asymmetry
  - Asymmetric prognathism of the mandible
  - Unilateral condylar hyperplasia
  - Hemifacial hypertrophy (rare).

Asymmetrical Mandibular Prognathism

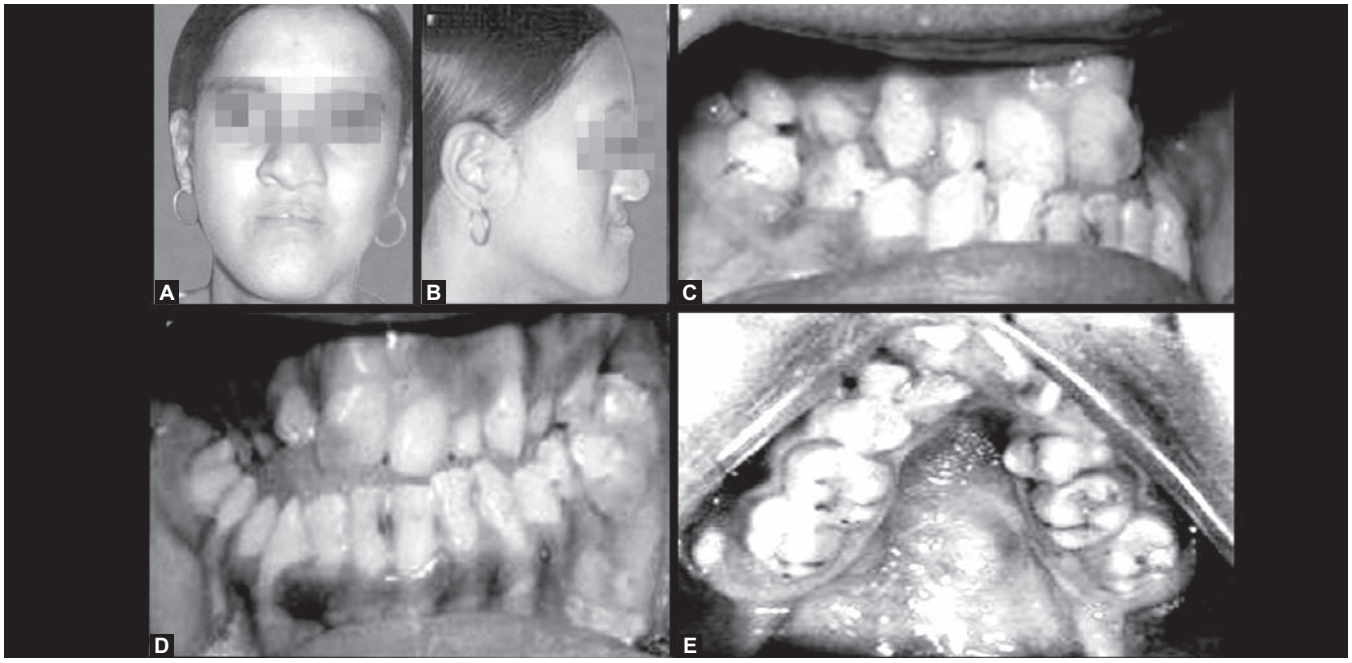
With Anterior Open Bite (Figs 25.11A to C)

Clinical Features

- Severe facial asymmetry
- Eccentric bilateral mandibular protrusion
- Deviation of the chin
- High gonial angle
- Anterior open bite (anterior and posterior cross bite seen unilaterally)
- Midline of the mandibular arch is shifted.

Without Anterior Open Bite (Figs 25.12A to C)

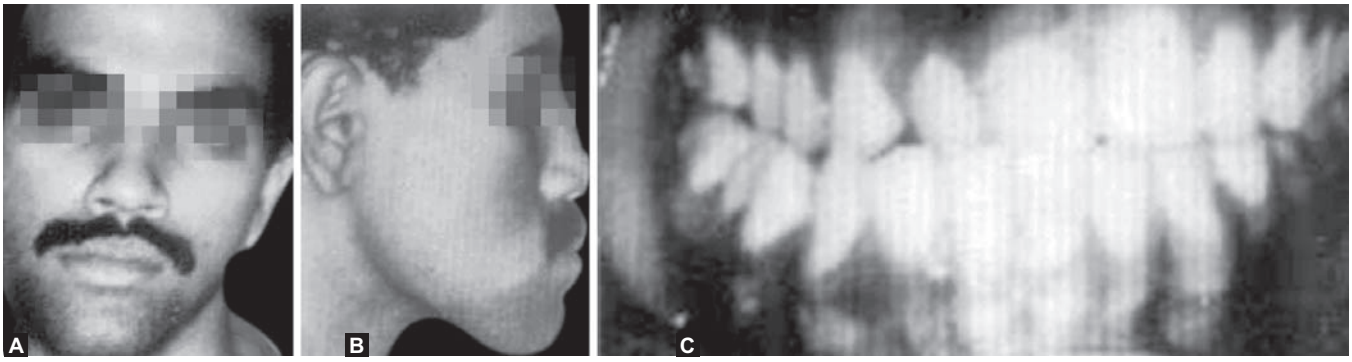
- Eccentric bilateral mandibular protrusion
- Deviation of the chin
- Class III dental malocclusion



Figs 25.10A to E: Nasomaxillary hypoplasia associated with cleft lip and palate deformities. (A) Frontal view; (B) Profile view; (C) Anterior and posterior cross bite; (D) Dental occlusion; (E) Constricted maxillary arch



Figs 25.11A to C: Asymmetrical mandibular prognathism with anterior open bite



Figs 25.12A to C: Asymmetrical mandibular prognathism without anterior open bite

Table 25.8: Conditions with facial asymmetry (Figs 25.11 to 25.14)

1.	Asymmetrical mandibular prognathism a. With anterior open bite b. Without anterior open bite
2.	Unilateral condylar hyperplasia a. Hemimandibular elongation b. Hemimandibular hyperplasia
3.	Hemifacial hypertrophy (rare)

- Associated maxillary hypoplasia
- No anterior open bite.

Unilateral Condylar Hyperplasia

Further divided into two types **(Table 25.8)**.

Hemimandibular Elongation (Figs 25.13A to C)

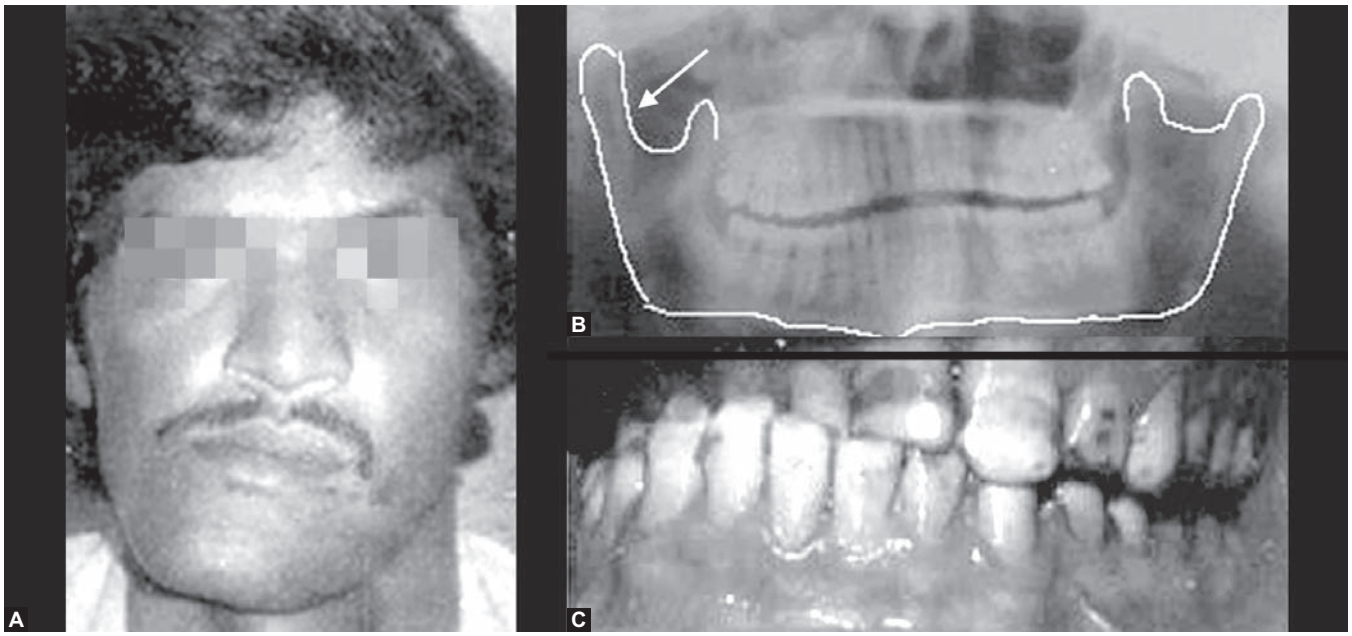
Clinical Features

- Horizontal displacement of the mandible and chin towards the unaffected side.
- Usually there is a mild protrusion and lip line slopes down, towards the affected side.
- On the unaffected side there may be a lateral cross bite.
- The occlusal plane sometimes slopes upwards to the unaffected side.
- Secondary over eruption of the maxillary teeth on the affected side to maintain the functional occlusion.
- In severe cases lateral open bite may be present on the affected side.
- In the radiographs Orthopantogram (OPG) and posteroanterior (PA) view elongation of the neck of the condyle with increased ramal height on the affected side will be seen. Condylar head also may show enlargement.

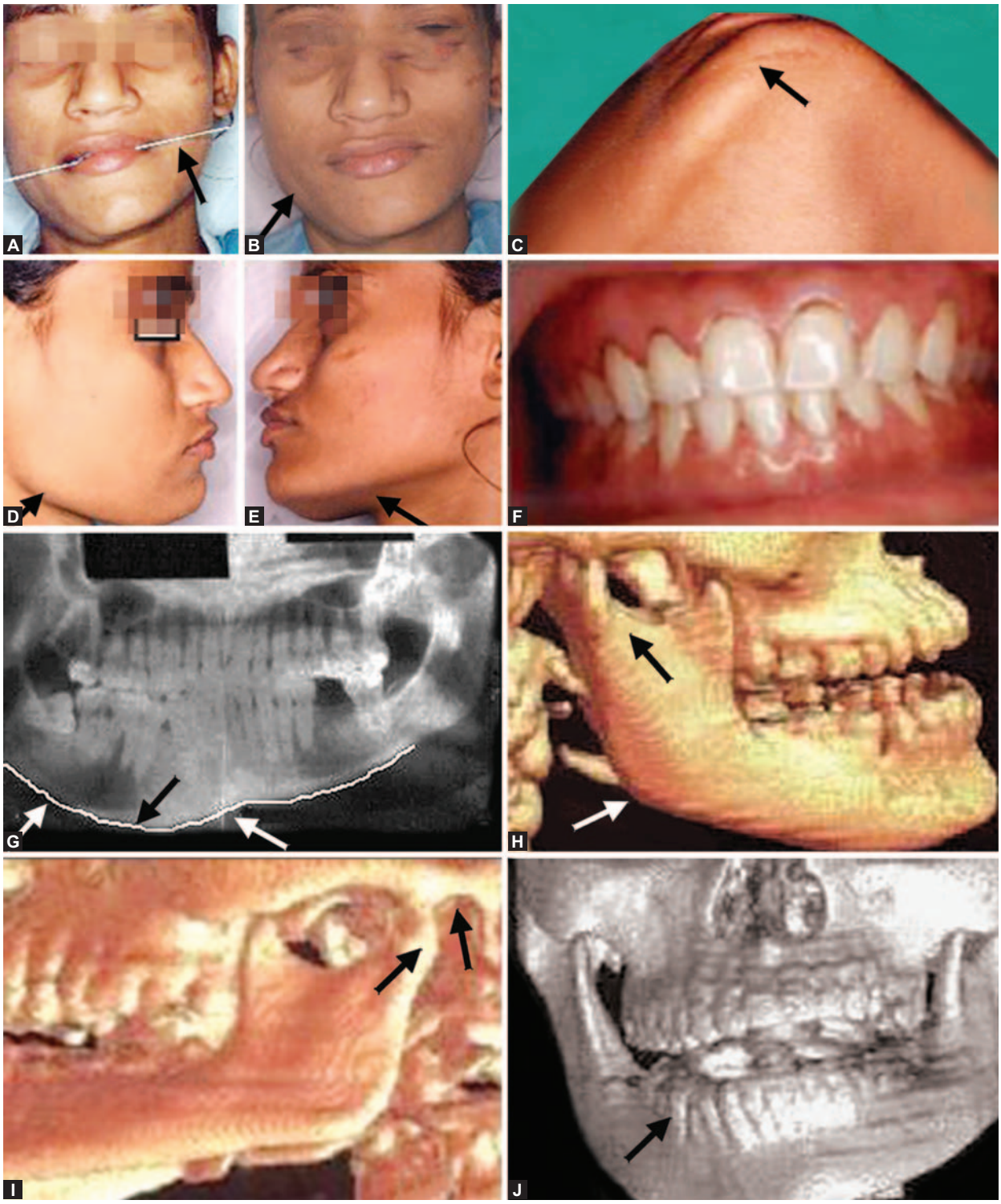
Hemimandibular Hyperplasia (Figs 25.14A to J)

Hemimandibular hyperplasia condition is characterized by a three-dimensional enlargement of one side of the mandible, thus, there is enlargement of the condyle, the condylar neck and the ascending ramus and the body. The abnormal growth terminates precisely at the symphysis, giving rise to a sharp "step" in the mandible at that site and justifying the term hemimandibular hyperplasia.

- One side of the face appears to be enlarged.
- Unilateral "bowing" of the inferior border of the mandible is seen on the affected side.
- The lip-line slopes downwards on the affected side.
- Gross occlusal discrepancies like lateral open bite on the affected side, overeruption of posterior teeth in the maxilla with occlusal cant and increased vertical maxillary height on the affected side may be seen.
- Associated temporomandibular joint (TMJ) pain symptoms may be present
- *Radiographically*—the entire hemimandible on the affected side is enlarged and the inferior dental



Figs 25.13A to C: Unilateral condylar hyperplasia. Hemimandibular elongation. (A) Marked facial asymmetry in front view of a patient; (B) Orthopantogram (OPG) showing elongation of the neck of the condyle on the affected side; (C) Occlusal plane discrepancy



Figs 25.14A to J: Unilateral condylar hyperplasia. Hemimandibular hyperplasia. (A) Occlusal cant; (B) Facial asymmetry; (C) Bowing of (Right) inferior border of the mandible; (D) (Right) Profile; (E) (Left) Profile. On the (Right) side, lower level of the inferior border can be appreciated; (F) Occlusion; (G) OPG showing "Bowing" of the inferior border of the mandible; (H to J) 3D CT scan; (H) Unilateral elongation of ascending ramus and condyle. Enlargement of condyle is seen; (I) Shift of (Left) condyle out of fossa; (J) Asymmetry of the lower jaw, unilateral rounding off of the angle and typical bowing of the inferior border of the mandible. Increased height of the body of the mandible is also seen unilaterally

canal is displaced towards the lower border. The OPG demonstrates a pathognomonic appearance
- The elongation of ascending ramus (unilateral)
- Elongation and thickening of the condylar neck (unilateral)
- An irregular and deforming enlargement of the condyle (unilateral)
- The angle is characteristically rounded off (unilateral)
- Typical "bowing" of the inferior border of the mandibular body— (unilateral)
- Increased height of the body of the mandible (unilateral).

During active growth phase of hemimandibular elongation and hemimandibular hyperplasia, scintigraphy carried out demonstrates increased uptake in the condyle of the affected side.

SEVERE SKELETAL DENTOFACIAL DEFORMITIES AND ASSOCIATED PROBLEMS

- Esthetic problems
- Functional problems
- Psychological problems (Tarnishing self-image)
- Impairment of mastication
- Impact on digestion—general health
- Associated speech problems
- Difficulty in maintaining oral hygiene
- Susceptibility to caries and periodontal problems
- Possible TM joint pain dysfunction.

TREATMENT OPTIONS

When a patient has got mild dentofacial deformities, it can be treated with orthodontic tooth movement alone. But, whenever there is severe skeletal dentofacial deformity exists, there are three broad options for treating these deformities.

1. Growth modification
2. Orthodontic camouflage
3. Orthognathic surgery

Growth Modification

Growth modification or dentofacial orthopedics can be useful in children, where there is growth potential present and modification of the growth can be achieved in some of these patients.

Growth modification can be achieved by using the following:

- High pull headgear to a complete or partial maxillary fixed appliance.
- Myofunctional appliances—used for 14–16 hours a day.

But this modality has got limitations and only few millimeter changes can be brought about. Myofunctional appliances need to be worn for a long time by the patient and if patient is not cooperative, the desired results cannot be achieved.

Orthodontic Camouflage

Orthodontic camouflage is a biologically acceptable dental compensations, that has been built in, to mask the skeletal malocclusion, brought about by means of orthodontic treatment, in borderline skeletal deformities. Orthodontic camouflage should be carried out, if:

Orthodontist is able to carry out biologically acceptable dental compensations:

- With desired soft tissue results
- Willingness of the patient to cooperate (treatment modality, tolerate prolonged treatment)
- Growth potential study is done. When quantity, direction or timing of orthodontic treatment is poor, it can bring about disastrous results.

Orthodontic camouflage should be undertaken after careful patient selection/examination for ultimate facial esthetics and occlusal stability. Treatment planning for satisfactory dental occlusion, at the expense of undesirable facial esthetics, is of little value to the patient and should not be attempted.

Orthognathic Surgery

Orthognathic surgery includes surgical repositioning of the jaw and/or dentoalveolar segments. This option is used for the correction of a severe skeletal discrepancy after growth has ceased.

Orthognathic surgery is the art and science of diagnosis, treatment planning and execution of treatment by combining orthodontics and oral and maxillofacial surgery to correct musculoskeletal, dento-osseous, and soft tissue deformities of the jaws and associated structures. In the severe skeletal deformities, orthodontics alone may compromise esthetics and stability and surgery alone, may compromise function and stability.

The objective of orthognathic surgery is to achieve best function, best esthetics and best stability, thereby enhance the personality and lifestyle and channel the patient into self-esteem. For the successful outcome of the orthognathic surgery, both orthodontist as well as

oral and maxillofacial surgeons are equal partners. Since this treatment modality targets at adult population, time factor is also equally important. The combined surgical orthodontics (orthognathic surgery) also should be aimed at minimizing the total treatment time.

Timing for surgery: In skeletal dentofacial deformities, if patient is having severe psychosocial problems, then only surgery can be undertaken in actively growing patient. But, with the warning, that resurgery may be required later on. Otherwise, the best timing for orthognathic surgery is after the growth potential for the patient is over.

Combined surgical orthodontics demands interdisciplinary team approach of orthodontist and oral and maxillofacial surgeon. The team conference should have proper communication to avoid frustration and disappointing results.

Diagnosis and treatment planning: When the diagnosis and treatment planning for the particular patient is being done, both orthodontist and oral and maxillofacial surgeon should take equal interest. Good communication and proper interaction of the team members are absolutely mandatory; ideally both the members should interview the patient together. Patient's expectations and chief complaint should be taken into consideration and after the detailed treatment plan is decided, patient conference should be held with both the members of the team. All the details of the entire treatment plan and the time and cost factor for the entire treatment should be discussed in detail with the patient. Any questions, doubts on patient's/relative's part should be sorted out at the onset **(Table 25.9)**.

Goal of the diagnostic process is to

- Produce a concise list of patient's problems
- Synthesize the various treatment possibilities into a rational plan that gives maximum benefit to the patient.

Table 25.9: Diagnosis and treatment planning

Phase I	• Assemble the database • Synthesize the problem list • Diagnosis • Team conference
Phase II	• Interdisciplinary problem list • Dentofacial problems in order of priority • Possible solutions • Tentative treatment plan • Patient/team conference • Definitive plan
Phase III	• Preparatory therapy— endodontic, periodontics, prosthetics, etc. • Definitive orthodontic— surgical treatment • Continuous team monitoring, re-evaluation interaction, modifying the therapy
Phase IV	• Maintenance

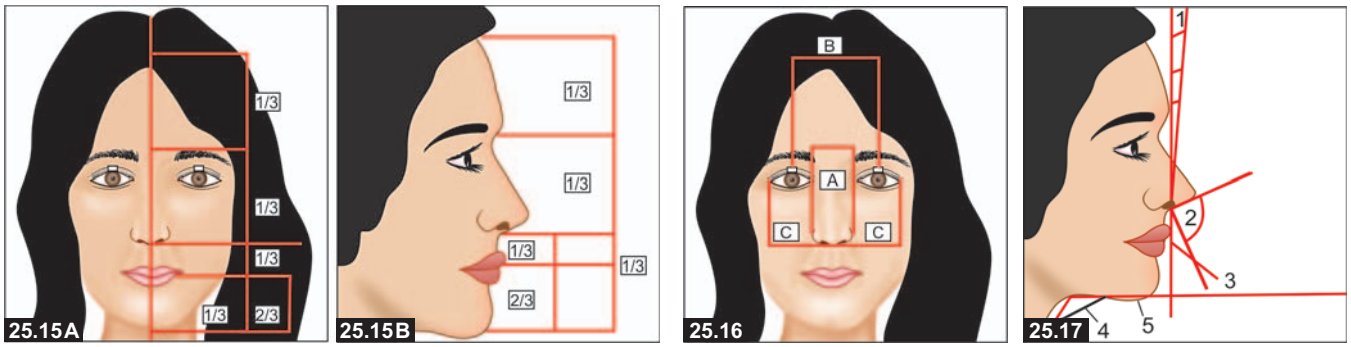
Collecting Patient's Data

- Patient's personal data—name, age, sex, race, body type, occupation, hair, habits, physical fitness, any allergies, systemic diseases, airway obstruction problems, previous surgeries, etc.
- Facial esthetic analysis—frontal, profile
- Lateral cephalometric analysis—soft tissue, dental, skeletal
- Occlusal analysis and model analysis:
  - Dental arch form/length
  - Dental alignment/symmetry
  - Dental occlusion
  - Tooth mass relation
- Final treatment plan:
  - Presurgical orthodontics
  - Surgery plan
  - Postsurgical orthodontics
  - Maintenance.

FACIAL ESTHETIC ANALYSIS

We have to be familiar with the normal facial proportions, before we carry out face-to-face evaluation of an individual. The entire face is divided into three equal parts—upper-, middle-, and lower-thirds. Any change in these proportions can be noted easily in frontal and profile view of the face.

- Patient is asked to sit upright at the eye level of the clinician. Patient's head should be adjusted in such a way that:
  - The pupillary plane should be parallel to the floor.
  - The plane of the ears also should be parallel to the floor.
  - Clinical Frankfort Horizontal Plane (CFHP), i.e. a line from the tragus of the ear to the bony infraorbital rim should be parallel to the floor (this is a natural head position, helpful for standardization of the measurements throughout the treatment sequence).
- Patient should be examined with the teeth in centric position (tip of the patient's tongue is touched to the most posterior aspect of the palate and teeth are closed together).
- Patient's lips should be relaxed (Evaluation of tooth to lip measurement, tooth display, gum display, lip incompetence, chin position, etc.).



Figs 25.15A and B: Normal facial proportions: (A) Front view; (B) Profile view. **Figs 25.16:** Frontal view analysis. The transverse facial balance. (A) Normal intercanthus distance—32 mm ± 3 mm; (B) Normal interpupillary distance—65 mm ± 3 mm. (C) The width of the palpebral fissures should be equal to the intercanthal distance. **Fig. 25.17:** Profile view analysis

- Patient is asked to look straight and remain steady throughout the evaluation.

The clinical photographs in frontal and profile view can be taken in this position for records and photographic analysis.

As mentioned earlier, the face is divided into equal-thirds. The upper-third is from the hair line to glabella. The middle-third is from glabella to subnasale. The lower third is from subnasale to soft tissue menton. The lower-third can be further divided from subnasale to upper lip stomion as one-third and lower lip stomion to soft tissue menton equaling two-thirds. This division can be done both for frontal as well as profile view of the patient. The normal facial proportions are equal-thirds. Most of the orthognathic surgery brings about changes in the lower-third of the face, therefore preoperative measurements can be taken both in frontal and profile views **(Figs 25.15A and B)**.

Frontal View Analysis (Fig. 25.16)

Larry Wolford and Fields have recommended the evaluation of 14 anatomic relationships in front view analysis which are as follows:

- The forehead, eyes, orbits and nose are evaluated for symmetry, size and deformity
- Normal intercanthal distance is 32 ± 3 mm
- Normal interpupillary distance is 65 ± 3 mm
- The intercanthal distance, alar base width, and palpebral fissure width should all be equal
- The width of the nasal dorsum should be one-half the intercanthal distance and width of the nasal lobule should be two-thirds the intercanthal distance
- A vertical line through the medial canthus and perpendicular to the pupillary plane should fall on the alar bases ± 2 mm
- The upper lip length is measured from subnasale to upper lip stomion. The normal upper lip length is 22 ± 2 mm for males and 20 ± 2 mm for females
- A normal upper tooth to lip relationship exposes 2.5 ± 1.5 mm of incisal edge with lips in repose
- The facial midline, nasal midline, lip midline, dental midline and chin midline all should be congruent and face should be reasonably symmetric, vertically and transversely
- Lip incompetence if present should be measured from upper lip stomion to lower lip stomion with lips in repose and teeth in centric occlusion (0–3 mm)
- Smile line—during smiling, the vermilion of the upper lip should fall at the cervicogingival margin with no more than 1–2 mm of exposed gingiva. Patient should be asked to give full smile to detect "gummy smile"
- The distance from the glabella to subnasale and subnasale to menton should be in 1:1 ratio, providing upper lip length is normal
- The length of the upper lip should be one-third the length of the lower facial third
- The lower eyelid should be in level with or slightly above the most inferior aspect of the iris.

Profile or Lateral View Analysis (Fig. 25.17)

This is helpful for determining vertical and anteroposterior plane problems of the jaws. The facial profile can be classified into three types—straight, convex and concave.

1. **The facial contour angle**: It is a measure of the relative concavity or convexity of the facial profile. The reference norm ranges between 8 and 11°. This angle is formed between the upper facial contour plane and the upwards extension of the lower facial contour plane. If the angle is anterior to the upper facial contour plane, the measurement is quoted as negative.

2. **Nasolabial angle**: The angle formed at subnasale by a line drawn tangent to the base of the nose with a line drawn from the upper lip to subnasale. The normal range is 100–110° in males and 110–120° in females. A large angulation is indicative of a convex face, generally associated with a recessive chin.
3. **Lip position**: The upper lip should protrude ahead of the lower facial contour plane by 3.5 mm. The lower lip should protrude by 2.2 mm.
4. **Lower lip, chin-throat angle**: The angle between a line drawn from the lower lip to the soft tissue pogonion and a line drawn tangent to the soft tissue contour below the body of the mandible. The normal angulation is 110° ± 8°. A large angulation is indicative of a recessive chin while low angulation suggests an excessive chin.
5. **The chin to throat length**: The distance between the angle of the throat and soft tissue menton. The norm is 51 mm ± 6 mm. An increased value indicates mandibular prognathism and will be associated with a concave face and an acute lower lip, chin throat angle.

Rest of the vertical proportions are same as frontal analysis **(Table 25.10)**.

Oral Examination

- Basic occlusal relationship (class I, II, III)
- Anterior overbite or open bite
- Anterior overjet and any cross bites
- Health of the dentition
- Tooth size discrepancies
- Curve of Wilson
- Curve of Spee
- Dental crowding or spacing
- Missing, carious, nonsalvagable teeth
- Periodontal evaluation
- Transverse, vertical or anteroposterior discrepancies
- Anatomical functional tongue abnormalities
- Attrition, etc. (loss of vertical dimension).

TMJ function should be recorded **(Table 25.11)**.

Dental Model Analysis

Dental model analysis can be carried out as routinely done in orthodontics. Arch length measurement, tooth size analysis, tooth position, arch width analysis. Curve of occlusion, cuspid molar relationship, tooth arch symmetry, etc. should be noted.

Clinical assessment, dental model evaluation and cephalometric analysis must be used to establish an accurate diagnosis of a dentofacial deformity.

Cephalometric Analysis

Cephalometric analysis of the lateral radiograph is a two-dimensional diagnostic aid.

Salzman (1964) has proved that cephalometrics can provide valuable information from both a clinical and research basis by the following:

- Establishing two-dimensional relationships of craniofacial components
- Classifying skeletal and dental abnormalities with respect to cranial base, skeletal pattern, inter- and intra-arch dental relationships and soft tissue profile
- Analyzing growth and development responsible for dentofacial pattern, whether for cranial base configuration, congenital abnormalities, pathologic conditions, or facial asymmetry
- Planning treatment for orthodontic and/or surgical procedures
- Analyzing changes after treatment effectiveness of different treatment modalities and effectiveness of retention
- Determining dentofacial growth changes after treatment

Table 25.10: Evaluation of five major esthetic masses of the face (Figs 25.16 and 25.17)

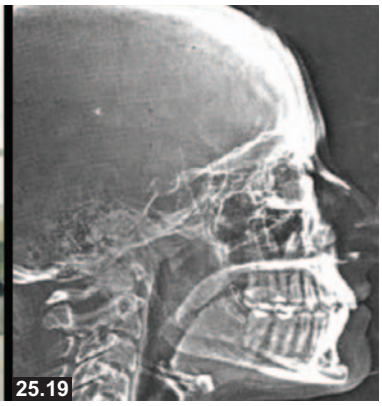
1.	Forehead	:	Nasofrontal angle
2.	Eyes	:	Interpupillary distance (6.5 mm normal) Intercanthal distance (3.5 mm normal) Outercanthal distance (9.8 mm normal)
3.	Nose	:	Length, width, projection nasolabial angle (90°–120° normal)
4.	Lips	:	Length, width, procumbency, recumbency, interlabial gap (3 mm normal)
5.	Chin	:	Mentolabial sulcus Lip chin complex contour Prominence, deficiency

Table 25.11: Presurgical data

Patient's personal data	*Frontal and profile view*	*Dental data*
Name, age	Symmetry	Dental arch form
Sex	proportion	alignment,
Race	Evaluate 5 major	symmetry, tooth
Body type	esthetic masses	mass relation,
Hair	of the face—	crowding, spaces,
Occupation	Forehead, eyes,	overjet, overbite
Habits	nose, lips, chin	anterior, posterior cross bite, edge to edge bite, open bite







Figs 25.18A and B: Positioning the patient in cephalometer. A natural head position. **Fig. 25.19:** Lateral cephalograph showing hard and soft tissue contours

- Predicting hard and soft tissue contours before initiation of treatment.

Diagnostic cephalometric radiographs should be taken after patient is placed in cephalometer with head adjusted in natural head position, sagittal plane of the patient's head should be parallel with film **(Fig. 25.18A and B)**.

Lips should be in repose and teeth should be placed in centric occlusion. Soft tissues must be reproduced on the cephalometric film without sacrificing details of osseous structures **(Fig. 25.19)**.

Soft Tissue Landmarks (Fig. 25.20)

- **Glabella**: The most prominent point of the forehead.
- **Soft tissue nasion**: The deepest point of the bridge of the nose.
- **Subnasale**: The point at which the base of the nose merges with the upper cutaneous lip.

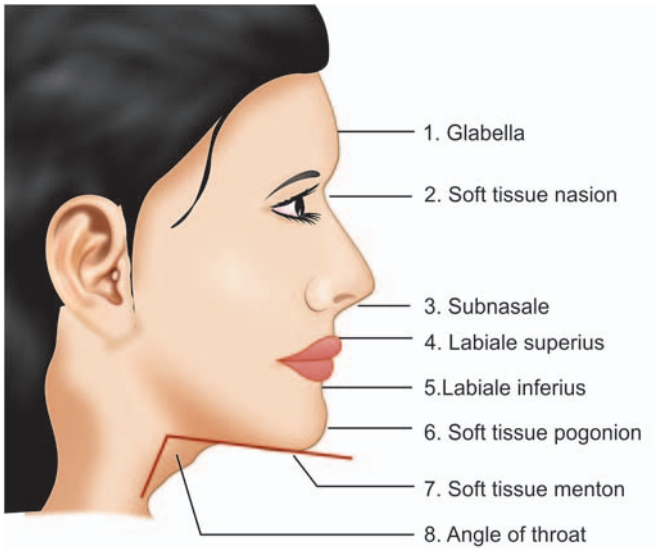


Fig. 25.20: Soft tissue landmarks

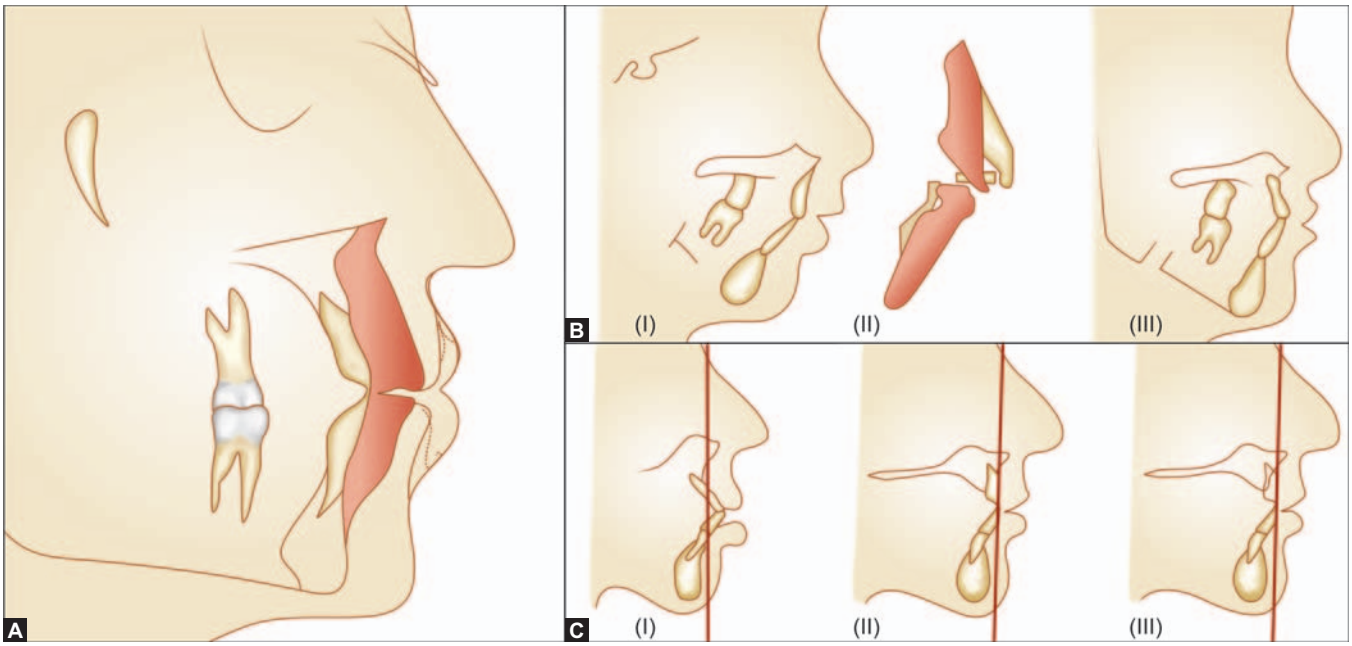
- **Labiale superius**: The median point of the upper margin of the upper membranous lip.
- **Labiale inferius**: The median point of the lower margin of the lower membranous lip.
- **Soft tissue pogonion**: The foremost point on the soft tissue chin in the midsagittal plane.
- **Soft tissue menton**: The lowermost point on the soft tissue chin in the sagittal plane.
- **Angle of throat**: The intersection of the horizontal and vertical tangents to the profile of the soft tissue throat.
- **The upper facial contour plane**: It extends between glabella and subnasale.
- **The lower facial contour plane extends** between subnasale and soft tissue pogonion.

Cephalometric Prediction Tracing (Figs 25.21A to C)

The importance of accurately estimating facial growth, based on facial pattern, was recognized as a result of work by Ricketts (1957), that stressed the necessity of predicting facial profile. Fish and Epker in 1980, put forwards a method to predict facial profile as a result of surgical orthodontic correction of dentofacial deformities. They advocated surgical movement of skeletal parts (maxilla and/or mandible) with a single acetate sheet overlying the original pretreatment cephalometric tracings.

Bell, Profitt and White (1980), advocated use of the cephalometric prediction with templates to double check the model surgery changes, to predict changes in bony relationships not seen on the dental casts, and to predict soft tissue changes.

- Prediction analysis presents a simple and accurate method of predicting results of surgical orthodontic treatment.
- Quantification of the surgical movements necessary to correct the deformity is also possible.



Figs 25.21A to C: (A) Bimaxillary protrusion setback. Soft tissue changes prediction; (B) Cephalometric prediction tracing for the correction of mandibular hypoplasia with class II malocclusion: (I) Preoperative cephalogram, (II) Desired tooth movement prior to surgery, with presurgical orthodontics, (III) Prediction tracing considering the mandibular surgical advancement. Note the changes in soft tissue profile; (C) Comparison of preoperative, prediction and postoperative cephalometric tracings for bimaxillary protrusion case (I) Preoperative cephalogram with soft tissue profile, (II) Prediction tracing considering bimaxillary setback surgery (III) Postoperative cephalogram with soft tissue profile

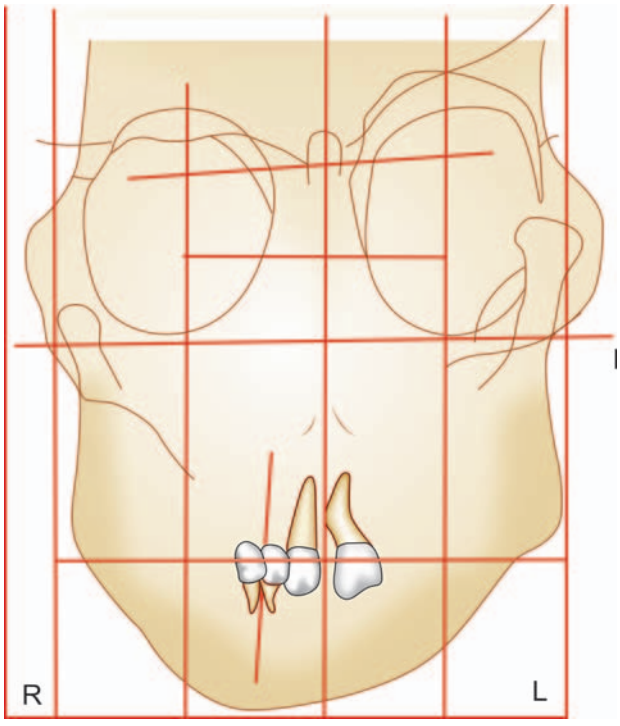


Fig. 25.22: Posteroanterior (PA) cephalometric analysis for assessment of facial asymmetry

- It can also accurately predict the resultant facial profile.
- Provides a visual aid with a single overlay.
- It can be also used for comparing with actual postsurgical cephalometric tracings for re-evaluating the surgical results.

Posteroanterior Cephalometric Analysis

Posteroanterior (PA) cephalometric analysis is mainly used for assessing asymmetry of the facial skeleton.

- First vertical line is drawn joining the midline of the nose and chin and the dental arch—midsagittal line.
- Second vertical line is drawn passing through the zygomatic arch on either side of midsagittal line.
- Third vertical line is drawn on either side of mid-sagittal line passing through the angle of the mandible.

These lines help to evaluate deviation, asymmetry or disproportions of facial skeleton and comparison can be made with the normal side measurements. Horizontal lines are drawn along zygomatic plane, occlusal plane, infraorbital plane, plane of the lower border of the mandible, etc. to assess the deviation in relation to horizontal plane **(Fig. 25.22)**.

A "QUICK CEPH" DENTOFACIAL PLANNER FOR ORTHOGNATHIC SURGERY

Cephalometrics are still imperfectly understood as a clinical tool. Since proper pretreatment assessment can mean the difference between successful and unsuccessful treatment. The purpose of this article is to present clinically useful information which is simple and not so lengthy, so that clinicians are encouraged to use it routinely.

This "Quick Ceph" '10' measurement analysis will give the most valuable diagnostic, treatment and follow-up information in a matter of minutes for evaluating a orthognathic case. A full generation of orthognathic, oral and maxillofacial surgeons, plastic surgeons have been fed on a "surplus" of cephalometrics, right from its invention by Broadbent. Many a times a clinically useful information may be "hidden" in a maze of cephalometric analysis like Down's, Steiner's, Tweed's, Jarabak's, Ricketts' and so many others.

The proposed "10" measurement analysis for orthognathic surgery will give a "quick" assessment as the points and measurements are also simple to locate, identify and trace. When the measurements are color enhanced by using different color pens and pencils, it can also be easily understood by "Patients" **(Tables 25.12 to 25.14)**.

The cephalometric "norms" are used the established "norms" for both the Caucasian and the Indian races.

The "Indian cephalometric norms" have been published by the "Indian Orthodontic Society" in a ready reckoner form in the year 1990.

Table 25.12: The cephalometric points and planes used in this analysis (Figs 25.23A to D)

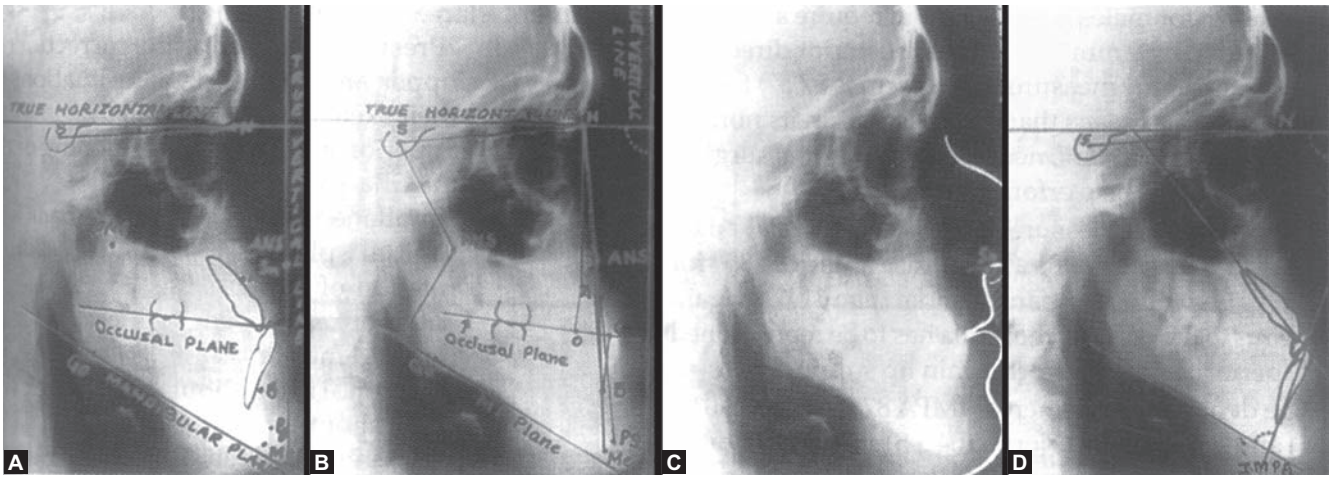
1. Nasion (N)	:	The anterior most point on the nasofrontal suture
2. Anterior nasal spine (ANS)	:	The anterior tip of the sharp bony process of the maxilla near the nasal opening
3. Sella (S)	:	The center of the pituitary fossa
4. Gonion (Go)	:	A point on the curvature of the mandible derived by bisecting the angle formed by the lines joining tangents to the posterior border of the ramus and the lower border of the mandible
5. Menton (Me)	:	The lowest point on the mandibular symphysis
6. Pogonion (Pg)	:	The most anterior point on the mandibular protruberance or the symphysis
7. Posterior nasal spine (PNS)	:	The most posterior projection of the palatine bones
8. Point A (A)	:	The deepest point in the concavity of the maxilla between the ANS and the maxillary alveolar process
9. Point B (B)	:	The deepest point in the concavity of the mandible between the pogonion and the mandibular alveolar process
10. Subnasale (Sn)	:	The point at which the base of the nose (columella) meets the upper-lip tangent
• Mandibular plane (MP)	:	A line drawn tangent to the lower border of the mandible
• Sella-nasion plane (SN plane)	:	It is the plane formed by the line joining the center of the sella with the nasion
• True vertical line (TV line)	:	It is the line drawn and dropped vertically through the nasion
• True horizontal line (TH line)	:	It is the line drawn perpendicular to the true vertical line
• Occlusal plane (OP)	:	A line drawn through the region of the overlapping 'CUSPS' of the premolars and the molars

Table 25.13: The "10" measurement analysis

Skeletal assessment	***Norm (Indian)***	***Norm (Caucasian)***
1. SNA	81.5°	82°
2. SNB	79°	80°
3. ANB	2.5°	2°
4. Posterior face height/Anterior face height (Jarabak ratio)	65%	65%
5. SN/MP	31.3°	32°
6. Wit's	0 mm in females –1 mm in males	0 mm in females –1 mm in males
7. Chin angle	87.5°	87.5°
Soft-tissue assessment		
8. Nasolabial angle	103°	110°
Dental assessment		
9. IMPA and ⊥ to SN	100,108°	95,104°
10. ⊥ to T	122°	131°

Table 25.14: The "10" measurement analysis

Skeletal assessment (Figs 25.23A and B)			
1.	SNA (norm-82°)	:	Will tell us whether the maxilla is protrusive/restrusive and also in a good vertical position
2.	SNB (norm-80°)	:	Will tell us whether the mandible is protrusive/retrusive. A smaller angle (less than 80°) indicates that the mandible is retrusive. A larger angle (more than 80°) indicates that the mandible is protrusive
3.	ANB (norm-2°)	:	Will tell us the maxillary/mandibular discrepancy of the two skeletal bases. A large value (e.g. 8°) will indicate maxillary skeletal protrusion. A small value (e.g. 0°) will indicate mild mandibular prognathism. A large negative value (e.g. –5°) will indicate true mandibular prognathism
4.	Posterior face height/Anterior face height (Jarabak ratio-norm-65%) Norms for vertical N-ANS-40 mm ANS-Me-2 mm S-PNS-32 mm PNS-MP-55 mm	:	The vertical components N-ANS and ANS-Me help to diagnose anterior upper and lower facial height problems respectively. S-PNS and PNS-MP help to diagnose posterior upper and lower facial height problems respectively. Any deviations from the normal values quickly suggest of a vertical maxillary excess (VME) or a vertical maxillary deficiency (VMD). Further the Jarabak ratio obtained by the formula will mean as follows: A ratio between 55% and 65% indicate backward or clockwise rotation of the mandible with a resultant increase in anterior facial height and a skeletal open bite. A ratio between 65% and 80% indicate a forwards or an anticlockwise rotation of the mandible with a resultant increase in posterior facial height and a skeletal deep bite
5.	Anterior face HT SN/MP (norm 31.3°)	:	This angle, if it is more than 32°, confirms a skeletal open bite and if it is less than 32°, confirms a skeletal deep bite, both warranting surgical intervention
6.	Wit's appraisal Norm is –0 mm in females –1 mm in males	:	Perpendiculars are dropped from points A and B on the occlusal plane. The points of contact on the occlusal plane are labeled as AO and BO. In females AO and BO coincide and hence the reading is 0 mm. In males BO is –1 mm ahead of AO. This measurement is more reliable than SNA and SNB. It is a measure of the antero/posterior discrepancy of the maxillary, mandibular skeletal bases. The severity of an antero/posterior jaw discrepancy will get reflected in a huge Wit's reading in a positive or a negative way. Skeletal class II cases may have a reading of +8 mm or more and True Class III cases may have a reading of –12 mm or more.
7.	Chin angle (norm-87.5°)		The angle formed between the nasion-pogonion line (NPg) to the true horizontal line (TH). It is a very reliable measure of chin *prominence or its restrusiveness or deficiency.*
Soft tissue assessment (Fig. 25.23C)			
8.	Nasolabial angle (norm –103 + 5)		The angle formed by a tangent to the columella of the nose (base of the nose) and the upper lip tangent. This angle is a further aid in planning maxillary surgery. Maxilla is to be repositioned posteriorly in case the angle is acute (values of 96° and less) as in class II cases. Maxilla is to be repositioned anteriorly in case the angle is obtuse value of 114° and more as in class III cases. A corrected nasolabial angle within the range of 90°–110° creates a very stable lip support for the patient.
Dental assessment (Fig. 25.23D)			
9.	IMPA and ⊥ to SN IMPA (Norm is 90 + 5) ⊥ to SN (Norm is 104 + 5)	:	IMPA is the angle formed by a line passing through the axis of the lower incisor to the mandibular plane (MP). Values of less than 90° indicate mandibular incisor protrusion. ⊥ to SN is the angle formed by a line passing through the tip of upper incisor to Sella-Nasion plane (SN-plane). Values of 110° and more indicate upper incisor protrusion and values of less than 95° indicate upper incisor retrusion.These dental measurements are brought within normal limits by postsurgical orthodontic finish, which will enhance incisal function and stability.
10.	⊥ to —1 (norm is 131°) (Interincisal angle)	:	This angle is formed by a line passing (interincisal angle) through the incisal edge and apex of the root of the maxillary and mandibular central incisors. If the value is less than 115°, it indicates upper and lower incisor protrusion. If the value is more than 150°, it indicates upper and lower incisor retrusion. A corrected interincisal angle within the normal range will lock the occlusion and add to the stability of a surgically corrected case.



Figs 25.23A to D: The "10" measurement analysis

Natural Head Position (See Fig. 25.18)

The "natural head position" (NHP) has been found to be reliable in both Caucasian and non-Caucasian races. Analysis based on NHP has greater clinical application than the traditional method adopted earlier.

It is proven fact that a NHP cephalogram of a patient with dentofacial deformities will differ by at least one or two degrees from the traditional method of a Frankfort head positioning. Hence for patients needing surgical orthodontic treatment, the difference can be very significant diagnostically.

A natural head position cephalogram is taken with the patient looking straight ahead in a mirror. The head should be in its natural position and the patient should be relaxed. The ear-rods and the orbital pointer are then "lightly contacted" to the skin, this secures the patient in the NHP. Check that the patient's pupil is in the middle of the eye and that he/she is looking straight ahead in the mirror with his/her teeth in occlusion and lips in repose.

The "X-ray" is then taken. The entire procedure should not take more than 5 minutes.

Case Evaluation (Table 25.15)

The following "case evaluation" demonstrates the thinking process used with "10" measurements to evaluate an orthognathic problem.

A 30-year-old Indian male patient came for a consultation with the chief complaint of a "protrusive lower jaw" and that his teeth and jaws bite in "reverse way" as compared with his family members:

- A lateral cephalogram was taken in the natural head position.
- According to the "10" measurement cephalometric analysis and considering Indian cephalometric norms, the following data was obtained.
- Maxillary/mandibular antero/posterior skeletal relationship as indicated by the angle ANB is –5°. This being a negative value on the higher side confirm a true mandibular prognathism, requiring surgical correction.
- The second skeletal measurement N-ANS is 55 mm (norm is 40 mm) indicates an excessive anterior upper facial height.
- ANS-Me is 68 mm (Norm is 62 mm) also points out that there is an increased anterior lower facial height. The total anterior facial height (N-ANS + ANS–Me) is 123 (norm is 102 ± 5) shows that the total anterior facial height is also excessive.
- The posterior facial height components S-PNS is 55 mm (norm is 32 ± 5 mm) and PNS-MP is 33 mm (norm is 55 mm) reveals that total posterior facial height is within its normal range (of 87 mm) after adding up S-PNS ± PNS-MP, i.e. 55 mm + 33 mm = 88 mm. Here the posterior lower facial height could be increased and the posterior upper height decreased in balance by a surgical procedure of LeFort I osteotomy carried out together with a mandibular push-back and clockwise rotation of the mandible.
- The ratio (Jarabak) posterior face –Ht/anterior face-Ht works out to be 71.5% signifying that the mandible has rotated anticlockwise with a resultant deep bite. This is again provided by the angle SN/MP which for the patient is 28°, implying a skeletal deep bite needing surgical intervention.

Table 25.15: Case evaluation

Cephalometric measurements	*Norms*	*Patients values*	*Conclusion*	*Interpretations*
1. SNA	81.5°	88°		
2. SNB	79°	93°	Maxillary and mandibular	
3. ANB (SNA-SNB)	2.5°	–5°	Skeletal relationship in A/P plane is a large negative value than the norm	Confirms true mandibular prognathism
4. ANT, facial Ht			excessive ANT. Upper facial Ht (AUFH)	Superior and forwards positioning of the maxilla by 10 mm is necessary along with autorotation and push-back of the mandible to balance the profile
N-ANS	40 mm	55 mm		
ANS-Me	62 mm	68 mm	Excessive ANT. Lower facial Ht (ALFH)	
Total ANT. facial Ht (N-ANS + ANS—Me)	102 ± 5 mm	123 mm	Total ANT. Facial Ht is excessive	
Postfacial Ht			Excessive postupper facial Ht (PUFH)	
S-PNS	32 ± 5 mm	55 mm	Postlower facial Ht (PLFH) is reduced	
PNS-MP	55 mm	33 mm		
Total post-facial Ht (S-PNS + PNS—MP)	87 ± 5	88 mm	The total postfacial Ht is within normal range	
Jarabak ratio	65%	71.5%	A forwards or anticlockwise rotation of the mandible	Autorotation of the mandible is indicated
5. SN/MP	31.3°	28°	A skeletal deep bite	Surgical correction of the deep bite is warranted
6. Wit's appraisal in male	–1 m	–10 m	Reflects severity of mandibular prognathism	Confirms true mandibular prognathism which requires surgical push-back by 9 mm
7. Chin angle	87.5°	88.5°	The chin or the bony protuberance is within normal limits	No additional genioplasty procedures are indicated
8. Nasolabial angle	110 ± 5	135°	Maxilla will have to be repositioned anteriorly	Maxillary superior and forwards repositioning is necessary to gain better lip support
9. IMPA, ⊥ to SN	90°, 104°	87°, 124°	The lower incisors are retrusive while the upper incisors are protrusive	Needs presurgical orthodontics to bring them within the range of 90° and 110°
10. T to ⊥	131°	123°	Indicates maxillary/mandibular incisor procumbency	Needs presurgical orthodontics to get an interincisal angle of 131°

- The Wit's reading of –10 mm for the patient reflects the severity of the anteroposterior jaw discrepancy pointing to the fact that since the patient is a male and the norm for males is –1 mm, he will require a surgical correction by 9 mm in the anteroposterior direction.
- The chin angle measures 88.5° (Norm is 87.5°) for the patient. This means that the chin is within its normal skeletal limit with no need for any additional surgical procedures to be performed on the chin.
- The soft-tissue measurement of the nasolabial angle (Norm is 110°) reveals a high obtuse angle of 135° for the patient. Since this angle is more than 114°, it again points to the fact that the maxilla has to be repositioned superiorly and anteriorly to gain lip support.
- The dental measurements of IMPA 87° (norm is 90° ± 5) and ⊥ to SN 124° (Norm is 104 ± 5) shows that lower and upper incisors need to be corrected orthodontically to the normal range of IMPA of 95° and ⊥ to SN of 104 ± 5.
- The interincisal angle of 123° for the patient (norm is 131°) also needs orthodontic correction to get a postsurgical, good interdigitated and a stable occlusion, to minimize the chances of a "relapse".

FINAL TREATMENT PLAN

Phase I : Presurgical orthodontic correction of upper and lower incisor inclinations to their skeletal bases.

Phase II : Superior and forwards repositioning of the maxilla by a LeFort I osteotomy with simultaneous mandibular push-back by a sagittal split osteotomy and clockwise rotation of the mandible. The maxillary superior repositioning will be by 8–10 mm and maxillary anterior repositioning by 4 mm. The mandibular push back will be by about 5 mm.

Phase III : Postsurgical orthodontic detailing of the occlusion followed by retention.

CONCLUSION

This analysis, hence, has a potential to assess and diagnose orthognathic problems when combined with good clinical judgment to strengthen the surgeon's first impressions on clinical examination.

Traditional orthognathic surgical planning-as mentioned above is carried out to develop a blue print of the existing relationship of maxilla to mandible and associated dentofacial skeletal dysplasia. The entire process is time consuming, laborious plus there is also a possibility/risk of incorporating error at every step, as it is manually done. It uses 2D data, which has limited understanding of 3D deformity. It also amounts to large documentation space occupied by the data collection material. However, it has stood the test of time. **Table 25.16** throws light on the entire traditional process.

RECENT ADVANCES

Virtual Surgical Planning

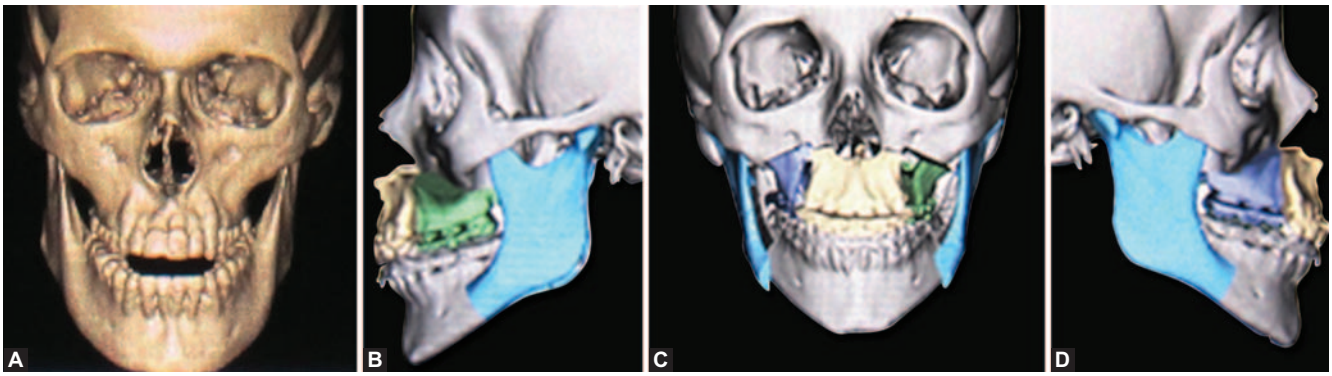
Three-dimensional planning in orthognathic surgery, using cone beam computed tomography (CBCT) and computer software. This new method is also known as virtual surgical planning (VSP).

Table 25.16: Traditional orthognathic surgical planning

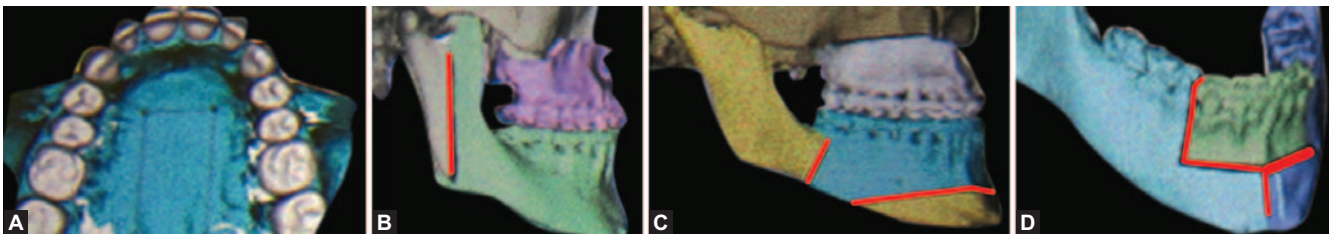
1. Detailed preoperative quantitative clinical analysis
2. Standard facial photography
3. Radiographic/cephalometric tracing/analysis
4. Dental cast preparations
5. Articulator mounted models/face bow transfers
6. Model/mock surgery-explained in next chapter
7. Construction/fabrication of occlusal intermediate splint/final splint-also see the information in next chapter

Technological advances and the advent of CBCT have revolutionized the entire planning process of orthognathic surgeries. The advantage is taken of a virtual computer environment to make the treatment plan by visualizing the craniofacial complex anatomy in 3D. This technique of 3D imaging and VSP have gained tremendous foothold in orthognathic surgical planning with simplified VSP rapidly replacing traditional planning and model surgery in many parts of the country and the world. Different 3D modalities and user-friendly software have become popular as it can provide 3D DICOM format (Digital Imaging and Communication in Medicine) data of the entire craniofacial complex. It is a new tool that animates the patient's skeletal and facial changes in real time and outputs a precise surgical guide. Requirements—3D DICOM dataset, vitual models and optional facial photos, combined with intraoral scan or electronic models for accurate virtual model surgery.

- *Acquisition of a 3D digital copy of the patient:* A 3D stereophotogrammetrical camera is used to capture a 3D photographs of the face. Image fusion, i.e. registration of a 3D photographs upon CBCT results in an accurate and photorealistic digital 3D dataset of a patient`s face with relatively low radiation dose. Data from CBCT is then exported in DICOM format of the skeletal and dental structures registered with photorealistic textured skin surface. Soft and hard tissue of the face can be computed in the natural head position, which is important for the analysis and simulation of planned virtual surgery **(Fig. 25.24A)**.
- *Computer aided 3D planning software:* There are several commercially available software programs in the market. Dolphin imaging, USA is one of the most used program by orthodontists and surgeons worldwide. By using specific software, the analysis of the entire dataset with precise measurements can be done easily. The images can be enhanced, segmented to assist landmark location with minimum error. Proper preoperative evaluation of the deformity in all three dimensions can be done by plotting the anatomical landmarks on 3D skull models and 3D cephalometric analysis can be done for accurate diagnosis. Diagnosis thus made can be shared with the patient, team members and residents. Detailed measurements of the teeth and the anatomic relation of vital structures can also be obtained using measurement tools found in these software.
- *Virtual surgery:* It Can be performed on 3D virtual models. Simply one has to follow step-by-step



Figs 25.24A to D: Virtual surgical planning (VSP). (A) Virtual 3D image of a patient with vertical maxillary excess (VME) and anterior open bite and mandibular prognathism; (B to D) VSP for the same patient— three segments LeForte Osteotomy with Bilateral Sagittal Split Osteotomy (BSSO) is planned. Images show final surgical outcome (Images by Dolphin Software).



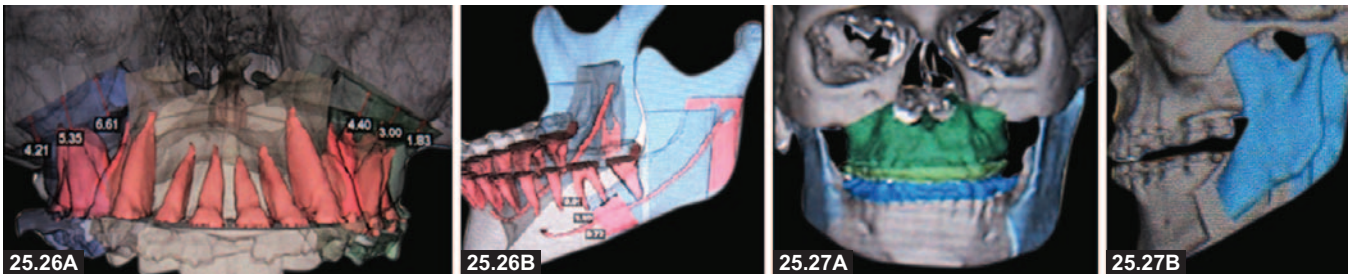
Figs 25.25A to D: Various osteotomy procedures can be virtually planned by VSP software. (A) Three-piece osteotomy of maxilla being planned; (B) Vertical subsigmoid osteotomy on VSP; (C) LeFort I with BSSO on VSP along with genioplasty; (D) Anterior mandibular subapical osteotomy procedure on VSP

segmentation wizard to create the proper virtual surgery. The desired movements of different bony segments/osteotomies and possible bony obstructions/overlaps can be visualized, along with vital structures relationship. Different surgical plans can be studied and optimum procedure can be chosen with improved surgical outcome. Simulation of final proposed surgery can be discussed at length by using presentation tool. Animated sequences of pre-/postoperative configurations in all three dimensions can be stored **(Figs 25.24 and 25.25)**.

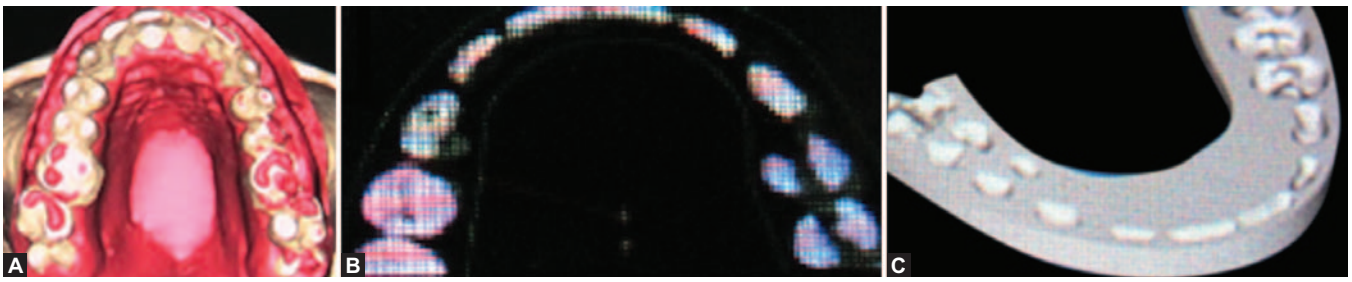
The software is able to identify areas of bony overlap and interferences and it can present numeri-cal values in millimeter to such overlaps to guide surgical reduction/bone cuts/bone removal intraoperatively **(Figs 25.26A and B)**. The preoperative evaluation about rotation and translation in 3D planes helps to minimize potential surgical risks and complications and surgical surprises. Therefore, it reduces total surgical time. Software also provides more precise vision of how the condyle will rotate, when the mandibular osteotomy segment is mobilized. The condyle-fossa relationship in centric stable relationship is very important throughout planning process **(Figs 25.27A and B)**. Software allows modification of the position of the jaw bones, also improves surgical outcome by predicting modification in airway, hard and soft tissues. Because of all these possibilities, precise planning of more complex surgeries can be carried out in a single procedure, rather than previous multiple staged procedures.

- *Soft tissue simulation:* As the soft tissue changes are directly related to hard tissue changes, precise measurements of both can be achieved. Prediction of both soft/hard tissue changes can be readily done, which is clinically helpful for communication purpose. Predictive images of virtual surgeries can be compared with postoperative actual surgery images for research purpose.
- *Three-dimensional splint fabrication with CAD/CAM (Computer-assisted designing and manufacturing) software program—(3D Printer)*

Customized 3D stereolithographic occlusal splint fabrication, which is vital in orthognathic surgery for intraoperative positioning of the jaws/jaw segments. This has replaced traditional time consuming, tedious mock surgery and splint making into the lab.



Figs 25.26A and B: Bony overlaps in repositioning osteotomized segments can be measured in mms. Helps in precise bony cuts. (A) Maxillary movement with bony overlap measurements in VSP; (B) VSP mandibular movements with bony overlap in mms **Figs 25.27A and B:** (A) Proposed VSP LeFort I osteotomy with BSSO for mandibular a-dvancement; (B) VSP final position of the ramal segments and their rotation keeping the condyles in centric condyle-fossa relationship



Figs 25.28A to C: Virtual surgical planning (VSP) dental arch reconstruction and interdental wafer designer with intermediate splint preview

It generates accurate splints in a fraction of the time **(Figs 25.28A to C)**.

Advantages of VSP

- Valuable aid for the construction of high precision 3D surface models/dynamic cephalometry and for diagnosis of skeletal discrepancy and evaluation of growth response and long-term stability.
- Greater predictability and precision in virtual surgical planning, especially useful in patients with complex dentofacial deformity.
- Simplification for choosing optimum treatment plan.
- It allows semiautomatic mirroring in case of facial asymmetry.
- Presurgical prediction of proposed jaw movements, along with interactive cutting of bone, bony segment repositioning is possible.
- Visualization and prediction of soft/hard tissue changes. Motivational tool.
- Predicts the possibility in achieving balance between functions and esthetics.
- Useful module for surgery training for residents is possible.
- Can be stored online-space saver.
- Can be viewed in different locations.
- Can be used for assessment of intraoperative difficulties.
- Accurate CAD/CAM generated splints can be obtained easily.

Points to Remember

- Types of severe skeletal dentofacial deformities and associated problems
- Treatment options
- Facial esthetic analysis
- A "quick ceph" dentofacial planner for orthognathic surgery
- Final treatment plan
- Latest trends in orthognathic treatment planning.

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CHAPTER 26

Presurgical Orthodontic Phase

INTRODUCTION

Severe dentofacial skeletal deformity has been described by Proffit and White as "severe problems of jaw function and facial esthetics that require combined orthodontics and surgical treatment." So, the main objective of orthognathic surgery is to achieve a harmonious occlusion and facial appearance by normalizing the position of the teeth as well as the jaw bones.

Normally, orthodontic camouflage technique is used for a nongrowing patient with dentofacial deformities. Here, the malocclusion is corrected by conventional orthodontics to position the teeth in the correct relationship to their respective bases of the upper and lower jaws and coordinating the relationship of the upper dental arch to lower dental arch and thus, camouflaging the skeletal discrepancy.

In combined surgical orthodontics treatment plan, the orthodontic treatment should be aimed at creating a temporary or intermediate malocclusion after removing the nature's dental compensations. *This amounts to relocating the dentition to their respective skeletal bases and unmasking the nature's dental compensations. This will result in worsening the malocclusion temporarily, so that the exact nature of dentofacial skeletal deformity is highlighted.* This will definitely help the surgeon to carry out various osteotomy procedures on the jaw bones with maximum set back or advancement. The results of this fully revealing or maximizing the skeletal deformity and then subjecting it to surgery, will be definitely much stable and esthetically pleasing.

Careful presurgical planning is prerequisite to assure predictable results: 30 years back, most of the orthodontists used to complete all orthodontic teeth movements before surgery. In combined surgical orthodontic treatment planning, it is a waste of time and undesirable:

- Unplanned orthodontic treatment for severe skeletal problems results into unsuccessful functional or esthetic results
- Referral for surgery thereafter, ends in compromised results
- Only desired presurgical orthodontic preparation prior to surgery should be undertaken
- Extensive presurgical conventional orthodontics is unnecessary and contraindicated
- Orthodontics should be planned to coordinate with specific surgical procedures. This practice (a) minimizes total treatment time, and (b) prevents relapse
- Inadequate presurgical orthodontics jeopardizes the quality of postsurgical results.

The mechanotherapy and treatment objectives are the opposite of normal orthodontic treatment plan in presurgical orthodontics **(Reversed orthodontics)**.

In orthognathic cases, the "old cook book" plan of orthodontics is inappropriate.

- Treatment objectives
- Extraction patterns
- Type of mechanics

} Reverse than the conventional orthodontics

Deliberately worsen the occlusion: This enables the surgeon to achieve perfect occlusion and precise jaw positioning. Inappropriate presurgical orthodontics will lead to following problems:

- The skeletal dento-osseous segments cannot be placed in a satisfactory relationship, because of gross occlusal interferences or gross malposition of the teeth in respect to their supporting bone.
- Postsurgical orthodontic mechanics could accentuate relapse tendencies.
- Projected osteotomy cuts would be impossible, because of the proximity to the roots of the adjacent teeth.

The sequence of the entire treatment can be divided into following three distinct phases, each with specific objectives, that need to be met for the optimal attainment of the next stage:

Three phases of combined surgical orthodontics:
1. Presurgical orthodontics
2. Surgery
3. Postsurgical orthodontic detailing.

Meticulous Presurgical Orthodontics

- Lessens the total treatment time
- Controls the relapse tendencies
- Removes the gross occlusal interferences
- Positions the teeth in an ideal relationship to their respective dental bases
- The dental restrictions imposed for the surgical correction of the jaw discrepancy are eliminated
- Allows maximum surgical correction
- Allows proper intraoperative interdigitation
- Significantly reduces operating time and surgical morbidity
- Allows quick and easy postsurgical efficient orthodontic detailing.
- The goal, therefore, is to locate the teeth in an optimal and decompensated position, so that the surgical correction is not hindered by the dentoalveolar component and an optimal skeletal and occlusal change can be produced.

PRESURGICAL ORTHODONTICS OBJECTIVES

Treat upper and lower dental arches separately/independently. Align the teeth, with inclination and angulation correction:
- To relieve arch crowding (correct the arch length deficiency)
- To close the spaces (eliminate tooth size discrepancies)
- To correct derotations
- To eliminate gross dental interferences.

Presurgical Intra-arch Objectives

- Alignment of the incisors in "ideal" position
- Establishment of correct torque
- Removal of dental compensations
- Increase the severity of vertical and/or horizontal aspects of malocclusion
- Establishment of desired anteroposterior (AP) and vertical position of the incisors
- Achievement of arch compatibility on models
- Establishment of class I canine and molar relationships on models
- Create space for segmental osteotomy by root paralleling.

Time Estimation

1. Presurgical orthodontics—3 to 12 months, (varies with the difficulty in alignment)
2. Surgery—3–8 days hospitalization
3. Under surgeon's care—3–8 weeks
4. Postsurgical orthodontics—3–6 months (over 6 months due to inadequate preparation).

As orthognathic surgery brings about three-dimensional change/improvement, whenever combined surgical orthodontics is planned, the deformity should be considered in three planes of space. Hence, presurgical orthodontic treatment plan also should be drawn keeping all three planes in the mind.

Presurgical Orthodontic Objectives for Anteroposterior—Sagittal Plane (AP)

Removal of dental compensations or decompensation phase.

Transverse Plane

- Differentiation of skeletal from dental problems
- Identification of relative and absolute discrepancies
- Achieve reasonable arch compatibility on the models
- If not, plan for segmental osteotomy procedures.

Vertical Plane

- Maximizing presurgical orthodontics in open bite cases
- Minimizing the presurgical mechanics in deep bite cases.

  This is essential for the following:
  1. Avoidance of adverse dental relapse potential
  2. Maximizing the speed and efficiency of the treatment.

Presurgical Orthodontics—Relieve Crowding

Presurgical orthodontics for relieving arch crowding
- If arch length deficiency is greater than 6 mm, then carry out extractions of teeth
- First premolar extraction gives 7 mm of space

Table 26.1: Presurgical arch wires used for alignment

Wire size	*Use*
• .008″, .009″, .010″ • supreme grade • Australian Wilcock wires	• Excellent properties for alignment without fabrication of loops
• .012″, .014″, .016″ • Australian Wilcock wires of premium + grade	• Ideal for correction of rotations, alignment, and leveling when used in loop form (traps food)
• Coaxial wires in sizes of 016″, .018″, .0175″, .0195″	• Good properties for correction of rotations and alignment of crowded anteriors at a low cost
• Nickel titanium wires • –.014″, .016″, .018″ .016″ × .016″, .017″ ×.025″, .016″ × .022″	• Outstanding initial wire for leveling and unraveling crowding gently. Costly wires

- Whenever the basal bone limit permits, relieve the crowding by multiloop wires, either 014 or 016 Australian Wilcock premium + grade wire [4–5 mm space gain **(Table 26.1)**]
- Additional 3 mm space can be gained by interproximal stripping of 0.25 mm from the mesial and distal surfaces of six anterior teeth.

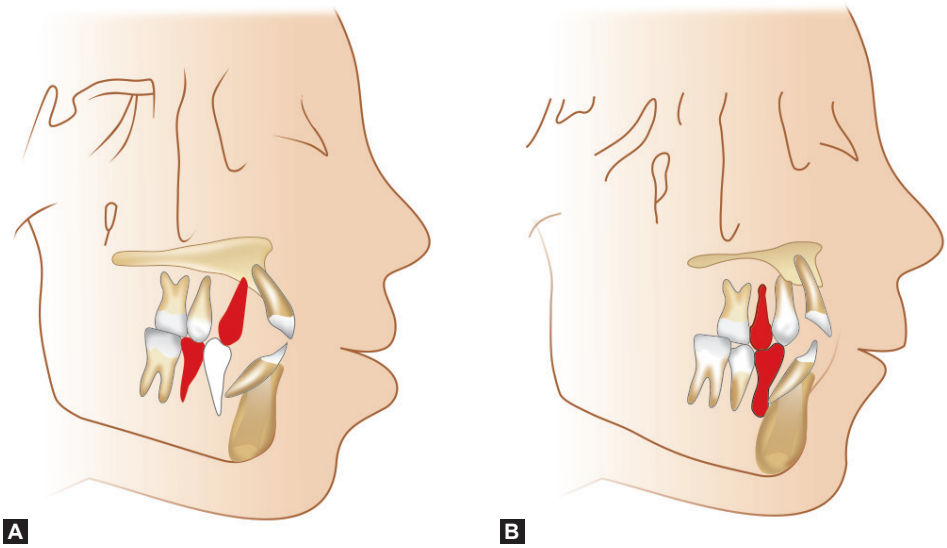
Extraction Pattern for Presurgical Orthodontics

There is definite difference in extraction patterns chosen for conventional camouflage orthodontics and presurgical orthodontics.

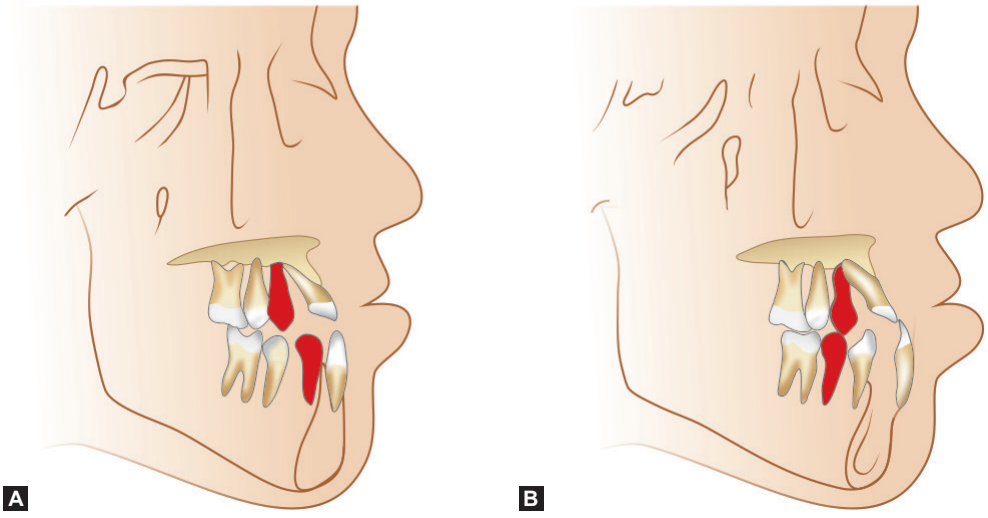
For skeletal class II malocclusion **(Figs 26.1A and B)**, no maxillary tooth extraction or extraction of upper second premolar should be done (this is to prevent over retraction of the maxillary anterior teeth which would compromise the mandibular advancement) and lower first premolar extraction should be planned to allow leveling of the arch and to correct the lower anterior proclination.

In skeletal class III malocclusion, the extraction pattern chosen will be reverse. In these cases extract upper first and lower second premolars **(Figs 26.2A and B)**.

Extraction of upper first premolar in these cases is done to correct the proclination of the upper anteriors. If the space is needed in the lower arch, then second premolar extraction is done to prevent over retraction of the lower anteriors.



Figs 26.1A and B: Extraction pattern for class II malocclusion (A) For routine orthodontics; (B) For surgical orthodontics. No maxillary extraction is done, or upper second premolar extraction is done



Figs 26.2A and B: Extraction pattern for class III malocclusion (A) For routine orthodontics; (B) For surgical orthodontics. Extraction of upper first and lower second premolars is carried out

Selection of Orthodontic Appliance

Fixed Orthodontic Appliance System

Fixed orthodontic appliance system is chosen. This appliance is used not only to move the teeth, but also to stabilize them against the stresses encountered at surgery and during maxillomandibular fixation.

Modern preadjusted edgewise .022" slot appliance with its myriad of variations can be used. In this appliance, round or rectangular wire is tied into a bracket slot. It is well-adapted for tooth movement as well as for stabilization of teeth.

Conventional Begg appliance is not suitable for stabilization. Clear or tooth-colored plastic brackets or ceramic brackets are not suitable for surgical orthodontics. They are susceptible for breakage and tend to discolor. Bracket placement on the teeth is typical for the usual orthodontic patient, except in the area of a planned osteotomy site, it is advisable to tip the brackets on two adjacent teeth, so that a straight wire will cause root divergence during the presurgical orthodontic phase or to use arch wire bends to produce the desired tooth movements. Sometimes to make the roots divergent at osteotomy site, the right and left canine and premolar brackets are deliberately switched during presurgical treatment phase, it is recommended that all the molars be banded.

Integral hooks—built in hooks in the bracket of molar teeth can be helpful, (or crimpable hooks on the wires) for surgical stabilization and postsurgical finishing, for intra-arch elastic attachments.

Anteroposterior-Sagittal Plane Presurgical Orthodontic Objectives

To remove nature's compensation by correcting the axial inclination of the incisors (achieve ideal axial relationship) **(Figs 26.3A and B)**.

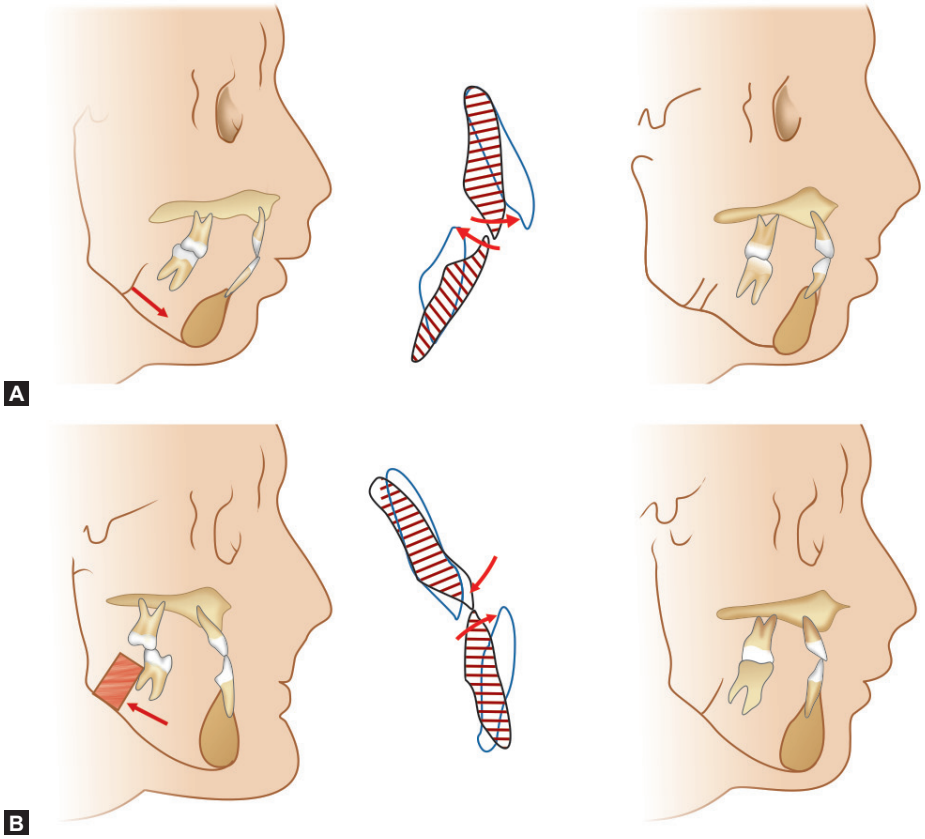
In skeletal class II malocclusion, the maxillary teeth are often retroclined and the mandibular incisors are proclined to compensate for the skeletal discrepancy and to reduce the incisor overjet and to have functional occlusion (nature's compensation).

In these cases, orthodontic decompensation is achieved by uprighting the proclined mandibular incisors and proclining of the maxillary incisors and thereby increasing the amount of overjet to maximum. This will allow surgeon to carry out maximum mandibular advancement **(Fig. 26.4)**.

In skeletal class III malocclusion, the maxillary incisors are often proclined and the mandibular incisors retroclined to minimize the reverse overjet of the incisors and to have functional occlusion (nature's compensation).

In these cases, orthodontic decompensation is achieved by making the maxillary and mandibular incisors upright on their respective dental bases and thereby increasing the reverse overjet to maximum. This will allow the surgeon to achieve maximum set back of the mandible with stable occlusion and pleasing esthetics **(Fig. 26.3B)**.

The ultimate goal in AP plane, orthodontic decompensation is to produce sufficient overjet/reverse



Figs 26.3A and B: Anteroposterior plane presurgical orthodontic objectives. Orthodontic presurgical decompensation to alter the existing overjet. (A) Class II case; (B) Class III case

overjet to allow for the establishment of class I canine relationship on model prior to surgery as well as in the patient intraoperatively. An ideal incisor overjet/overbite produces better chin-lip balance (use of class III elastics in class II patients to upright or retract the mandibular incisors and help to procline the maxillary incisors or left in their original position. Reverse is done in class III cases with class II elastics).

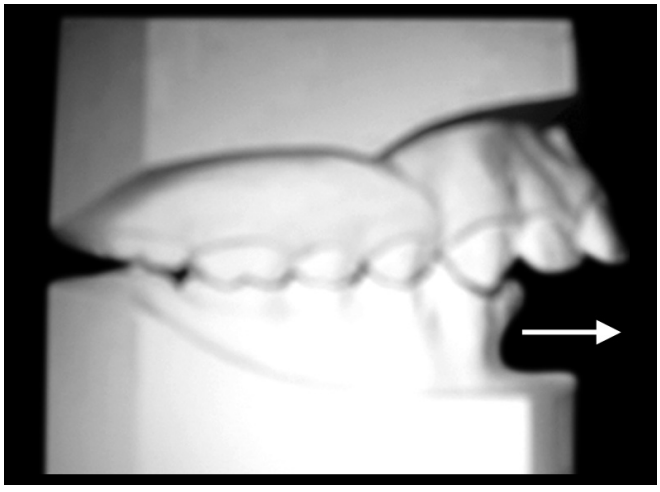
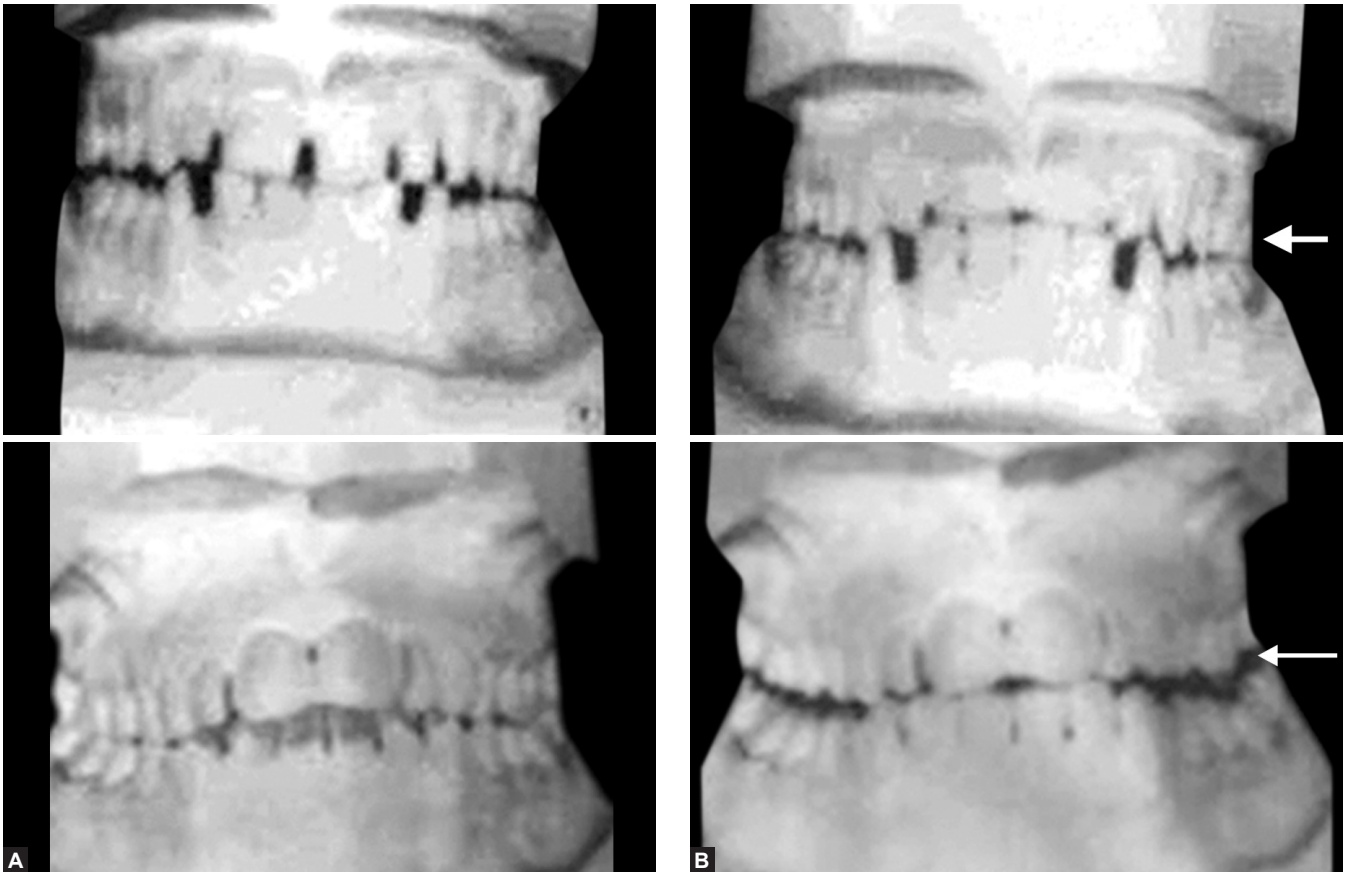


Fig. 26.4: Increasing overjet in class II cases prior to surgery

Presurgical Orthodontics Objectives for Transverse Plane

The dentofacial deformities in this plane have commonly defects in the arch width, usually of the maxilla, i.e. posterior cross bites—unilateral or bilateral. They are often combined with AP and vertical problems and also can be associated with deviation of the mandible in centric occlusion.

Transverse plane discrepancies are usually treated either by buccal tipping or bodily movement of posterior teeth. In surgical orthodontics, it is important to know—(1) whether the problem is skeletal or dental, and (2) whether the problem is relative or absolute.



Figs 26.5A and B: (A) Relative transverse discrepancy; (B) Absolute transverse discrepancy

This is determined by taking upper and lower impressions and making study cast **(Figs 26.5A and B)**. The hand-held models are brought into class I canine occlusion to know whether the problem is relative or absolute. A relative problem can be tackled by presurgical orthodontics, but absolute skeletal problem should be solved by planning segmental osteotomies of the maxilla to correct the arch width and arch form. As a rule, orthodontic expansion should be limited to 2–3 mm per side (4–6 mm total), i.e. not more than half-cusp crossbite. Excessive buccal tipping will cause elongation of lingual cusp, which will interfere with the postoperative result, plus there will be great relapse tendency.

In an isolated skeletal transverse discrepancy, where no other maxillary surgery is anticipated, surgically assisted rapid palatal expansion is a procedure of choice. Where a skeletal maxillary discrepancy is combined with other maxillary problems, multiple segment maxillary osteotomies are indicated (surgical movement of 5–8 mm laterally is possible). Cases with minor dental discrepancies are dealt as routinely. Many times orthodontic minor expansion can be done in the postoperative orthodontic phase, as there will be no more occlusal interferences present.

Presurgical Orthodontics for Vertical Plane

Vertical maxillary excess (VME) or vertical maxillary deficiency (VMD), i.e. long face and short face cases demand consideration for presurgical orthodontics in vertical plane.

VME with anterior open bite will exhibit typical step behind maxillary canine (a rainbow curve). The level of anterior teeth occlusal plane will be higher than the posterior teeth occlusal plane in the maxilla **(Fig. 26.6)**.

- No attempt should be done to close the anterior open bite presurgically
- Avoid intrusive mechanics in the posterior teeth and concurrently avoid any extrusive mechanics in the anterior region (potential adverse relapse tendencies)



Fig. 26.6: White lines showing anterior and posterior occlusal plane discrepancy in anterior open bite cases. Each segment should be leveled separately by presurgical orthodontics

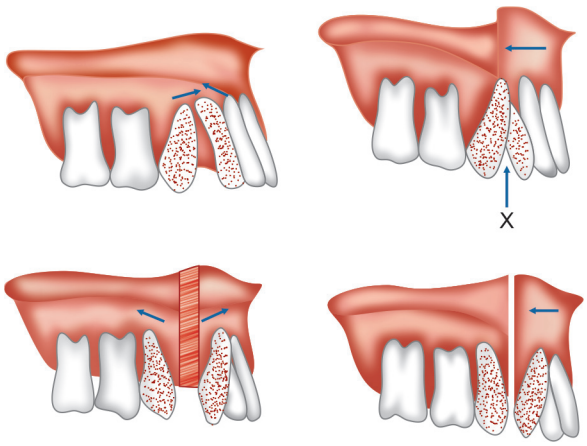


Fig. 26.7: Root paralleling in presurgical orthodontic phase to create a space for segmental osteotomy

- Severe accentuated or reversed curve of Spee should be treated with segmental orthodontics
- Only dental alignment should be carried out separately in the anterior segment and two posterior segments (level each segment separately).

Skeletal open bites are best treated by segmental maxillary osteotomies, which allow differential vertical movement of anterior and posterior segments. VME without anterior open bite will exhibit nature's dental compensation, i.e. overerupted extruded anterior teeth. In these cases presurgical decompensation with alignment as well as orthodontic intrusion of the anterior teeth will be needed.

Skeletal Deep Anterior Overbite Pattern

Skeletal deep anterior overbite pattern will have three types:

1. Short face
2. Average face
3. Long face.

In short face or VMD with skeletal deep anterior overbite, there is a need to increase the lower facial height for better esthetic results. No leveling of curve of Spee in the mandibular arch should be done presurgically. Level only the maxillary arch. After surgical advancement of mandible is carried out, lateral open bites will be created in the posterior region. This can be corrected in postsurgical orthodontic phase by tripoding and extrusion of posterior teeth.

In average face and long face with skeletal deep anterior overbite, to prevent increase in the lower facial height, the curve of Spee is leveled by intrusion of anterior teeth prior to surgery.

Root Positioning and Retaining Extraction Spaces

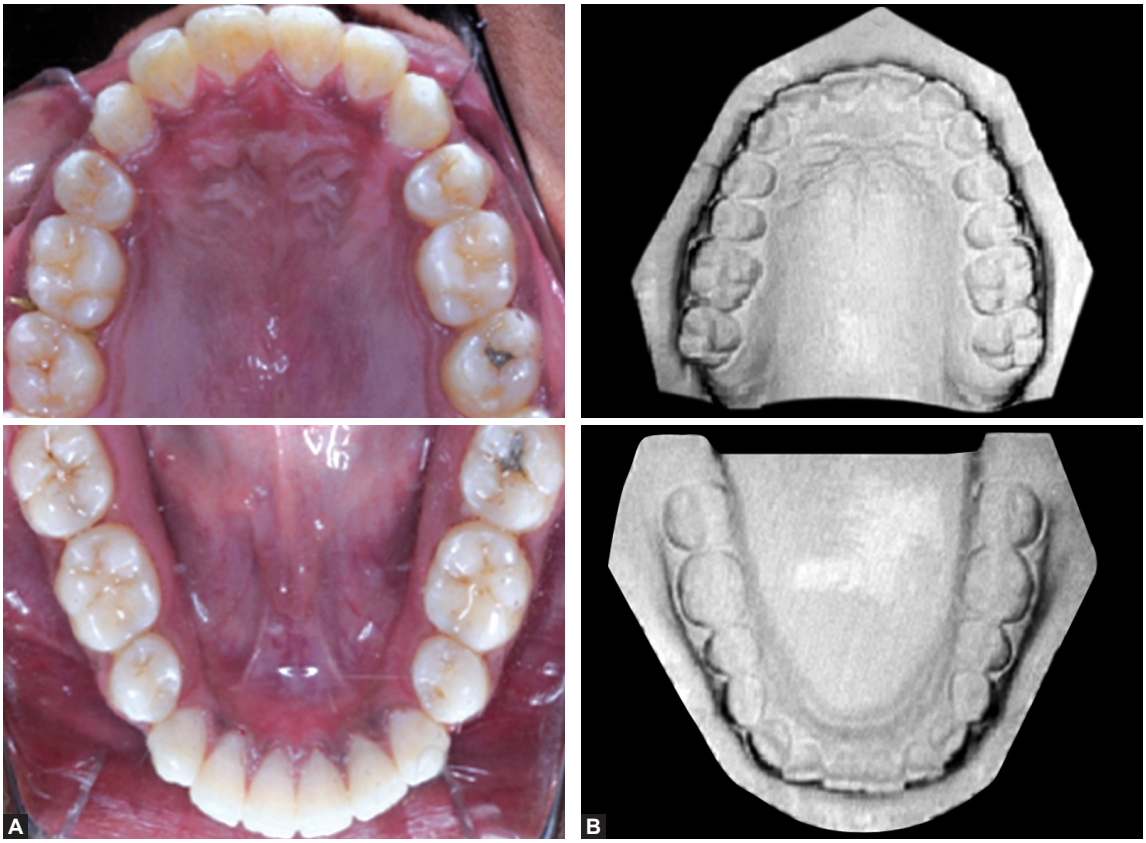
Whenever premolar extractions are carried out for relieving the crowding, the total extraction space should not be utilized. At least 3–4 mm space should be left for making the segmental osteotomy cuts, without jeopardizing the periodontal status of the adjacent teeth. Judicious interproximal stripping can be carried out wherever possible, so that the entire premolar space can be utilized for set back of the anterior segment.

Periapical X-rays of the planned osteotomy region should be taken and if roots are convergent, they are made divergent. The equal amount of space should be created between the crowns as well as roots of the teeth adjacent to the osteotomy sites **(Fig. 26.7)**.

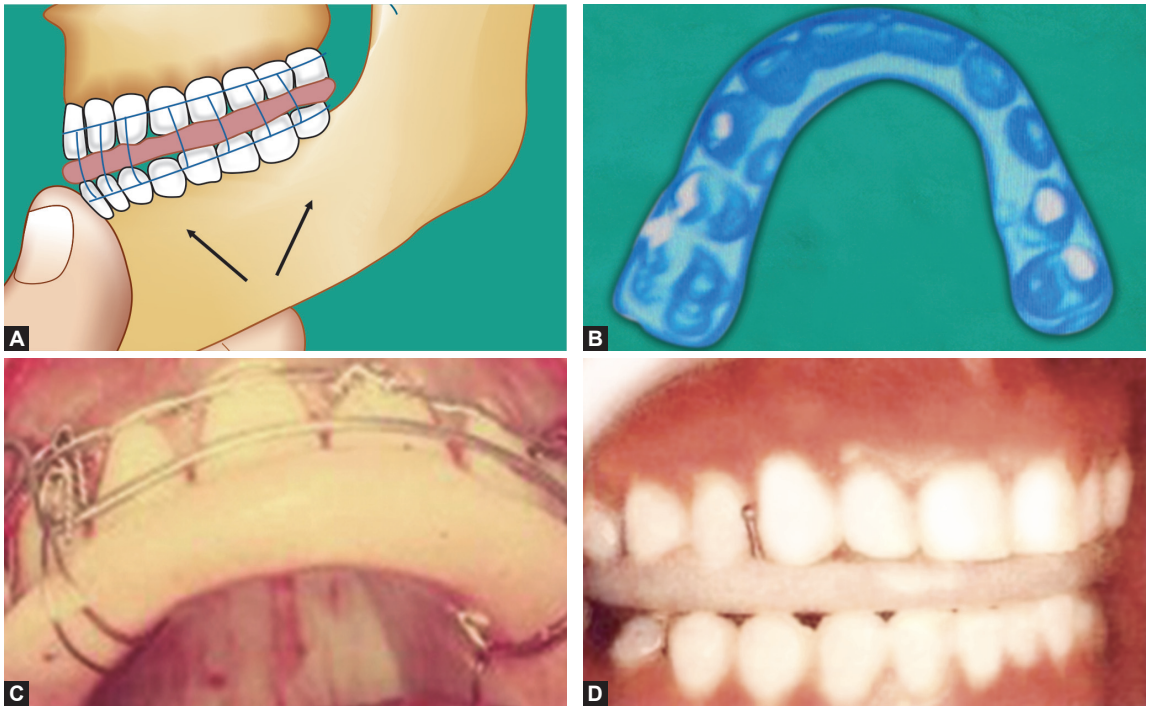
Completion of Presurgical Orthodontic Phase

Fresh records should be taken at the completion of presurgical orthodontic phase. The models should be duplicated. One set is kept for the record and another one handed over to the surgeon for mock surgery or model surgery and preparation of the occlusal wafer splint.

Impressions for models should be taken before fixing the stabilizing arch wire. Interocclusal wafer splints should not be more than 2–3 mm thick. (Prior to splint making, the models should be checked whether class I canine and molar relationship can be achieved postsurgically) **(Figs 26.8 and 26.9)**.



Figs 26.8A and B: (A) Presurgical orthodontic phase complete and study models should be prepared to check the new interarch relation (B) Models prepared at the end of presurgical orthodontic phase



Figs 26.9A to D: Interocclusal wafer splints

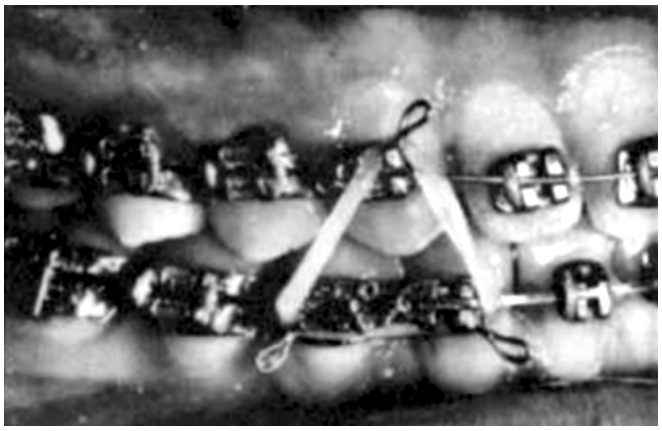


Fig. 26.10: Multiple lugs are helpful in postoperative period for intermaxillary elastic ligation

Before handing over the patient to the oral and maxillofacial surgeon, a stabilizing passive rectangular wire with multiple lugs soldered or incorporated onto the arch wire (a lug between every two teeth). These should be placed at least 3 weeks prior to surgery. This will ensure that no further teeth movement will occur and occlusal splint fit will not change at the time of surgery **(Fig. 26.10)**.

POSTSURGICAL ORTHODONTICS OBJECTIVES

After surgery, 4–6 weeks rest is advised for the patient to allow healing and consolidation of osteotomy sites. After the surgeon confirms the satisfactory healing, the interocclusal splint and stabilizing arch wires are removed and replaced by light arch wires to allow the settling of the occlusion. A box or rectangular patterns of light interdental elastics are used including the canines and premolars for desired interdigitation. In deep bite cases where lateral open bites are created, vertical elastic traction should be given in posterior molar region.

Objectives

- Closure of all residual spaces
- Root paralleling at the extraction sites
- Correcting the incisor torque
- Correction of residual deep or open bite (extrusion for leveling and settling)
- Finer tooth alignment
- Maximum interdigitation (detailing of occlusion)
- Retention phase to readapt and reorient oral musculature to prevent relapse.

Model Surgery (Mock Surgery)

All these years, the oral and maxillofacial surgeons used to "eyeball" the deformity and decide the surgical plan after model sectioning and aligning them. Now, the total treatment plan is made after using sophisticated tools like cephalometric analysis, photoanalysis, prediction tracings, computer assisted analysis, etc. But, with the present state of the art of the orthognathic procedures, model or mock surgery still holds important key position in the treatment planning and the occlusal wafer splints which are constructed after final mock-up, are still being used as an intraoperative navigator (guide). Cephalometric prediction tracings cannot reproduce three-dimensional view of the patient's dental arch status. Hence, tridimensional models are always helpful for the treatment planning.

Aims of Model Surgery

- To locate the problem areas preoperatively
- To determine the feasible surgical plan
- To determine the direction of movement of dento-osseous segments
- To view the osteotomy sites directly
- To obtain the measurements of osteotomies
- To reduce the operating time
- To improve the accuracy of overall results.

Hand Articulation

- The plaster models should be held manually, in the hand, to carry out analysis of the plaster casts in various occlusal positions. Hand articulation is done:
- To plan the presurgical orthodontics
- To find the existence of a possible tooth mass problem
- To ascertain the presence of transverse discrepancies
- To find the ideal site for interdental osteotomy
- To determine the number of segments required to achieve the desired occlusal results.

Prior to model surgery, a thorough clinical examination, cephalometric analysis, dental model evaluation should be carried out. Diagnosis of the patient's problem, considering occlusal and esthetic requirements is done. A tentative surgical treatment plan should be devised.

After the presurgical orthodontic phase is completed, then before fixing the stabilizing wire the fresh impressions are taken and casts prepared. The models are checked with hand-articulation for estimation of the success of the presurgical orthodontics. Model simulation should be done of the anticipated surgical movement. Prediction tracing and model surgery measurements should coincide.

Simulate the presurgical orthodontics on the diagnostic models. To meet the patient's esthetic and occlusal requirements the models are hand-articulated in a new position to: (1) align the dental midline, (2) to achieve maximum interdigitation anteriorly, (3) to bring canines in an Angle's class I occlusion, (4) to achieve Angle's class I molar relationships.

Protocol for Mock Surgery

- Cut the model exactly similar to surgery
- Avoid apices or root surfaces of teeth during cutting
- Detect the problem areas—proximity of roots, bony interferences, etc.
- Observe and note the movement of dento-osseous segments—rotations-expansion, etc.
- Reposition the anterior maxillary segment first.
- Consider—(a) best esthetics and functional requirement, (b) axial inclination, (c) lip coverage, (d) vertical relationship:—
- Achieve maximum interdigitation
- Keep the mandibular model fixed in two-jaw surgery
- Measure and record the AP, transverse and interdental changes
- Re-evaluate and compare with prediction tracing measurements
- Ascertain the difference in intrusion of one side to the other side in facial asymmetry cases in superior positioning of maxilla.

Marking Procedure for Models

To determine the magnitude and direction of the surgical movements in all the three planes, markings on the models should be made and the measurements should be taken using these markings as reference lines.

- **Base line:** It is drawn 35 mm above the maxillary canine tips and 25 mm above the maxillary first molar cusps tips.
- **Vertical reference lines (maxillary model):** Parallel to the long axis of the teeth in first molar, canine and between central incisors only. These lines are drawn perpendicular to the base line of the cast. Additional vertical lines can be drawn for segmental surgery.
- **Transverse markings (expansion or contraction):** Marks on the cusp tips of (R) and (L) canines and on the central fossa of the maxillary first molar. Measure intercanine and intermolar distance.
- **AP marking:** Hold the models in centric relation. Vertical maxillary markings in first molar and canine teeth region are extended till the mandibular teeth.
- **For interdental osteotomies:** Horizontal lines at the level of tooth apices and at the alveolar crest. Intersecting the previous vertical lines on either side of the osteotomy site.

After the desired mock surgery is done and measurements are recorded, then the models are mounted on the articulator (mechanical or hinge articulator) in class I canine and molar occlusion and acrylic wafer splint is constructed (2–3 mm width). This acrylic wafer splint will be used as a guide intraoperatively. Intraoperatively, the osteotomy cuts are modified after checking the fit of the splint.

Points to Remember

- Presurgical orthodontics objectives in antero-posterior, vertical, transverse plane
- Extraction pattern for presurgical orthodontics
- Presurgical orthodontics for all three planes
- Model surgery protocols
- Postsurgical orthodontics objectives.

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CHAPTER 27 Orthognathic Surgery: Osteotomy Procedures

INTRODUCTION

Orthognathic surgery is the surgical procedure carried out to to correct the dentofacial deformities, which are not amenable to orthodontic treatment. Orthognathic surgery is used to improve/correct (1) Gross jaw bone discrepancies in anteroposterior, vertical, or transverse plane, (2) Facial skeletal discrepancies associated with documented sleep apnea, airway defects, and soft tissue discrepancies, (3) Facial skeletal discrepancies associated with documented temporomandibular joint pathology.

HISTORICAL DEVELOPMENT OF ORTHOGNATHIC SURGERY

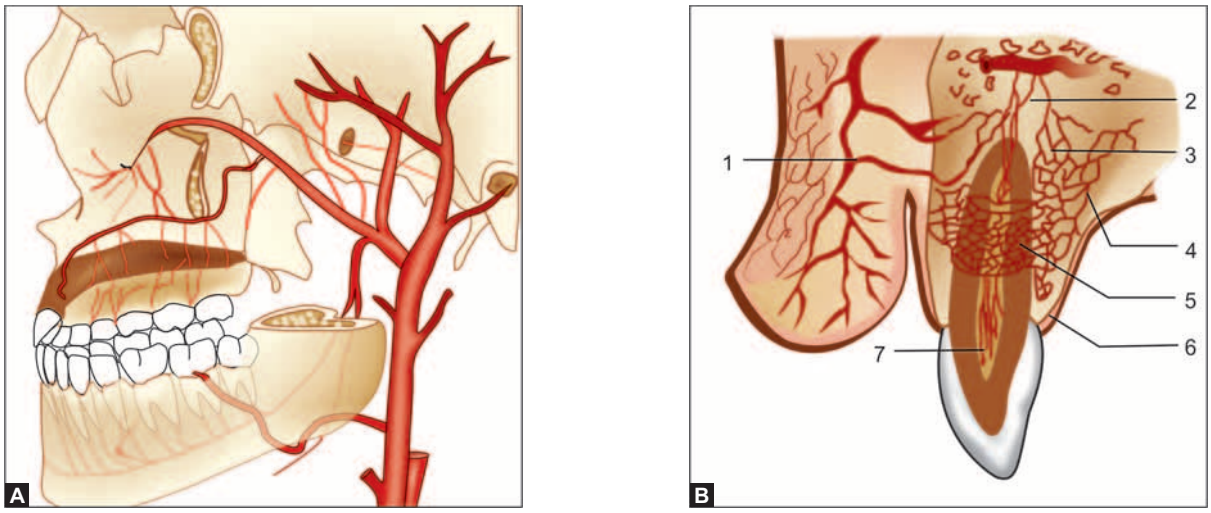
In 1849, in the United State of America, Hullihen performed first anterior mandibular osteotomy for the patient of distortion of face due to severe burns. The beginning of the early orthognathic surgery was in St. Louis, where the orthodontist Edward Angle and the surgeon Blair worked together. In 1897, Blair performed osteotomy of the mandibular body —"St Louis operation". Thereafter, in 1907, he was the first one to describe several operative techniques, for the correction of maxillofacial deformities. Blair was the first surgeon to realize the benefits of the cooperation between orthodontists and surgeons. He wrote in his article "Treating the skeletal deformities is really surgical work, but the earlier a competent, congenial orthodontist is associated with the case, the better it will be for both the surgeon and the patient." Several renowned maxillofacial surgeons invented new methods thereafter, for the correction of skeletal mandibular deformities. In 1955, in central Europe (Vienna), Trauner described inverted L osteotomy of the ramus for the correction of mandibular prognathism. Trauner trained Kole and Hugo Obwegeser, who gave the decisive boost to orthognathic surgery **(Table 27.1)**.

Biological Basis for Orthognathic Surgery

Simple splitting of the bone is known as osteotomy and removal of part of the bone is known as ostectomy.

Table 27.1: Historical development of orthognathic surgery

1921 : Cohn-Stock	• Anterior maxillary osteotomies (two stage)
1935 : Wassmund	• One stage anterior maxillary osteotomy
1952 : Converse	• Step osteotomy of the mandibular body for the correction of mandibular prognathism
1954 : Caldwell-Letterman	• Vertical subsigmoid osteotomy of ramus
1955 : Schuchardt	• Developed posterior maxillary osteotomy
1955 : Obwegeser	• Published the famous "intraoral sagittal split of the mandible"
1958 : Dal Pont	• Modified intraoral sagittal split technique
1959 : Kole	• First to describe bimaxillary surgery for the correction of bimaxillary protrusion
	• Proposed surgeries for open bite closure and for genioplasty procedures
1968 : Hunsuck	• Further modified sagittal split osteotomy
1969 : Obwegeser	• Presented a large series of LeFort I osteotomies
1970 : Obwegeser	• Two-jaw surgery
1974 : Spiessel	• First to apply rigid fixation in orthognathic surgery
1979 : Luhr	• Introduced the miniplate fixation in orthognathic surgery



Figs 27.1A and B: Bell's study—(A) Schematic representation of blood supply to maxilla and mandible; (B) Blood supply to anterior maxillary region, showing anastomosing vessels: (1) Labial artery, (2) Apical vessels, (3) Intra-alveolar vessels, (4) Palatal plexus, (5) Periodontal plexus (6) Gingival plexus, (7) Pulp vessels

In orthognathic surgery, the jaw bones are intentionally sectioned at various sites to correct the dentofacial deformities and then repositioned at desired position.

The maxillary osteotomies became popular after Bell's extensive research studies on rhesus monkeys in 1969 to 1975. He experimented and studied revascularization and bone healing after various osteotomy procedures. *He provided biological basis for orthognathic surgery and proved that the blood supply to the osteotomized segment will be maintained adequately, if at least one soft tissue pedicle is preserved intact. These studies also demonstrated that as long as the maxilla is pedicled to palatal mucosa and the labial gingiva and mucosa, downfracture of the maxilla with complete mobilization can be accomplished with adequate vascular supply* **(Figs 27.1A and B)**.

Various surgical procedures can be performed either in the maxilla or mandible or both together for the correction of dentofacial deformities.

PROTOCOL FOR OSTEOTOMIES

- Design soft tissue incision to maintain adequate collateral blood supply to the osteotomized segment and to avoid injury to vital structures in the vicinity.
- Provide optimum exposure to the site of osteotomy.
- Minimum or judicious periosteal stripping.
- Gentle soft tissue handling.
- Design osteotomy cuts without damaging the neurovascular bundle. Determine precise amount of bone cutting required by mock surgery and prepare an occlusal guide splint.
- Make osteotomy cuts under constant irrigation with normal saline.
- Plan interdental osteotomy cuts without damaging the periodontal status of adjoining teeth.
- Design subapical osteotomy cuts at least 4–5 mm away from the apices of the teeth.
- Remove all the bony interferences while approximating the osteotomized segments.
- Proper approximation with broad contact of osteotomized segments and stable fixation.
- Approximation of the osteotomized fragments in class I canine and molar occlusion (ideal).
- Adequate soft tissue coverage to prevent wound dehiscence.
- Proper follow-up.

OSTEOTOMY PROCEDURES

Various osteotomy procedures for the correction of dentofacial deformities are given in **Table 27.2**.

Soft Tissue Incisions for Osteotomies

1. All mandibular body osteotomies, including genioplasties can be performed through "degloving" vestibular incision taken intraorally. The extension of the incision will differ depending on the site of osteotomy **(Figs 27.2A to C)**.



Figs 27.2A to C: (A and B) Intraoral degloving incision and reflection of mucoperiosteal flap till inferior border; (C) Diagrammatic representation of degloving technique

Table 27.2: Various osteotomy procedures for the correction of dentofacial deformities

1.	Mandibular body osteotomies
	I. Mandibular body osteotomies—intraoral procedures
	A. Anterior body osteotomy
	B. Posterior body osteotomy
	C. Midsymphysis osteotomy
	II. Segmental subapical mandibular surgeries
	A. Anterior subapical mandibular osteotomy
	B. Posterior subapical mandibular osteotomy
	C. Total subapical mandibular osteotomy
	III. Genioplasties—horizontal osteotomy in the chin region
	A. Augmentation genioplasty
	B. Reduction genioplasty
	C. Straightening genioplasty
	D. Lengthening genioplasty
2.	Mandibular ramus osteotomies
	I. Subcondylar ramus osteotomy
	A. Extraoral subcondylar ramus osteotomy (subsigmoid)
	B. Intraoral subcondylar ramus osteotomy (subsigmoid)
	C. Arching ramus osteotomy (extraoral)
	II. Intraoral modified sagittal split osteotomy
3.	Maxillary osteotomy procedures—intraoral procedures
	I. Segmental maxillary osteotomy procedures
	A. Single tooth dento-osseous osteotomy
	B. Interdental osteotomies
	C. Anterior maxillary osteotomy
	D. Posterior maxillary osteotomy
	II. Total maxillary surgery—LeFort I osteotomy
	A. Superior repositioning of the maxilla
	B. Superior repositioning of the maxilla leaving nasal floor intact—horseshoe-shaped osteotomy
	C. Advancement of maxilla
	i. Simultaneous expansion of maxilla
	ii. Simultaneous narrowing of maxilla
	D. Inferior repositioning of maxilla
	E. Leveling of maxilla

2. Intraoral ramus osteotomies can be performed through the incision similar to the incision used for removal of impacted lower third molar.
3. Extraoral ramus osteotomies are carried out either through submandibular Risdon's incision or through postramal Hind's incision (more cosmetic results) **(Fig. 27.3)**.
4. Anterior maxillary osteotomy can be performed by taking three small horizontal vestibular incisions in the region of canine to second premolar on either side and midline incision over the anterior nasal spine. Tunneling of the mucoperiosteal flap can be done to reach the pyriform nasal aperture and the premolar

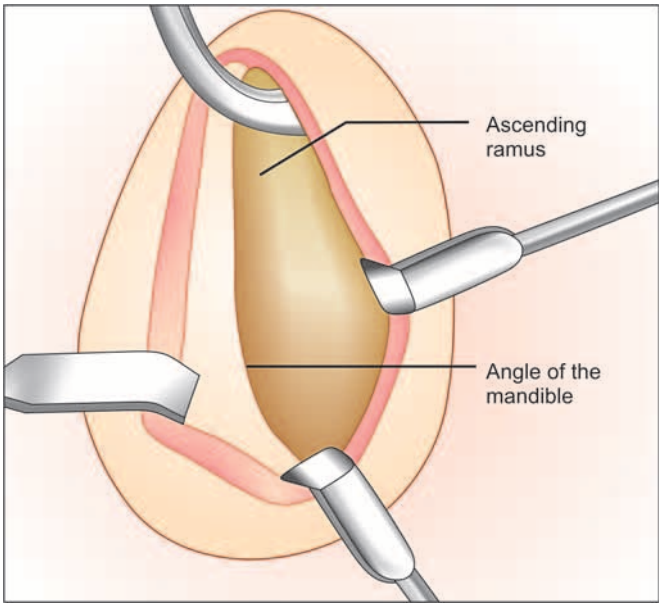
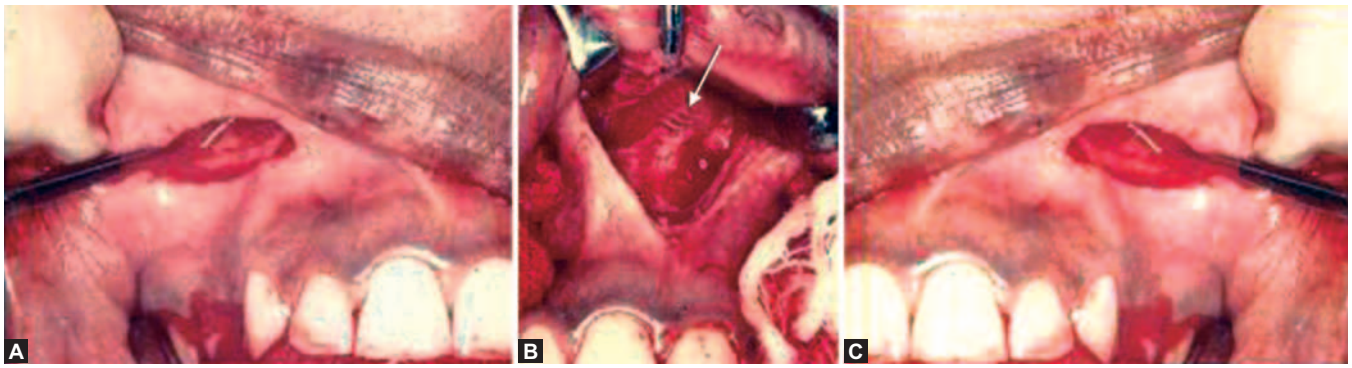


Fig. 27.3: Postramal Hind's or Irby's incision



Figs 27.4A to C: Three small vestibular incisions for anterior maxillary osteotomy procedure. Arrow in the middle picture shows anterior nasal spine is exposed and the horizontal central incision is sutured in a vertical manner for lip lengthening and to prevent scar contraction

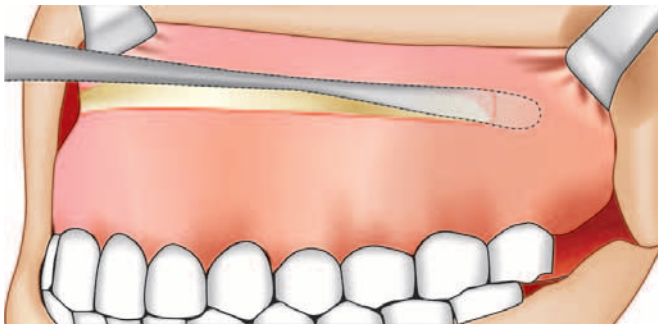


Fig. 27.5: Complete vestibular incision from right first molar to left first molar for LeFort I osteotomy



Fig. 27.6: Small incisions in the vestibule for LeFort I osteotomy procedure

extraction sites. Palatal pedicle is kept intact for maintaining the blood supply. Interdental osteotomies can be performed using the same type of incision **(Figs 27.4A to C)**.

5. Posterior maxillary osteotomy can be done through buccal vestibular incision starting from first molar to the tuberosity area.
6. Total maxillary osteotomy can be performed by taking complete vestibular incision starting from one maxillary first molar extending to other side maxillary first molar. Again palatal pedicle is kept intact. Other alternative is planning three small vestibular incisions—one in the midline over anterior nasal spine and two on either side, starting from second premolar going toward third molar region and tunneling the mucoperiosteal flap on either side keeping the palatal pedicle intact **(Figs 27.5 and 27.6)**.

Mandibular Osteotomies

These can be divided into

- Mandibular body osteotomies
- Mandibular ramus osteotomies.

Mandibular Body Osteotomy

Mandibular body osteotomy surgical procedures can be performed:

- Between adjacent teeth
- Through pre-existing edentulous space
- Through the extraction sites.

Whenever the osteotomies are performed anterior to the mental foramen, it is termed as anterior body osteotomy and if it is carried out posterior to the mental foramen, then it is termed posterior body osteotomy. Midsymphysis osteotomy can be used to widen or narrow the anterior arch width. Posterior body osteotomy is used to correct the level of the posterior segment or posterior cross bite or lingual inclination.

Anterior Body Osteotomy

Anterior body osteotomy—it is used in selected cases of

- Mandibular prognathism with functional posterior occlusion
- Class III malocclusion with or without anterior open bite, where the posterior teeth crossbite is dental in nature (can be corrected by orthodontics) **(Figs 27.7 and 27.8).**

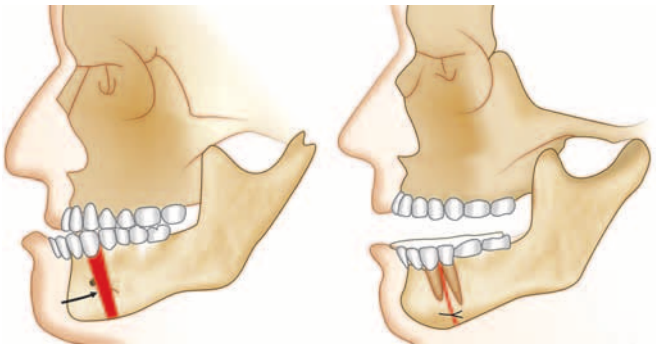


Fig. 27.7: Anterior body osteotomy procedure and setback of the osteotomized segment and fixation with intraosseous wiring

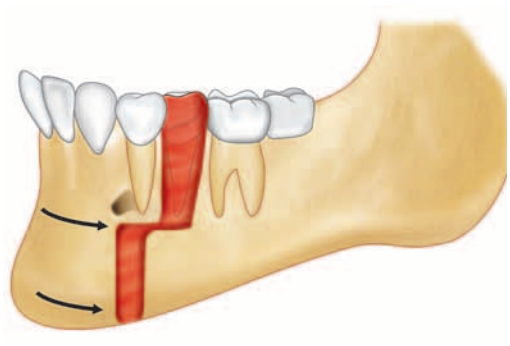
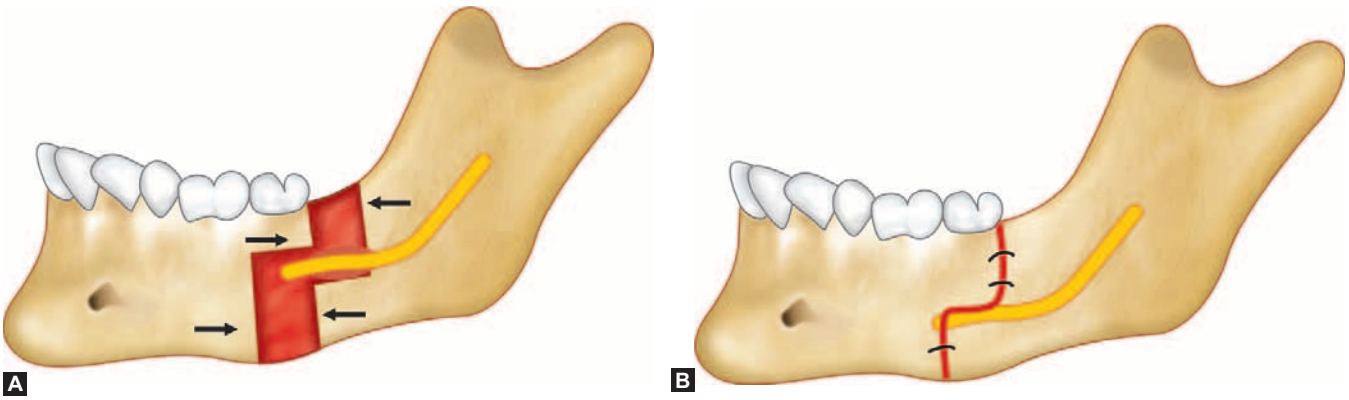


Fig. 27.8: Modified step or Z body osteotomy for anterior body mandible



Figs 27.9A and B: Posterior body osteotomy

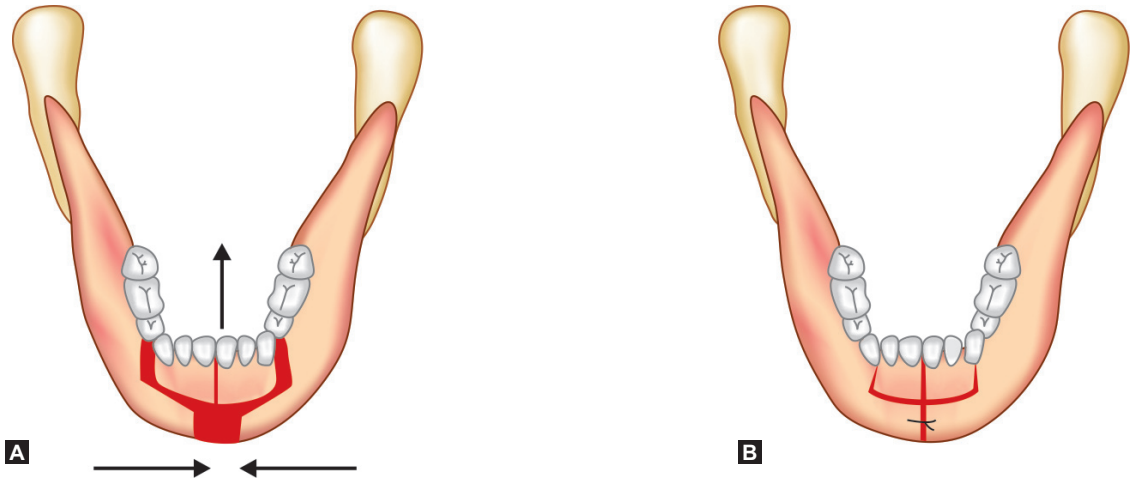
Removal of the first or second premolars is required for the correction of anterior crossbite.

Intraorally, two small vestibular incisions are taken bilaterally, leaving attached gingiva intact into first and second premolar regions, depending on the extraction. Mucoperiosteal tunneling is carried out superiorly till the alveolar crest and inferiorly till the inferior border in the area of extraction. Care is taken not to damage the mental nerve and its branches. A periosteal elevator is inserted lingually through the extraction site subperiosteally to protect the lingual soft tissue during osteotomy cuts. A modified retractor is placed at the inferior border of the body mandible at the proposed osteotomy cut. The vertical osteotomy cut is started in the socket at the alveolar margin involving both buccal and lingual cortices going towards the inferior border. The entire extraction socket should be utilized and the cuts are made parallel to each other or slightly convergent from buccal to lingual for better approximation.

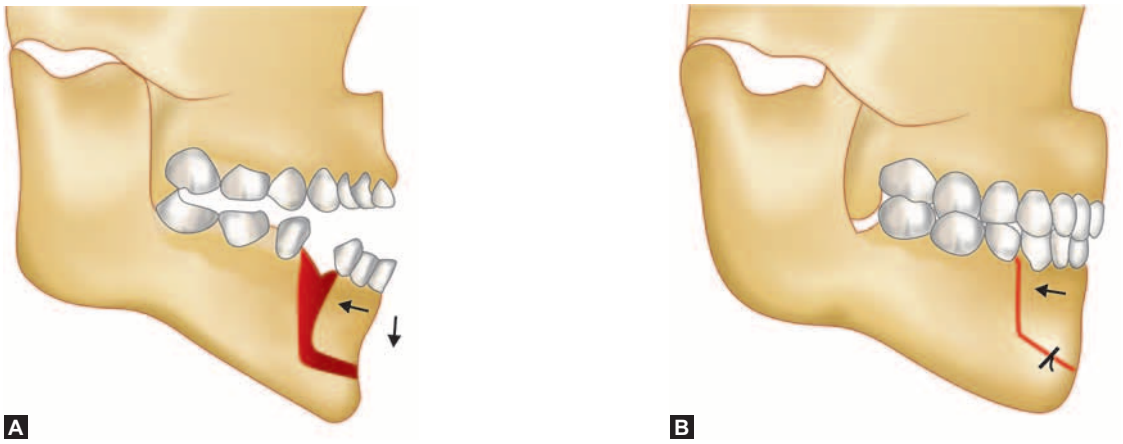
Care should be taken not to remove excessive crestal bone to prevent periodontal defects. The same procedure is repeated on the opposite side. Immediately occlusal splint is tried and osteotomy cuts are modified, if some bony interferences are present. Once the accurate fit of the occlusal splint is achieved, the fragments are stabilized at superior margin by passing figure of eight wires around the necks of the canine and premolar and inferiorly by using miniplate fixation or intraosseous wiring. Wound is closed in single layer. Instead of straight vertical osteotomy, the cut can be modified as step osteotomy to avoid damage to the mental nerve and to have better bony contact.

Posterior Body Osteotomy

Here, the preservation of neurovascular bundle is of utmost importance. This procedure is not commonly used **(Figs 27.9A and B)**. It can be used: (1) where there are missing posterior teeth, (2) in selected cases, with class III deformity, and (3) for correction of crossbite. Vestibular incision, one tooth anteriorly and one tooth distal to the osteotomy site, is taken. This incision can be extended posteriorly up the external oblique ridge for more relaxation. A channel retractor is inserted at the proposed osteotomy site at the inferior border. The cut is started superior to the neurovascular bundle and finished through both the cortices. At the level of neurovascular bundle small window is made by removal of only external



Figs 27.10A and B: Midsymphysis osteotomy along with anterior subapical mandibular body osteotomy



Figs 27.11A and B: Mandibular anterior subapical osteotomy

cortex and thus exposing the neurovascular bundle. The nerve hook is inserted to pull the bundle toward buccal side and lingual osteotomy cut is completed. Then the neurovascular bundle is retracted gently upward, so that the inferior border cut can be completed through and through. Same procedure is repeated on the other side and the fragments approximated in such a way that the neurovascular bundle is not damaged. The occlusal splint is fitted properly and the osteotomized segments fixed with either intraosseous wiring or bone plating at the inferior border.

Midsymphysis Osteotomy

If it is combined with posterior or anterior body osteotomy, then complete vestibular incision can be planned. Thin tapering bur or saw can be used for making the cut in between two mandibular incisors from the alveolar crest to the inferior border. Care is taken to place the osteotomy cuts without damaging the roots of the teeth **(Figs 27.10A and B)**.

Segmental Subapical Mandibular Surgeries

Segmental subapical mandibular surgeries can be used to reposition the anterior, posterior or entire mandibular dentoalveolar segment.

Anterior Subapical Mandibular Osteotomy

Anterior subapical mandibular osteotomy is very popular technique **(Figs 27.11 to 27.13)**. It can be used as a single procedure for:

- Correcting mandibular dentoalveolar proclination
- Closing mild anterior open bite

- Leveling an accentuated curve of Spee
- Correcting mandibular dental arch asymmetry.

It can be used as an adjunctive procedure with other surgical procedures such as:

- With anterior maxillary osteotomy to correct bimaxillary protrusion.
- With mandibular advancement to level the curve of Spee.
- With genioplasty procedure.

Following extraction of premolars on either side, a circumvestibular incision is taken from canine to canine area. The incision is made into the lip and carried tangentially down to the bone. While making the incision the finger is placed on the cutaneous side of the lip to appreciate the depth of the incision, which should limit itself without cutting through the entire lip. Care is taken to locate the mental nerve and protect it. A subperiosteal dissection is carried to the inferior border and the symphysis region is degloved. A periosteal elevator is placed on the lingual side of the extraction socket and vertical cut is made from the alveolar crest till the level of premolar root apex through both the cortices. The same procedure is repeated on the other side. Then both the vertical cuts are connected by the horizontal subapical osteotomy made about 5 mm below the anterior teeth apices.

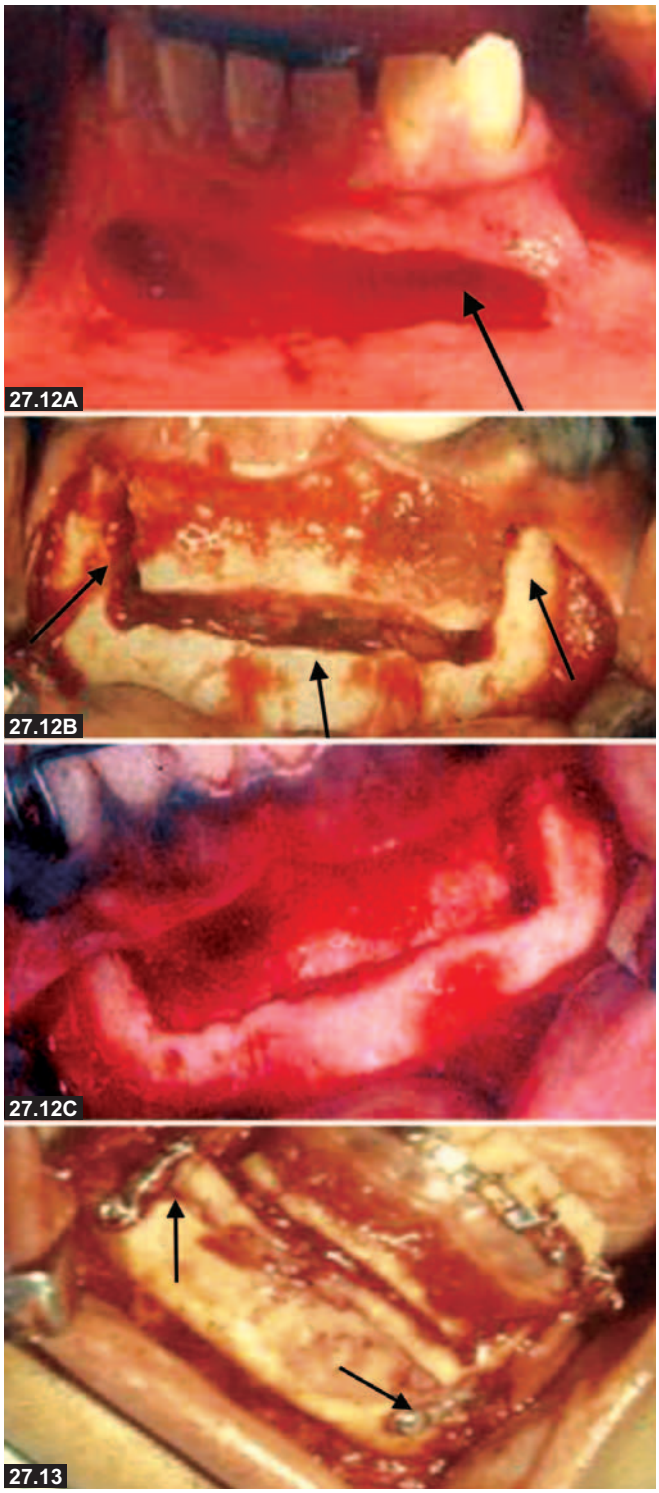
The segment is mobilized by using an osteotome. An attempt is made to place the teeth into the prefabricated occlusal splint. Bony interferences are removed if necessary and final fitting of the splint is checked and the osteotomized fragment can be stabilized by using miniplate fixation.

The incision is closed in two layers, the muscular and the mucosal layer; and a pressure dressing is given externally.

If anterior subapical mandibular surgery is to be used only for leveling the curve of Spee, then there is no need to extract the teeth. Vertical interdental osteotomies are done between canine and first premolars on either side, using a fine tissue bur and fine osteotome or a saw. Horizontal wedge of bone is removed to depress the anterior fragment.

Posterior Subapical Mandibular Osteotomy Procedure

Used rarely, as it is technically difficult and there is a high-risk of injury to the inferior alveolar neurovascular bundle **(Fig. 27.14)**. But with the proper skill, it can be used successfully for:



Figs 27.12 A to C: Intraoperative picture of anterior subapical osteotomy: (A) Incision; (B) Osteotomy cuts; (C) Final approximation. **Fig. 27.13:** Anterior subapical mandibular osteotomy procedure—an intraoperative picture. Fixation with bone plates is done

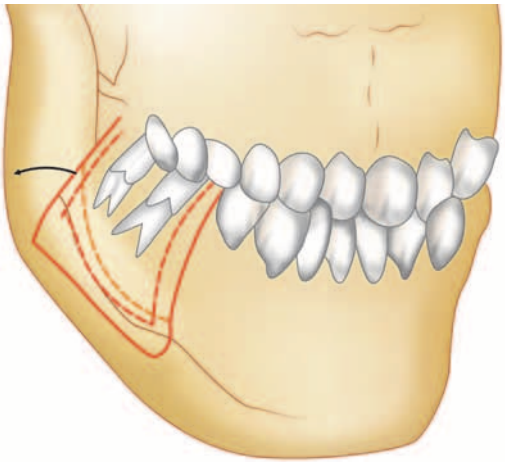


Fig. 27.14: Posterior subapical mandibular osteotomy procedure

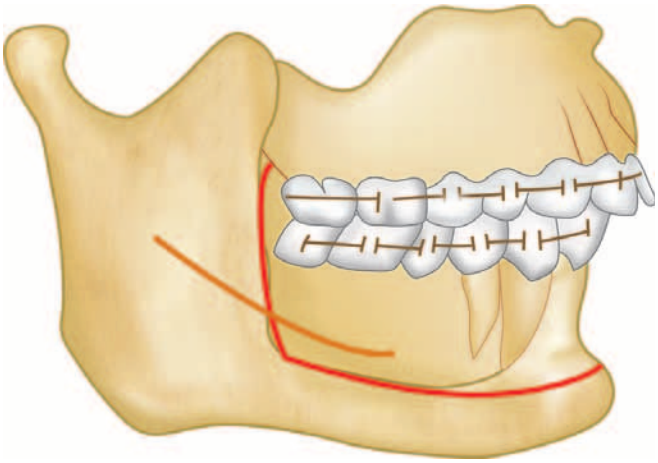


Fig. 27.15: Total subapical mandibular osteotomy

- Uprighting the posterior segment which is in extreme linguoversion or buccoversion
- Closing a premolar or molar space
- Leveling supraerupted posterior teeth **(Fig. 27.14)**.

A horizontal vestibular incision is taken and the mucoperiosteal flap reflected downwards till the inferior border of the mandible. Here, the anterior vertical cut is taken in the area of missing first premolar or first molar and second vertical cut is placed behind the last existing molar and horizontal cut is taken below the apices of the teeth, protecting the neurovascular bundle. Both the vertical cuts are carried out from the alveolar crest up to the level of neurovascular bundle. The portion of the buccal cortex that overlies the nerve bundle is removed. This window should extend several millimeters posteriorly to the distal vertical cut. The window is made in such a way that the cut extends only in the buccal cortex and the bone is removed with osteotome and saved. After the identification and protection of the nerve bundle, lingual cortex is osteotomized. Both vertical cuts are also completed till the horizontal cut level and the entire segment is mobilized with the osteotome in the desired position. The segment can be stabilized by fixing the occlusal splint and by placing a circummandibular wire over the splint. The outer cortical bony plate, which was saved should be fitted back prior to suturing.

Total Subapical Mandibular Osteotomy

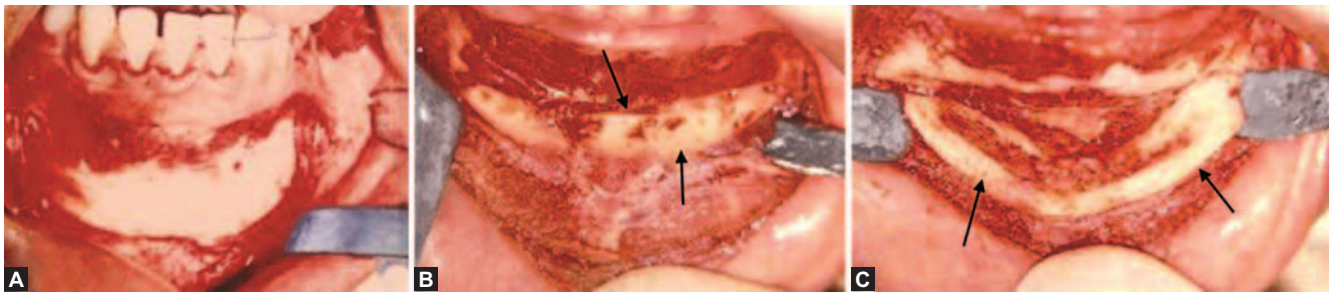
Again not performed routinely, as technically difficult and high-risk of damage to the neurovascular bundle. It can be used to reposition entire mandibular dentoalveolar segment anteriorly, posteriorly or superiorly. For lengthening of lower third of the face or for advancing the mandibular dentoalveolar segment, etc. Here, the location of the horizontal subapical osteotomy is done below the level of the inferior alveolar neurovascular bundle. The level is determined by radiographs and the actual osteotomy location is marked by taking direct measurements from the occlusal plane. The horizontal osteotomy is started initially anteriorly in the symphysis region and proceeds posteriorly. The horizontal osteotomy cut is completed through the lingual cortex by placing the guiding finger on the lingual side and bur is directed at the angle of 45° from buccal to lingual cortex. The entire horizontal cut is carried just posterior to the last molar. Then a vertical osteotomy is made approximately 5 mm posterior to the last tooth. This cut begins superiorly and carried through and through to the level just above the nerve bundle. The buccal cut is then completed through only the outer cortex and remainder of the lingual cortex adjacent to and below the bundle, is fractured with the osteotome. In advancement cases, care should be taken not to overstretch the nerve. It can tolerate 3–6 mm of stretching **(Fig. 27.15)**.

Genioplasties

Genioplasty can be used as a single procedure or it can be used as an adjunctive procedure along with other major osteotomies of the jaw bone **(Figs 27.16 A to C)**.

The deformities of the chin should be considered in all three planes—anteroposterior (AP), vertical and transverse as the morphology of the symphysis region is highly variable in different individuals, even with the same basic types of dentofacial deformities.

Genioplasties can be used to augment, reduce, straighten or lengthen the chin **(Figs 27.17 to 27.23)**.



Figs 27.16A to C: Basic genioplasty surgical procedure. (A) Degloving incision; (B) Horizontal osteotomy cut including the inferior border of the chin; (C) Mobilized bony segment ready for genioplasty procedure (reduction, augmentation, straightening or lengthening procedure)

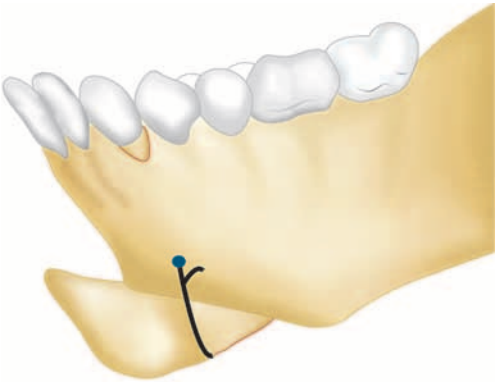


Fig. 27.17: Augmentation genioplasty

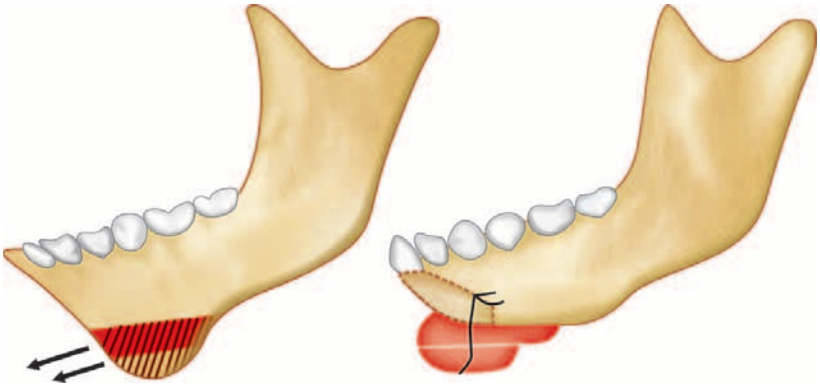
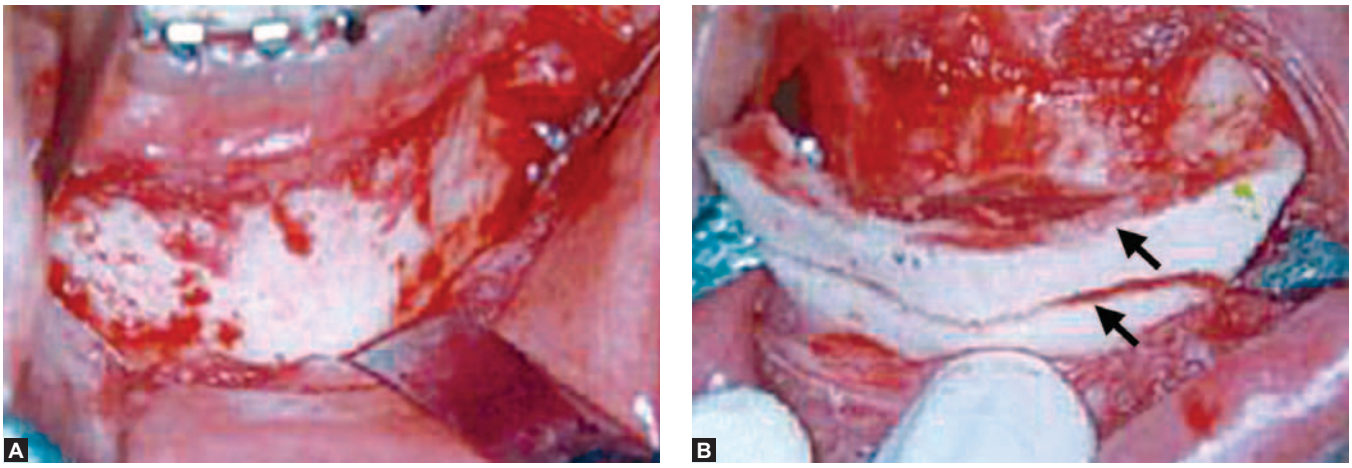


Fig. 27.18: Double sliding augmentation genioplasty



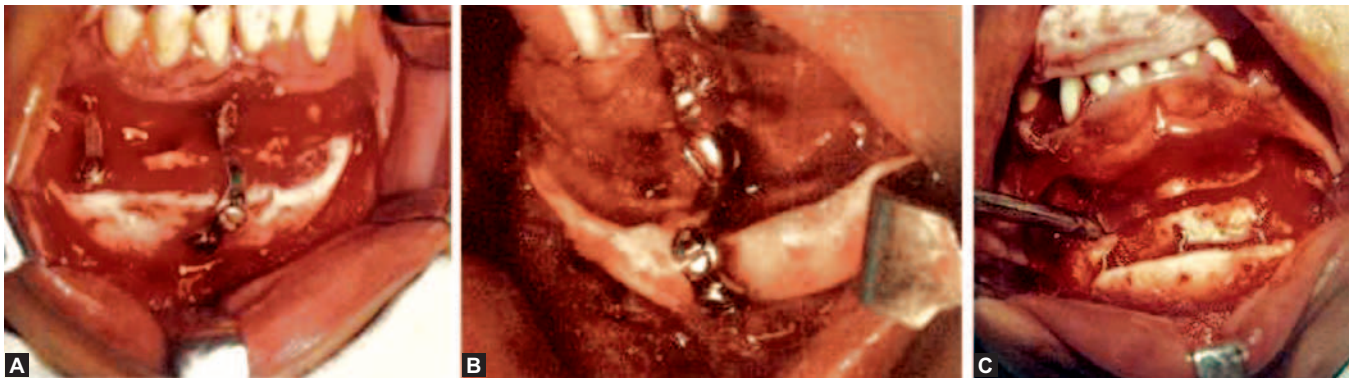
Figs 27.19A and B: Double genioplasty procedure: (A) Surgical exposure through degloving incision; (B) Double horizontal cuts in the anterior chin region to carry out double genioplasty procedure

Augmentation Genioplasty

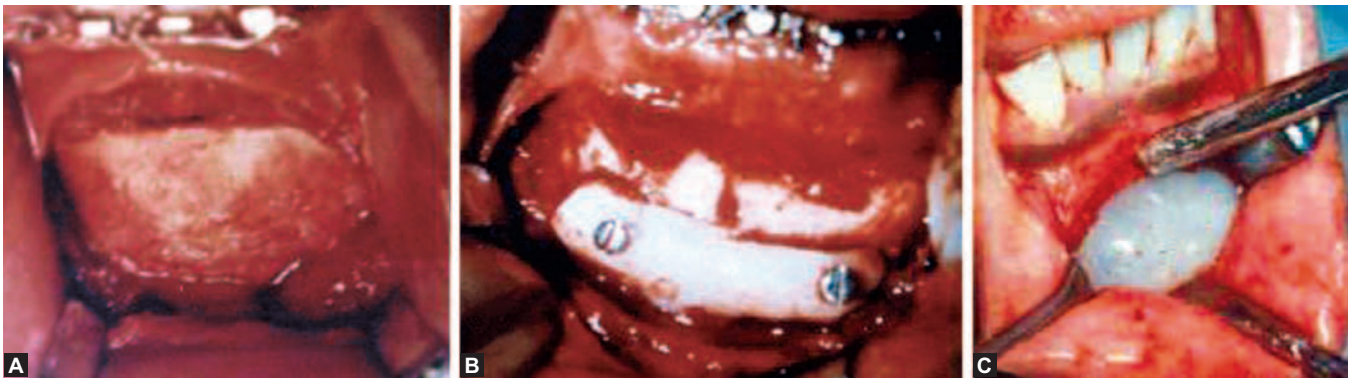
Augmentation genioplasty is used to increase the chin projection. It can be done by:

- Sliding horizontal osteotomy of the symphysis region
- Using autogenous bone graft
- Using alloplastic material—silastic, hydroxyapatite, etc.

Augmentation genioplasty surgical procedure: The entire inferior border of the symphysis is degloved by using vestibular incision. The digastric muscles are separated from the mandible to reduce the tension after advancement. Periosteal releasing incision also should be taken to provide adequate coverage after advancement. Generally, the AP dimension of the symphysis is about



Figs 27.20A to C: Augmentation genioplasty and fixation



Figs 27.21A to C: (A and B) Augmentation genioplasty with onlay graft; (C) Augmentation with prefabricated silastic graft

8–12 mm. So the same amount of advancement is possible. The horizontal osteotomy cut is made at least 4–5 mm below the apices of canines. The cut is completed through both buccal and lingual cortices. The segment is mobilized inferiorly and forward with the help of osteotome. This mobilized segment is pedicled over geniohyoid muscles and some amount of lingual periosteum. Any bony interferences for advancement are removed under direct vision. The mobilized segment should be then advanced into desired position by using towel clips and then external facial contour should be checked and the fragment is positioned to the final desired level. It can be fixed to the superior body with two intraosseous wirings at canine region or two mini bone plates **(Figs 27.17 to 27.20)**.

With major advancement, the periosteal relaxing incision should be made prior to suturing. Suturing is done in two/three layers.

Alloplastic augmentation can be done using the same incision, but which is relatively short in length. On both the sides, little tunneling is done to create a pocket into which the onlay grafting material can be slided for better fixation (silastic or hydroxyapatite blocks) **(Fig. 27.21C)**.

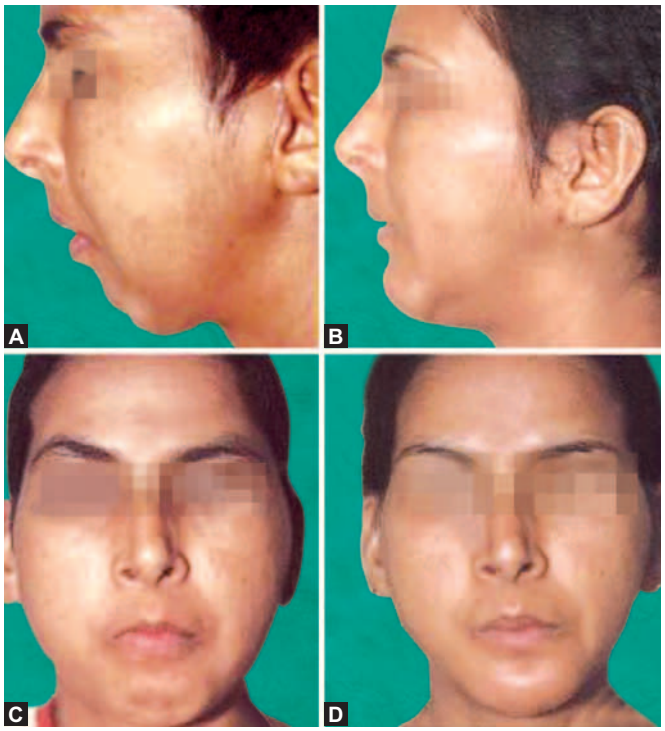
Reduction Genioplasty

The reduction of the symphysis region can be achieved both in the AP and vertical planes or in both planes depending on the need of the patient. This surgical procedure is also used as an adjunctive procedure. Three different types of procedures can be described **(Fig. 27.24):**

1. Horizontal osteotomy and setback of the fragment. Excess amount of bony wedge, which is left behind is excised and the segment is fixed.
2. Vertical reduction amounts to determining the required vertical movement. Two horizontal osteotomy cuts are made, the lower cut is completed first. Then the superior cut is done and bony wedge is removed. The inferior segment is then pushed upwards and stabilized.
3. Vertical reduction and posterior pushback may be required in some of the cases.

Straightening Genioplasty Procedure

It is indicated in patients with facial asymmetry, where the complete correction of the asymmetry cannot be achieved by appropriate jaw osteotomies, e.g. condylar hyperplasia,



Figs 27.22A to D: Augmentation genioplasty results: (A) Preoperative profile view; (B) Postoperative profile view; (C) Preoperative frontal view; (D) Postoperative frontal view



Figs 27.23A to D: Augmentation genioplasty procedure was carried out to improve the chin contour: (A) Preoperative frontal view; (B) Postoperative frontal view; (C) Preoperative profile view; (D) Postoperative profile view

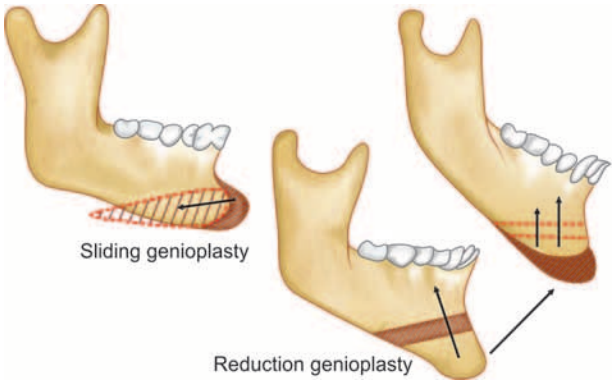


Fig. 27.24: Sliding and reduction genioplasty

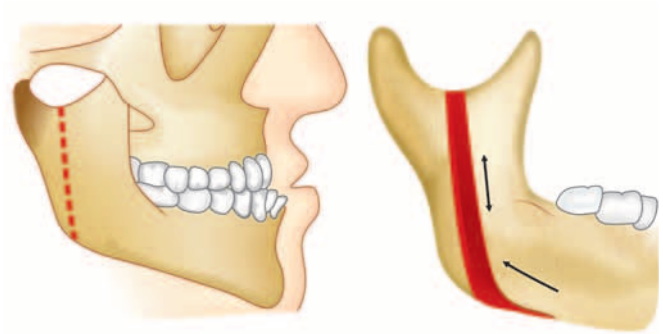
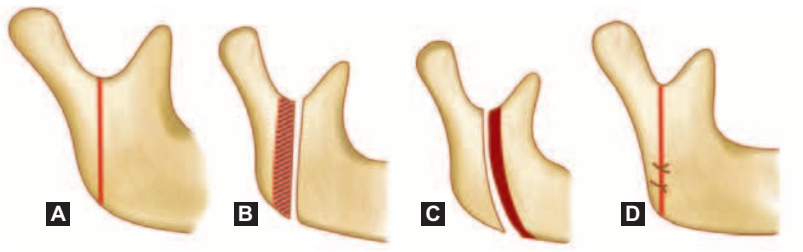
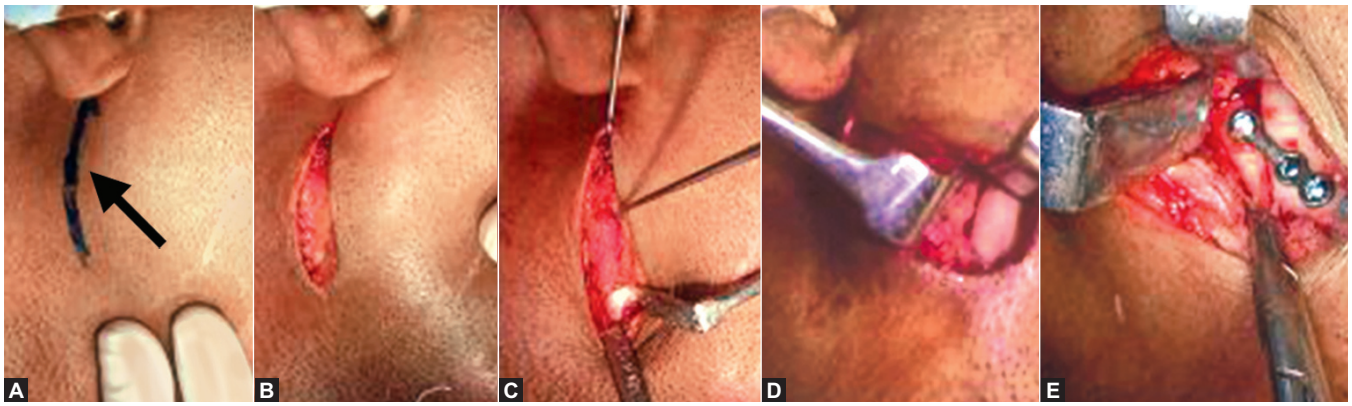


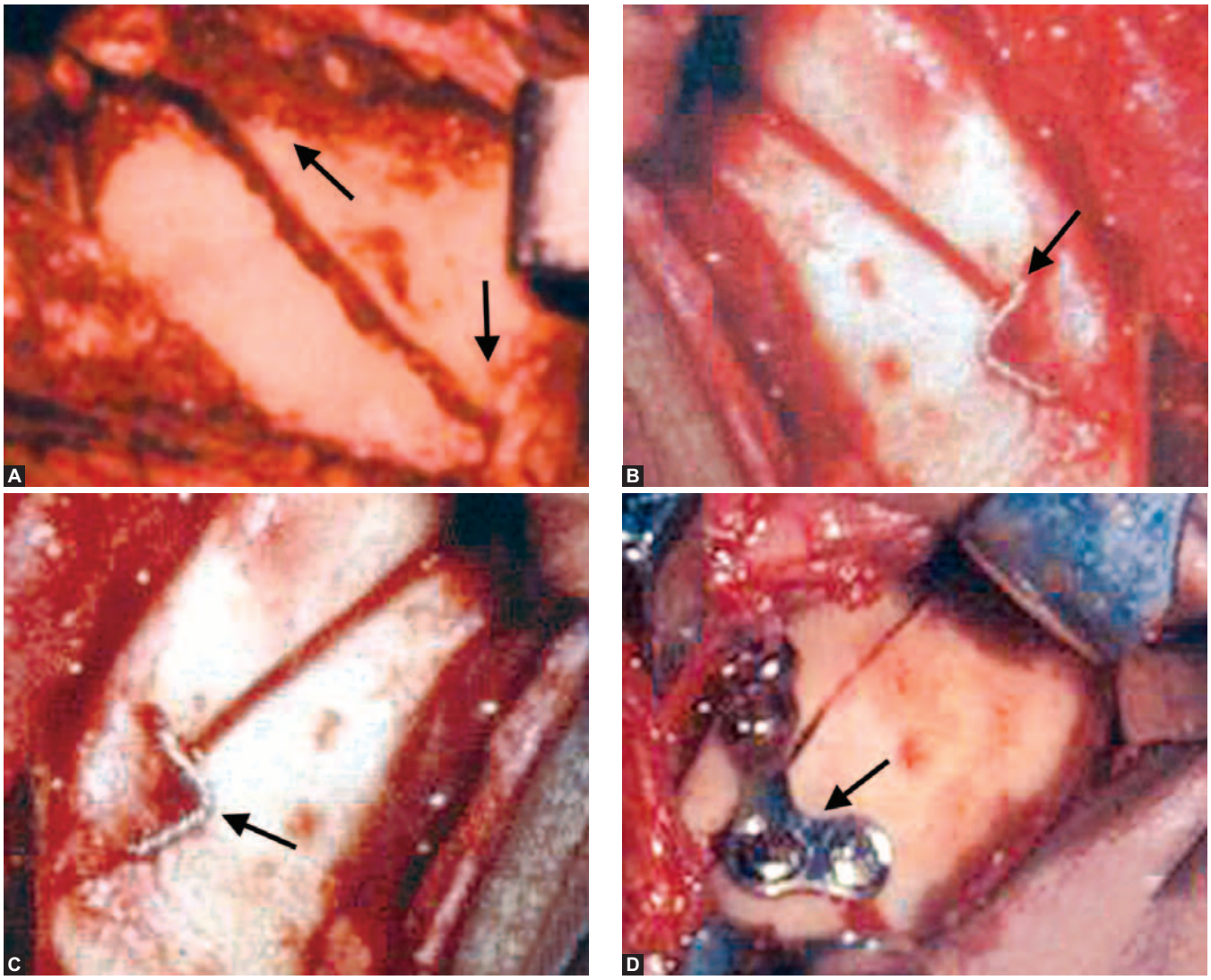
Fig. 27.25: Subsigmoid vertical osteotomy (Caldwell-Letterman osteotomy)



Figs 27.26A to D: Diagram of Caldwell-Letterman osteotomy procedure: (A) Osteotomy cut; (B and C) Decortication of osteotomized segments; (D) Fixation with intraosseous wiring



Figs 27.27A to E: Extraoral postramal incision and different steps of dissection till the exposure of mandibular angle and vertical subsigmoid ramal osteotomy and final bone plate fixation



Figs 27.28 A to D: Surgical procedure for extraoralsubsigmoid ramus osteotomy: (A) Osteotomy cut; (B) Fixation with intraosseous wiring (L) side; (C (R) Side wire fixation; (D) Fixation with stainless steel L shaped bone plate on (R) side for other patient

temporomandibular joint (TMJ) ankylosis, etc. This can be also used in conjunction with AP, vertical or transverse augmentation or reduction of the chin. The horizontal osteotomy is done and segment is shifted laterally and then contoured to get desired result.

Lengthening Genioplasty

Indicated in patients with short vertical facial height with Class I and Class II deep bites. After horizontal osteotomy, the osteotomized segment is pushed inferiorly and bone graft is sandwiched in between to increase the height.

Mandibular Ramus Osteotomies

Subcondylar Vertical Osteotomy

Subcondylar vertical osteotomy was first proposed by Caldwell-Letterman in 1954. The indications for extraoral subsigmoid vertical ramus osteotomy are as follows **(Figs 27.25 to 27.28)**.

1. Major setback of mandible more than 10 mm.
2. Asymmetric setback of the mandible.
3. Reoperation of previously operated case.

In this procedure, the ramus is approached through extraoral postramal or submandibular incision and is sectioned from the sigmoid notch to the lower border of the mandible just ahead of the angle **(Figs 27.25 to 27.28)**. The mandibular foramen remains on the distal fragment, thereby avoiding injury to the nerve, and the condyle attached to the proximal segment. After cutting through the pterygomasseteric sling, the angle and inferior border of mandible is exposed. A periosteal elevator is utilized to subperiosteally reflect all the tissues from the lateral aspect of the ascending ramus. The sigmoid notch and coronoid process is also exposed. The hook or curved instrument is

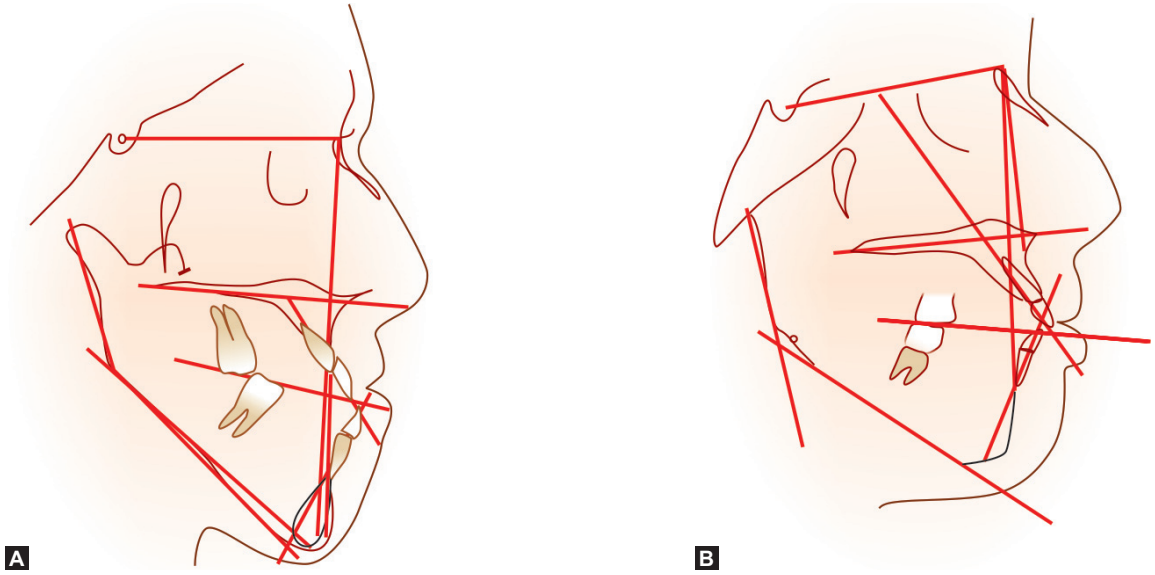


Figs 27.29A to I: (A) Asymmetrical prognathism in 19-year-old boy, front face; (B) Preoperative asymmetrical front face showing (L) side Bell's palsy of the eye; (C) Postoperative front face after both sides extraoral subsigmoid osteotomy (surgery); (D to F) Preoperative dental occlusion showing anterior open bite and reverse overjet; (G to I) Postoperative occlusion

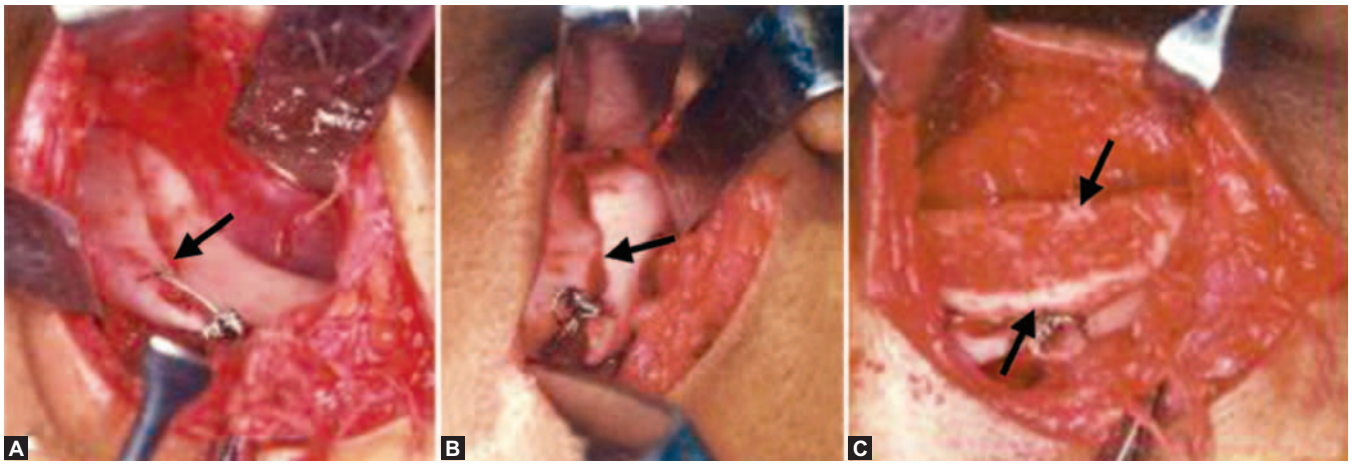


Figs 27.29J to O: (J and K) Preoperative (R) and (L) profile; (M and N) Postoperative (R) and (L) profile; (L) Preoperative lateral cephalogram; (O) Postoperative lateral cephalogram

engaged at the sigmoid notch and ramus is pulled slightly downwards. A bony prominence corresponding to the lingula and mandibular foramen is located on the lateral surface of the ramus. *This is called as Behrman's bump*. The vertical line going from the sigmoid notch to the inferior border is scratched just posterior to the mandibular foramen with the bur. The cut is started from the sigmoid notch up to the level of mandibular foramen through both the cortices. Care is taken to protect the medial tissues. Then the cut is started from inferior border going up to the level of mandibular foramen. Then both the cuts are joined together. This way if there is any inadvertent injury to neurovascular bundle which causes hemorrhage, then the two fragments can be quickly separated and the vessel is identified and ligated. Similar procedure is carried out on the opposite side. After both side osteotomies are completed the proximal fragments are placed over distal fragments and the assistant temporarily locks the mouth in desired occlusion by carrying out temporary intermaxillary fixation (IMF). The decortication of the distal segment is carried out on the lateral aspect of the overlap area and the proximal segment is decorticated on the medial aspect. The proximal segment is then fixed laterally to the distal segment overlapping it with intraosseous wiring or bone plates **(Figs 27.28A to D)**. There can be variations of this basic osteotomy procedure. *Subsigmoid oblique subcondylar* osteotomy is advocated by *Robinson* and *Hinds* in 1955. The cut is extended from the sigmoid notch



Figs 27.30A and B: (A) Preoperative cephalogram tracing; (B) Postoperative cephalogram tracing for the patient shown in Figures 27.29A to O



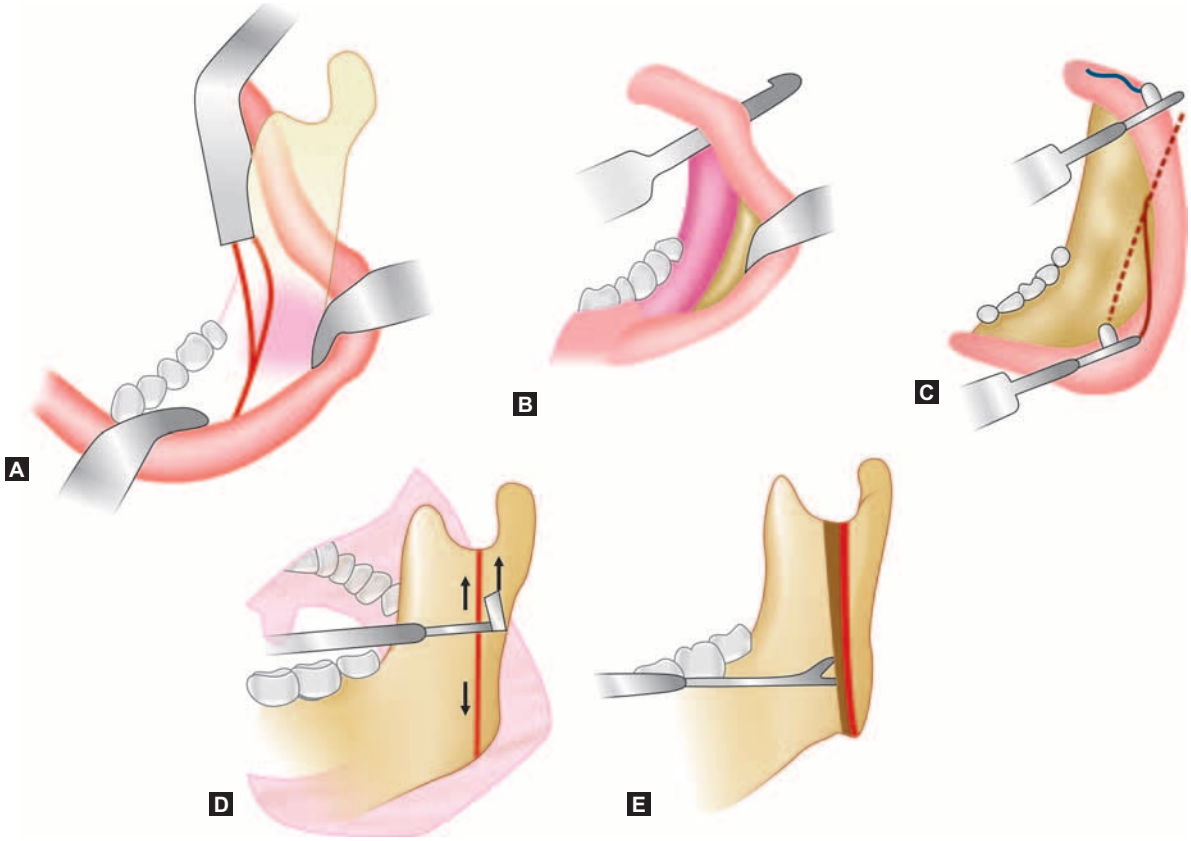
Figs 27.31A to C: (A and B) Surgical procedure of bilateral oblique subsigmoid osteotomy for the patient. Fixation by intraosseous wiring (C) Onlay bone grafting on the (R) side ramus after fixation of the osteotomized fragments to correct the flatness on the right side (Arrows)

to the posterior border. *C-shaped or arching osteotomy* can be done by curving the bony cut above the level of mandibular foramen extending it to the anterior border of the mandible, instead of going straight to sigmoid notch. These procedures can be also used for the advancement of mandible along with the use of bone grafts fitted between the distal and proximal segments **(Figs 27.29 to 27.31)**.

Advantages of Subsigmoid Vertical and Oblique Osteotomy

- Adequate direct access
- Adequate control of bony fragments
- Good surface contact between the bony fragments
- Minimal relapse tendency
- Gonial angle contour can be changed
- No loss of teeth or arch size.

Disadvantage: It is because of extraoral incision, there is an external scar formation. If the patient has keloid tendency, then this approach is contraindicated. Otherwise careful planning of the postramal incision gives minimum amount of scar, which is hidden behind the shadow of posterior border of the mandible and over the years, scar diminishes.



Figs 27.32A to E: Intraoral vertical ramus osteotomy (IVRO)

Intraoral Vertical Ramus Osteotomy and the Inverted L Osteotomy

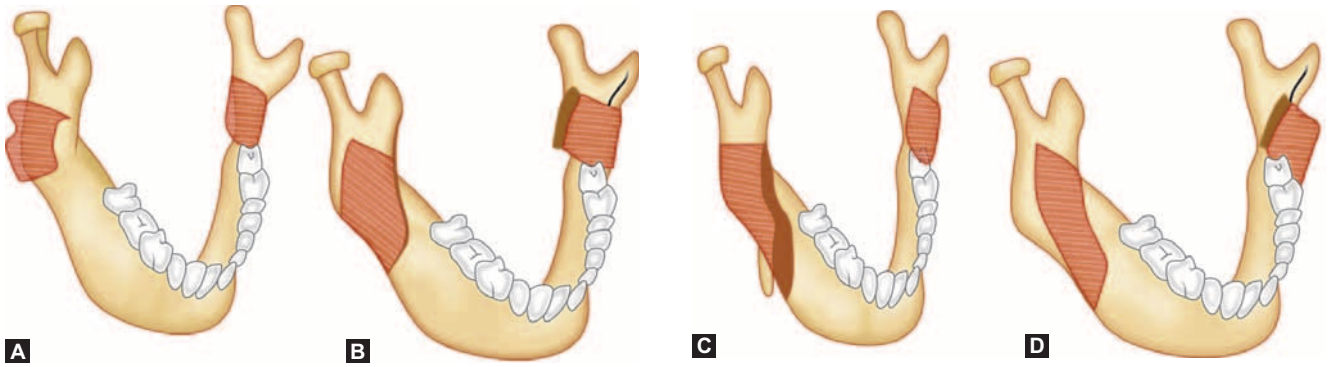
This technique was first described by Winstanley in 1968 **(Figs 27.32A to E)**. The indication for intraoral vertical ramus osteotomy (IVRO) mandibular setback procedure is in mandibular excess patients. This procedure is faster and simpler than the sagittal split ramus osteotomy (SSRO). The rehabilitation time is much shorter and there is lower incidence of inferior alveolar nerve injury. This procedure is also indicated in the patients with TMJ complaints.

For this procedure, the ramus is exposed by taking intraoral incision at the level of mandibular occlusal plane, medial to the external oblique ridge till mandibular first molar. The length of the incision is about 2–3 cm. The mouth is fully opened by inserting a bite block, between the teeth on the opposite side.

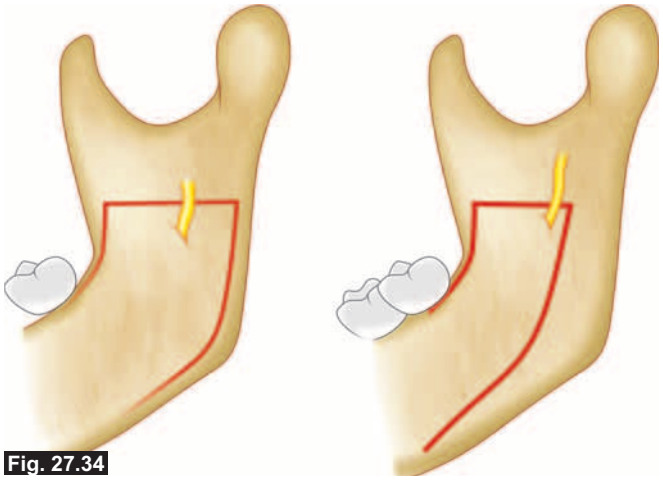
The subperiosteal reflection of the entire lateral, posterior and inferior borders of the ascending ramus of the mandible is performed. A J-periosteal elevator is used to separate the pterygomasseteric sling. A special curved retractor is used to engage the posterior border of the mandible, thus the ramus can be pulled slightly forward, improving access. The bone cut is made from the sigmoid notch and carried inferiorly to the region of mandibular angle, using a 120° beveled reciprocating saw blade. After completion of the osteotomies on both sides and placement of the mandible into the occlusal splint, IMF is done. The positions of the osteotomized segments are checked. The proximal segment should lie lateral to the distal segment. The approximation of the fragments and fixation is done with intraosseous wiring.

Intraoral Modified Sagittal Split Osteotomy

Bilateral sagittal split osteotomy (BSSO): This is a very popular, most versatile procedure performed on the mandibular ramus and body. First described by *Obwegeser* and *Trauner* and later modified by *Dal Pont, Hunsuck* and *Epker.* This is accomplished through transoral incision, similar to that used for IVRO. The osteotomy splits the ramus and the posterior body of the mandible sagittally, which allows either setback or advancement. This is a highly cosmetic procedure, as it is done intraorally, (no extraoral scar) plus there is broader bony contact of the



Figs 27.33A to D: Improvements of the sagittal split ramus osteotomy procedures: (A) Obwegeser and Trauner technique 1957; (B) Dal Pont modification 1961; (C) Hunsuck modification 1968; (D) Bell, Schendel and Epker modification 1977–78



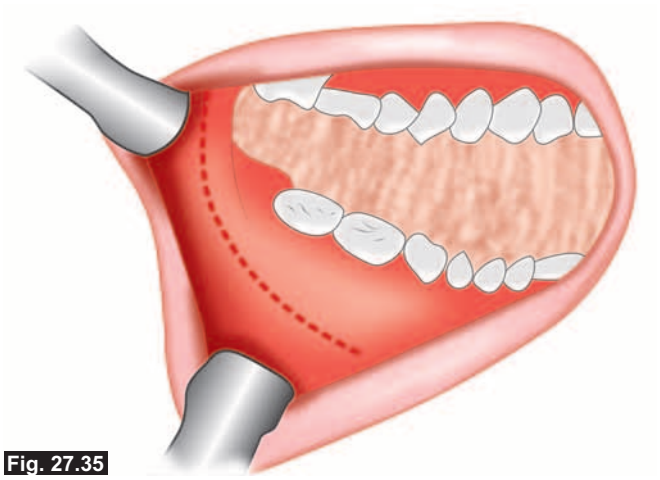


Fig. 27.34: Hunsuck's modification. He advocated a shorter horizontal medial cut just posterior to the lingula instead of extending it till posterior border. **Fig. 27.35:** Intraoral incision for sagittal split osteotomy

osteotomized segments ensuring good healing **(Figs 27.33 to 27.40)**.

For mandibular advancement, there is no need for bone grafts. Thus donor site morbidity and second operative site for the bone graft is totally avoided. BSSO gives excellent results. Only drawback is the technique demands high level of operative skill and experience to minimize the surgical complications.

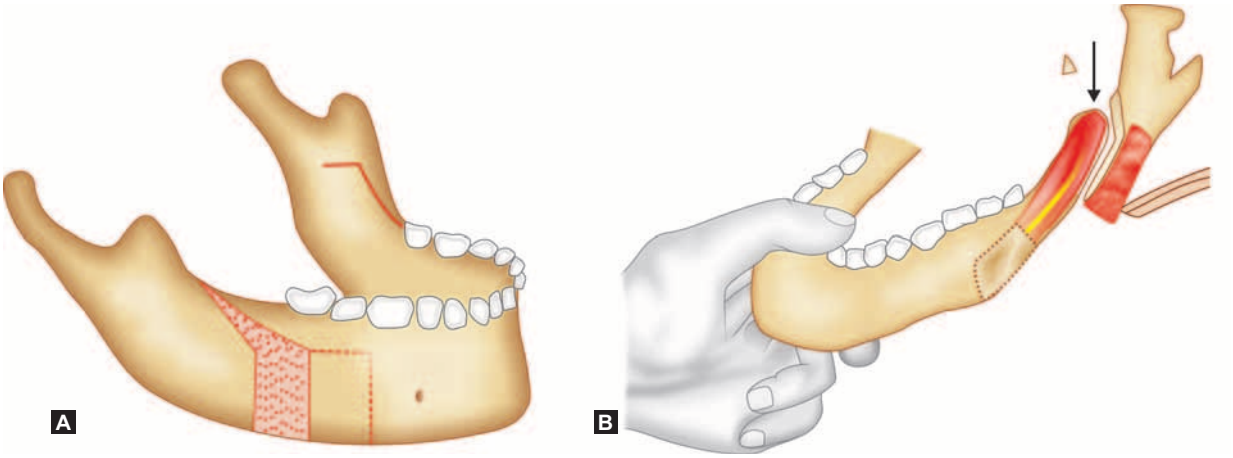
In 1957, Obwegeser and Trauner first described the sagittal split osteotomy of the ramus region, only by placing buccal and lingual cortical horizontal cuts. The procedure has undergone numerous modifications over the years.

In 1961, Dal Pont changed the lower horizontal cut to a vertical cut on the buccal cortex between the first and the second molars, thereby obtaining broader contact surfaces and requiring minimal muscular displacement with improved access.

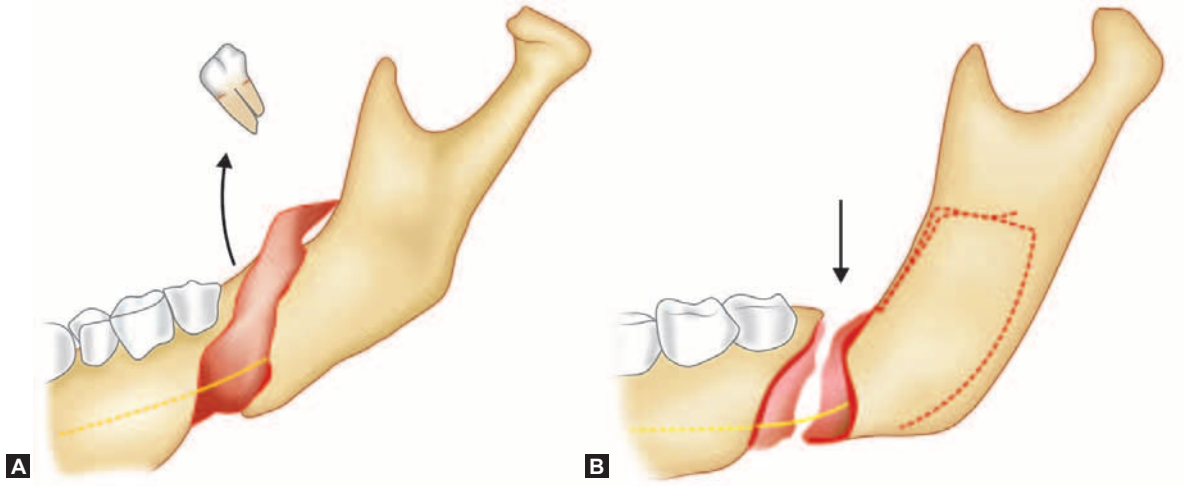
In 1968, Hunsuck further modified the technique, advocating a shorter, horizontal medial cut, just posterior to the lingula, (instead of posterior border) to minimize soft tissue dissection. His anterior vertical cut was similar to Dal Pont's **(Fig. 27.34)**.

In 1977, Epker suggested several modifications. These include minimal stripping of the masseter muscle and limited medial dissection. These modifications helped to reduce postoperative swelling, edema, hemorrhage **(Fig. 27.33D)**.

Surgical procedure: A bite block is inserted on the opposite side in between the upper and lower teeth for making easy access and projecting the ramus anteriorly. An incision is made on the lateral aspect of the anterior border of the ramus, overlying the external oblique ridge, from midway up the ascending ramus (to avoid buccal pad of fat) downward into vestibular depth till mandibular first molar region **(Fig. 27.35)**. The soft tissue dissection is started subperiosteally along the anterior border upwards, towards the coronoid process. Medially the soft tissues are reflected, until the lingula and the inferior alveolar nerve



Figs 27.36A and B: Intraoral sagittal split osteotomy (Arrow—before approximation of osteotomized fragments bony interferences should be removed)

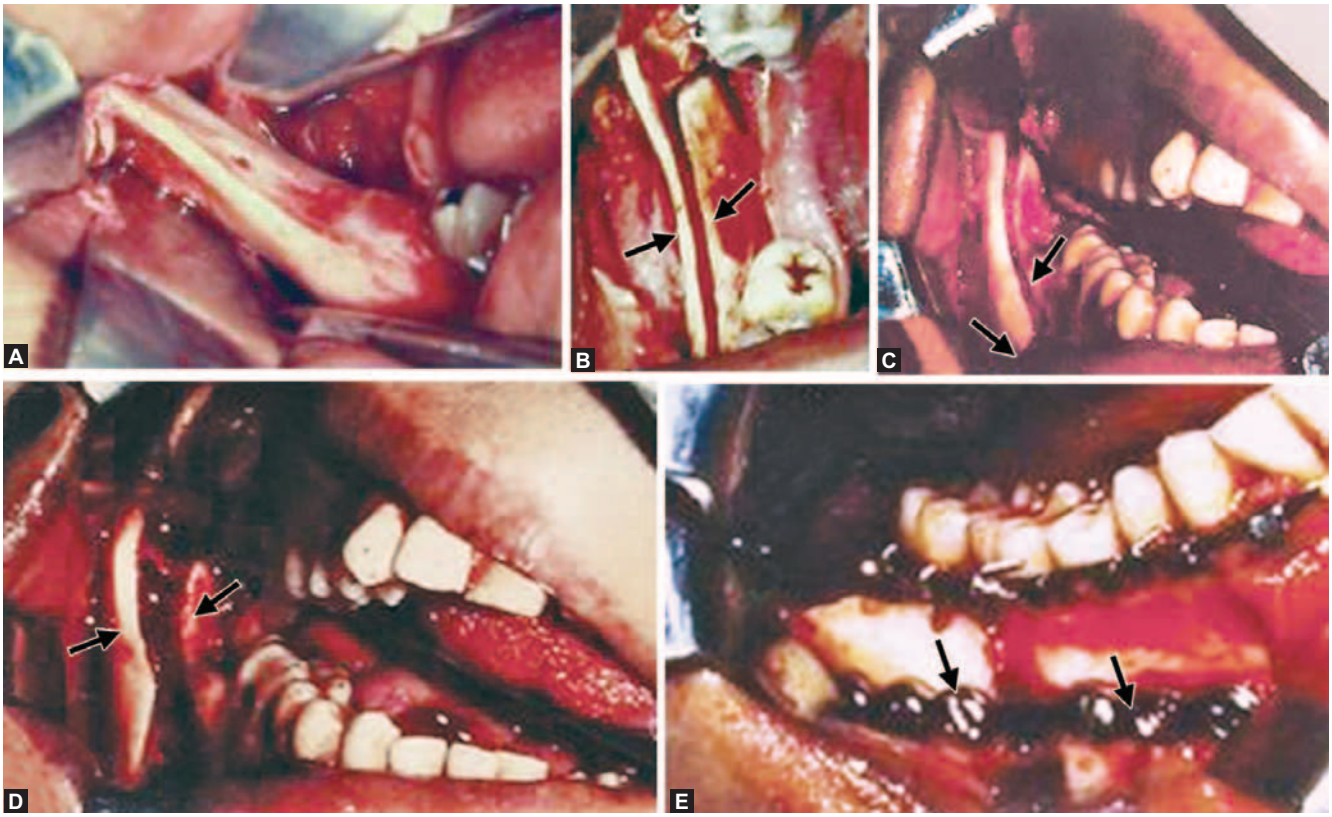


Figs 27.37A and B: During sagittal split osteotomy, the impacted third molar should be removed with minimum bone loss. Otherwise, inadvertent fracture can occur during the split (arrow)

bundle and mandibular foramen is identified. The medial soft tissue dissection is stopped slightly posterior and superior to the lingula. While the medial soft tissues are being retracted, the medial bone cut is made through only the lingual cortex about 2 mm above the neurovascular bundle and just posterior to the lingula **(Figs 27.36A and B)**.

Following the completion of horizontal medial osteotomy, cut is then carried down the lateral most aspect of the anterior border of the ascending ramus to the region of the second molar. This osteotomy is made parallel to the lateral cortex. The bite block is removed and the periosteum from the lateral aspect of the mandible is elevated in the molar area till the inferior border of the mandible. For setback procedure, the vertical osteotomy cut is taken lateral to second molar, however, in major advancement cases, vertical cut is placed forward in the region of the premolar. Vertical cut is completed through the lateral cortex only. *The cut extends through both the cortical plates at the inferior border of the mandible.* With osteotome, all bony cuts are checked for their completeness. Two osteotomes are then inserted and used as levers to separate the segments. Spreader can be used to finally separate the segments. The same procedure is repeated on the other side. In case of advancement, the bony interferences should be checked and the distal fragment is advanced and locked into desired occlusion. The fixation of the fragments can be done by intraosseous wiring or lag screws or by bone plates **(Fig. 27.38)**.

In case of setback, the distal fragment is pushed back. There will be overlap of the proximal fragment in the molar region. The excess bone on the proximal fragment is cutoff



Figs 27.38A to E: Surgical procedures for sagittal split osteotomy: (A) Intraoral incision. Minimum medial tissue dissection; (B and C) Lateral osteotomy cuts; (D) Sagittal split complete. Check for bony interferences; (E) Final fixation with six-hole bone plate and screws

by taking another vertical cut, distal to the previous cut, including only proximal fragment. The fragments will be checked now for proper approximation and fixation is carried out. This procedure gives excellent stable results **(Figs 27.39 and 27.40)**.

MAXILLARY OSTEOTOMY PROCEDURES

Segmental Maxillary Osteotomy: Surgical Procedures

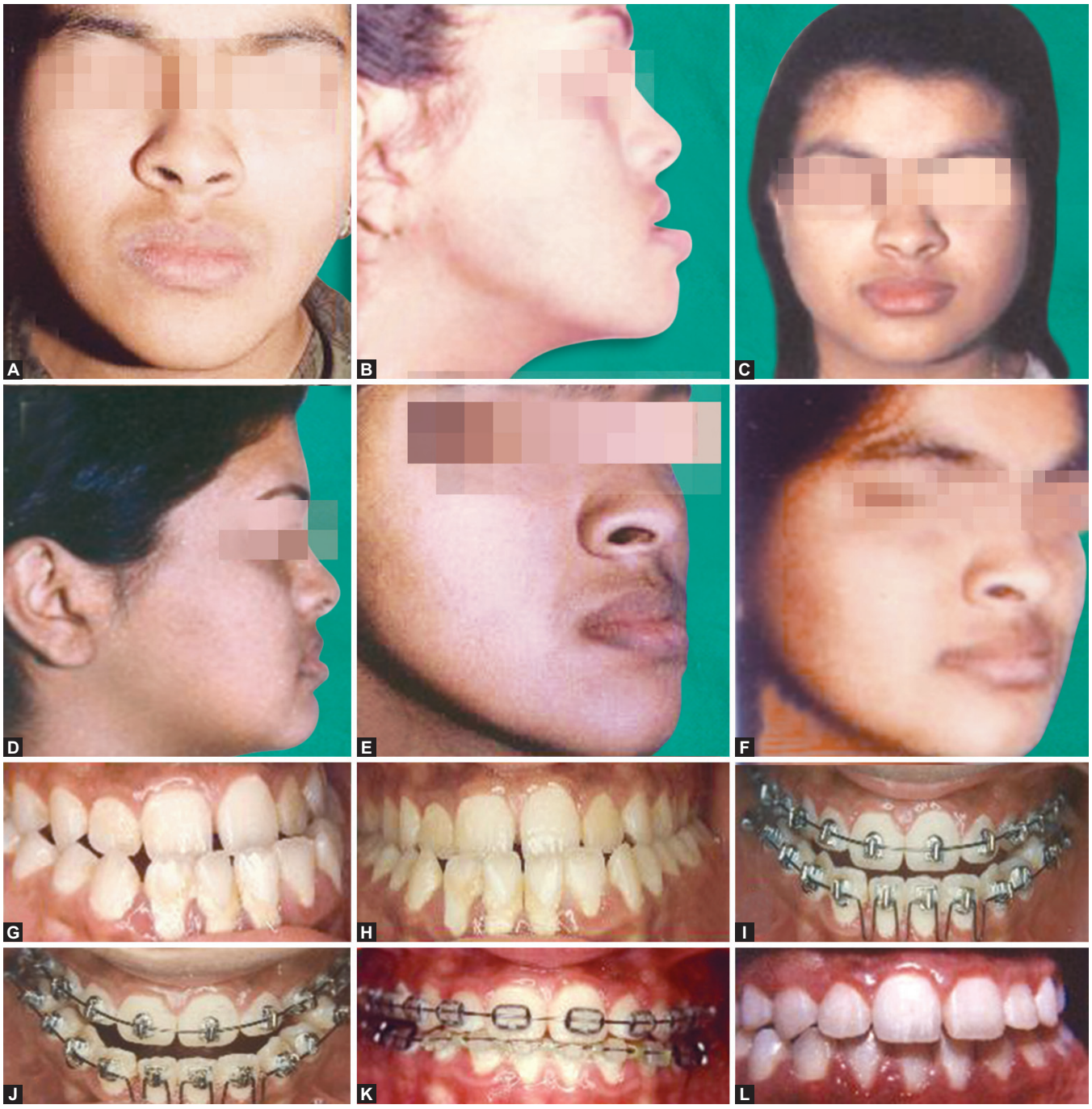
Segmental maxillary surgery is commonly indicated in the correction of dentofacial deformities, where only a portion of the maxillary dental arch requires repositioning for functional and esthetic reasons. Single tooth osteotomy is used to correct tooth malposition, dental ankylosis or closure of a diastema. Interdental osteotomy procedure was first advocated by Kole and was used to close diastema in the maxillary dental arch, much prior to surgical orthodontics came into vogue. Now the diastema are closed in the presurgical orthodontic phase and the residual spaces are left behind canines, so that the segmental osteotomy can be planned utilizing this available space.

Single Tooth Dento-osseous Osteotomies

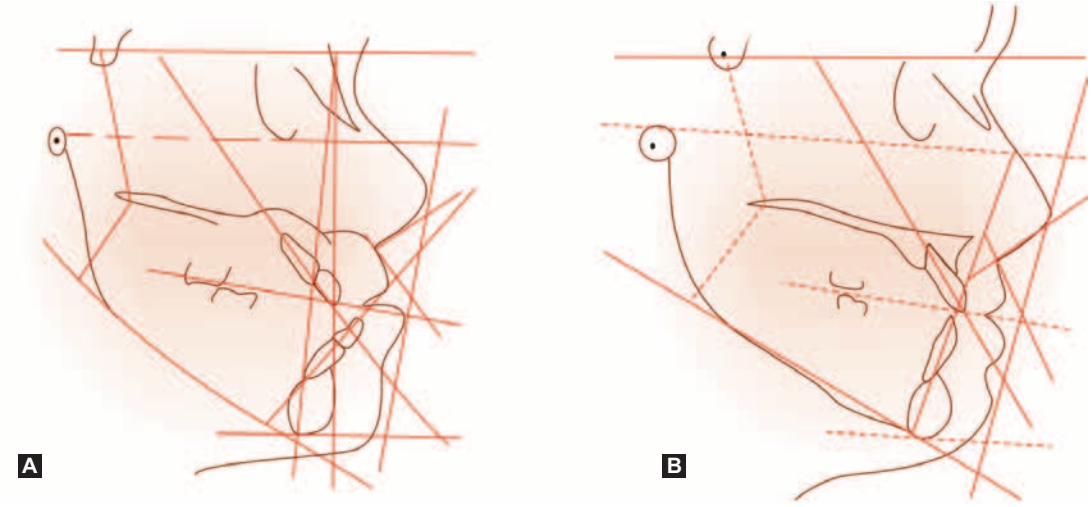
The basic criterion for this type of osteotomy is that, there must be sufficient space available between adjacent tooth roots, so that a fine osteotomy cut can be placed without injuring the roots. There should be also adequate space in the dental arch to reposition the osteotomized segment into proper occlusion without interference.

Incision: (a) A horizontal vestibular incision or (b) multiple vertical incisions can be taken.

Surgery: A horizontal vestibular incision is made one tooth distal to those being mobilized. The mucoperiosteal flap is reflected superiorly exposing anterior nasal spine and piriform apertures of the nose. The nasal mucosa is protected by keeping periosteal elevator at the nasal floor and piriform aperture. The oral mucoperiosteum is reflected only till attached gingiva to maintain blood supply. Vertical interdental osteotomies are then made with a fine fissured bur, through the labial cortex from the



Figs 27.39A to L: A 21-year-old girl with mandibular prognathism: (A) Preoperative front view of face; (B) Preoperative profile; (C and D) Postoperative front face and profile; (E and F) Three-fourths facial view preoperative and postoperative; (G and H) Preoperative dental view. Note the nature's compensation. Upper anteriors are proclined. Lower anteriors lingually inclined, resulting in minimum reverse overjet; (I and J) Presurgical orthodontic phase. Note that the teeth are upright on their dental bases and increased reverse overjet (decompensation). Bilateral sagittal split osteotomy surgery carried out; (K) Postsurgical orthodontic detailing; (L) Final finished occlusion



Figs 27.40A and B: Preoperative and postoperative cephalometric tracing of the patient shown in Figure 27.39

nasal floor to the level of attached gingiva (4 mm above the alveolar crest). By keeping the finger on the palatal aspect the cut is completed through palatal cortex. When diastema are present some amount of bone will have to be removed interdentally to close the spaces and approximate the fragments **(Fig. 27.41)**.

The alveolar crestal bone is then sectioned with a fine osteotome. Generally, the vertical interdental osteotomy cuts extend into the anterior nasal floor. However, if there is sufficient bone present between the root apex and nasal floor, the separate horizontal cut can be taken, leaving the nasal floor intact. The osteotomized segment is then mobilized into the desired position by using fine osteotome. The occlusal splint is positioned into place and suturing is done.

When multiple, large (4–6 mm) diastema are present, then multiple vertical interdental soft tissue incisions can be taken. The vertical incisions permit the labial mucoperiosteal pedicle to move more freely in addition to having better attachment to the individual segment.

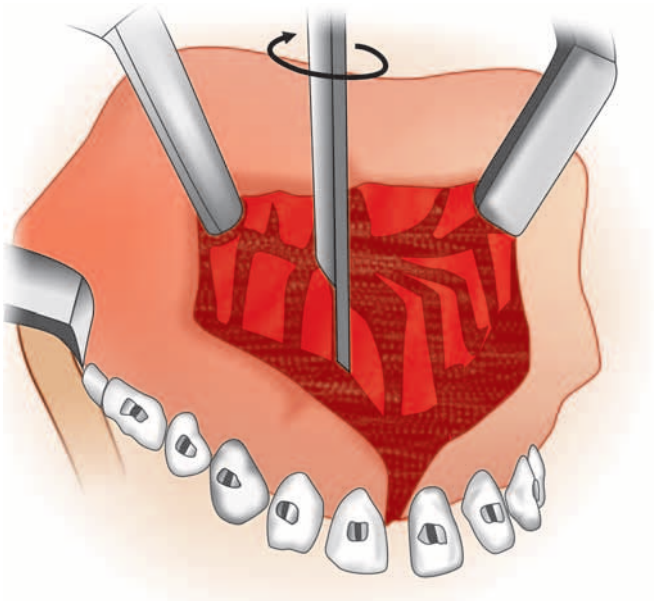


Fig. 27.41: Interdental osteotomies

Anterior Maxillary Osteotomy

This is a very frequently used most popular technique for the correction of dentoalveolar protrusion of the anterior maxilla. Correction is accomplished with an anterior maxillary osteotomy with or without a midline split. The anterior segment can be moved superiorly or inferiorly and posteriorly as indicated. It can also be used in conjunction with mandibular subapical osteotomy for the correction of bimaxillary protrusion **(Figs 27.42 and 27.43)**. The first anterior maxillary setback was performed by Cohn Stock in 1921. *Wassmund in 1935, modified this procedure and advocated that the bony palate be approached by tunneling the palatal mucosa*. He suggested vertical incisions in between the canine and premolar area extending towards the nasal floor. Additional midline incision was taken to approach nasal septum and small midpalatal incision, if necessary to complete the palatal cut. *Wunderer* in 1962, further modified the technique by advocating that the

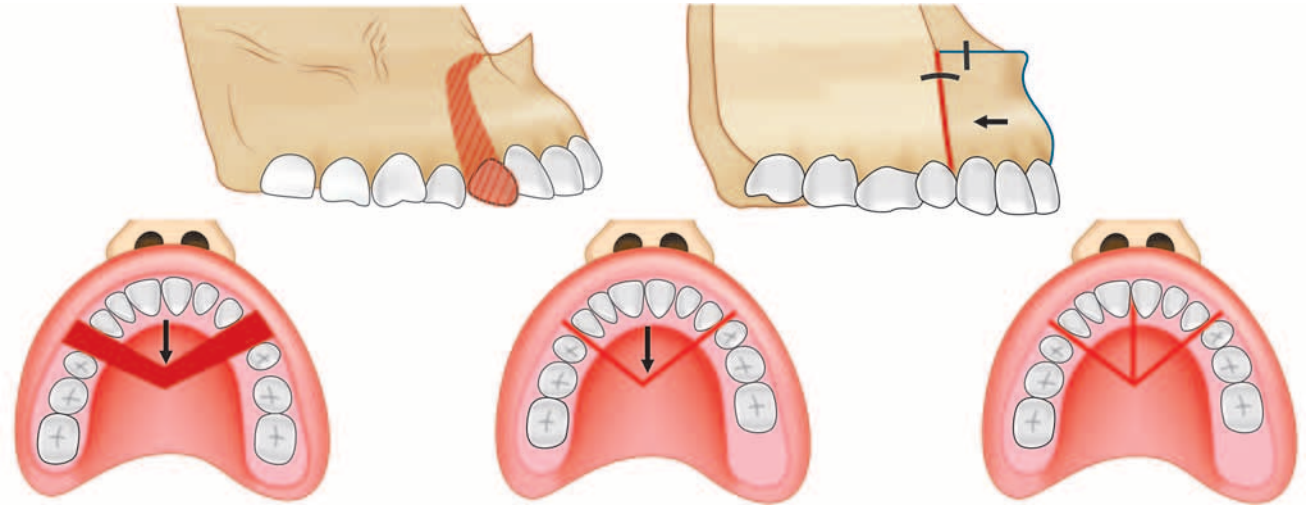
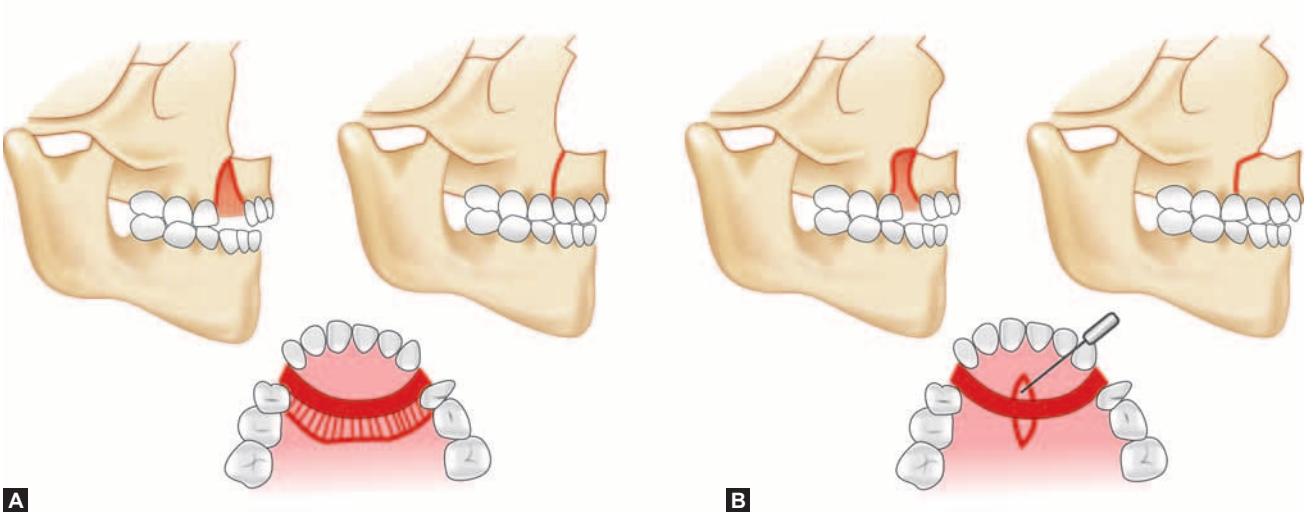


Fig. 27.42: Anterior maxillary osteotomy procedure



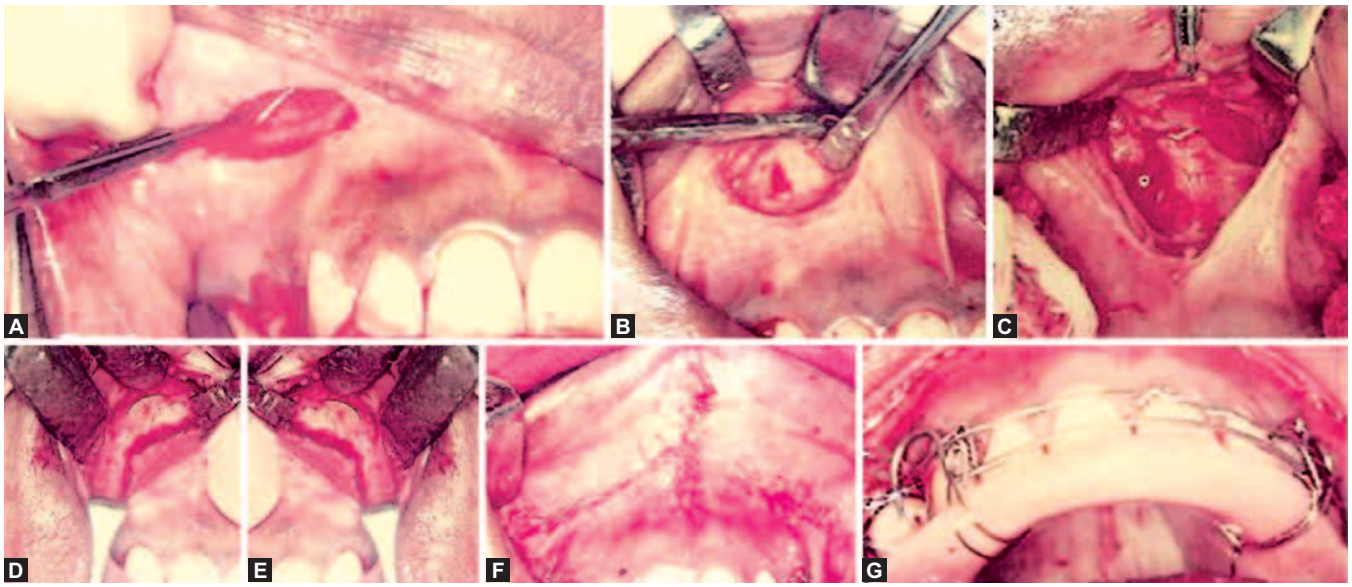
Figs 27.43A and B: (A) Wunderer technique; (B) Wassmund technique

palate be approached by an incision taken transversely across the palate, anterior to the planned osteotomy cut. Bony cut is made through the palatal side by reflecting the incision on either side. The anterior segment is pedicled on the labial mucosa **(Figs 27.43A and B)**.

Köle (1959), Heiss (1963) and Steinhauser (1972), described midline splitting of the maxilla. Epker (1980), suggested a horizontal vestibular incision from premolar to premolar region.

Surgical Procedure (Followed by Dr Malik)

Normally upper first premolars are extracted on either side. In extreme bimaxillary protrusion both first and second premolars can be extracted to achieve the desired setback of the anterior fragment **(Figs. 27.44A to G)**. In presurgical orthodontic phase, if diastema are closed after leaving the residual space behind canines, then that space can be used for osteotomy cuts, with or without first premolar extractions, depending on the need. If first molars are carious and unsalvageable, then the vertical cuts can be taken in that available extraction space. Two separate incisions are taken in the buccal vestibule, which allow the preservation of the maximum soft tissue pedicles. One small horizontal incision is taken in the midline to expose the anterior nasal spine (at the end of the surgery, if this incision is sutured lengthwise, making it vertical, then it will help to increase the upper lip length). Two small horizontal vestibular incisions



Figs 27.44A to G: Anterior maxillary osteotomy. Intraoperative pictures: (A) Intraoral incision; (B) Periosteal elevator at the piriform fossa to protect nasal mucosa; (C) Midline incision to expose the nasal spine; (D and E) Anterior maxillary osteotomy cuts complete; (F) Inverted Y-type suturing for lip lengthening; (G) Prefabricated acrylic splint in position

are taken, one on either side, from canine to first molar region. The mucoperiosteum is elevated superiorly through these incisions to expose the anterior wall of the maxilla and the piriform aperture. Tunneling is done through and through from one side of the incision to another side for achieving proper access and enough mobility for the anterior segment. Careful separation of the nasal mucoperiosteum from the anterior nasal floor and piriform rims is done by using periosteal elevator without tearing the mucosa and without inducing excessive hemorrhage. Inferiorly at the extraction site mucoperiosteum is tunneled till the alveolar crest so that small L-shaped retractor can be placed during osteotomy cuts to prevent damage to the mucoperiosteal flap.

Vertical osteotomies, on the either side using the extraction space are completed through and through the labial and palatal cortices till the level of canine root apices.

A periosteal elevator is inserted along the lateral nasal wall beneath the nasal mucoperiosteum to protect it during the osteotomy cut. The horizontal osteotomy cut is started from the deepest part of the piriform aperture through the anterior aspect of the lateral nasal wall and 5 mm above the canine root apex and towards the superior end of the vertical cut. During this cut, small retractor is used for proper access and protecting the flap. While carrying out the osteotomy cuts from the labial to palatal side with the bur, a finger is maintained on the palatal mucosa all the while and laceration of the palatal mucosa is prevented by using tactile sense. If a midline split of the anterior maxilla is indicated to expand or narrow the dental arch, then it is completed before final mobilization of the anterior maxilla. It is also important to make the osteotomies through the dentoalveolar segment towards the osteotomy site on the opposite side. This allows completion of the transpalatal osteotomies easier. Through the small midline incision, the anterior nasal spine is identified and if it is very prominent, then it can be trimmed using rongeur forceps. The nasal septal osteotome is inserted and angled slightly inferiorly to separate the nasal septum. The osteotome is tapped with the hand pressure posteriorly only to the area of the planned transverse palatal osteotomy. The final mobilization of the anterior maxillary segment is done by placing osteotome transpalatally from the vertical cuts going downward and forward. The finger is constantly maintained on the palatal mucosa to avoid laceration. After completion of the transpalatal osteotomy, the anterior maxilla is downfractured with finger pressure. If significant resistance is encountered, then the bony cuts are checked and completed properly.

Following downfracturing, the nasal crest of the maxilla is removed with large round bur, to prevent deviation of the nasal septum, when the segment is repositioned. If the segment is to be placed superiorly, then the midline of

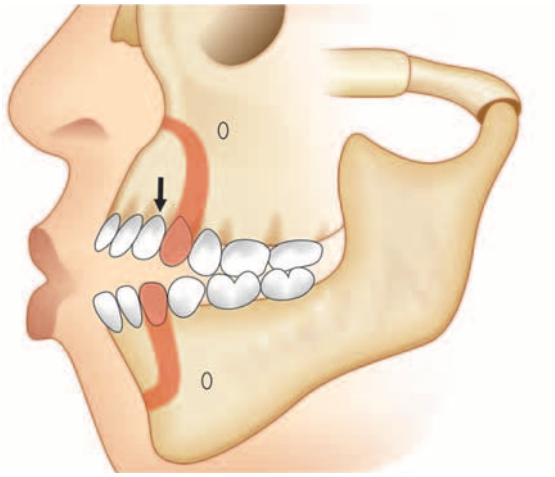


Fig. 27.45: Bimaxillary protrusion can be corrected by anterior maxillary and lower anterior subapical osteotomy procedures

the nasal floor can be grooved further. The occlusal splint is inserted and an attempt is made to place the anterior segment into its predetermined position. If the fragment does not fit properly, then under direct vision the bony interferences are removed selectively. Once the splint is fitted properly, it can be fixed to the maxillary dental arch by interdental wiring. Vertical stability can be achieved by means of intraosseous wiring or bone plates. The two side incisions are closed horizontally with absorbable sutures and midline incision is sutured vertically for lip lengthening. The occlusal splint is kept in place for 3–4 weeks.

Advantages of this Technique

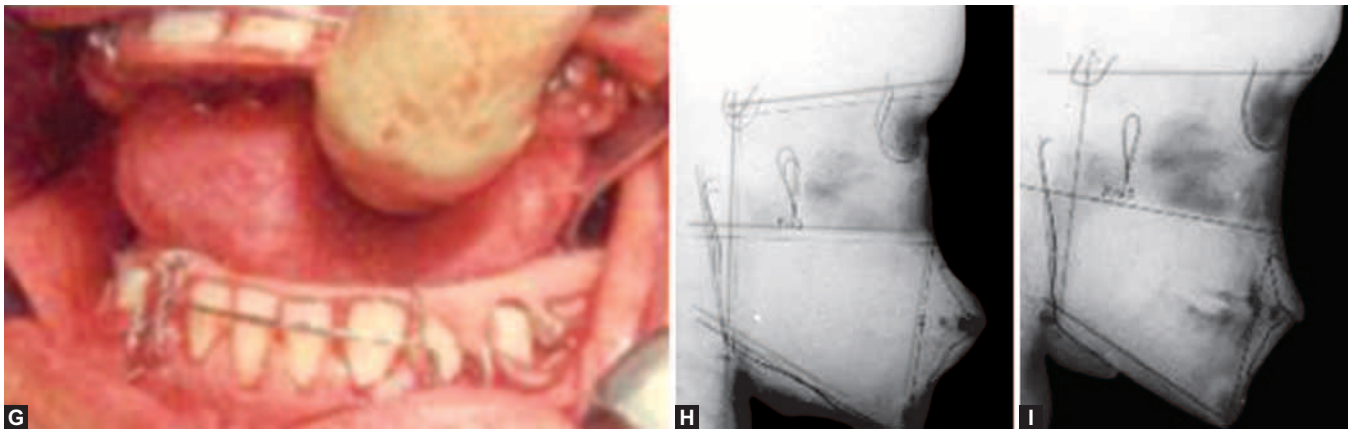
- Simple and versatile procedure **(Figs 27.45 to 27.47)**
- Provides direct access to the nasal crest and nasal septum and prevents buckling of the septum
- Permits removal of the necessary midpalatal bone easily
- Provides an excellent vascular pedicle
- Complete preservation of palatal pedicle.

Posterior Maxillary Osteotomy

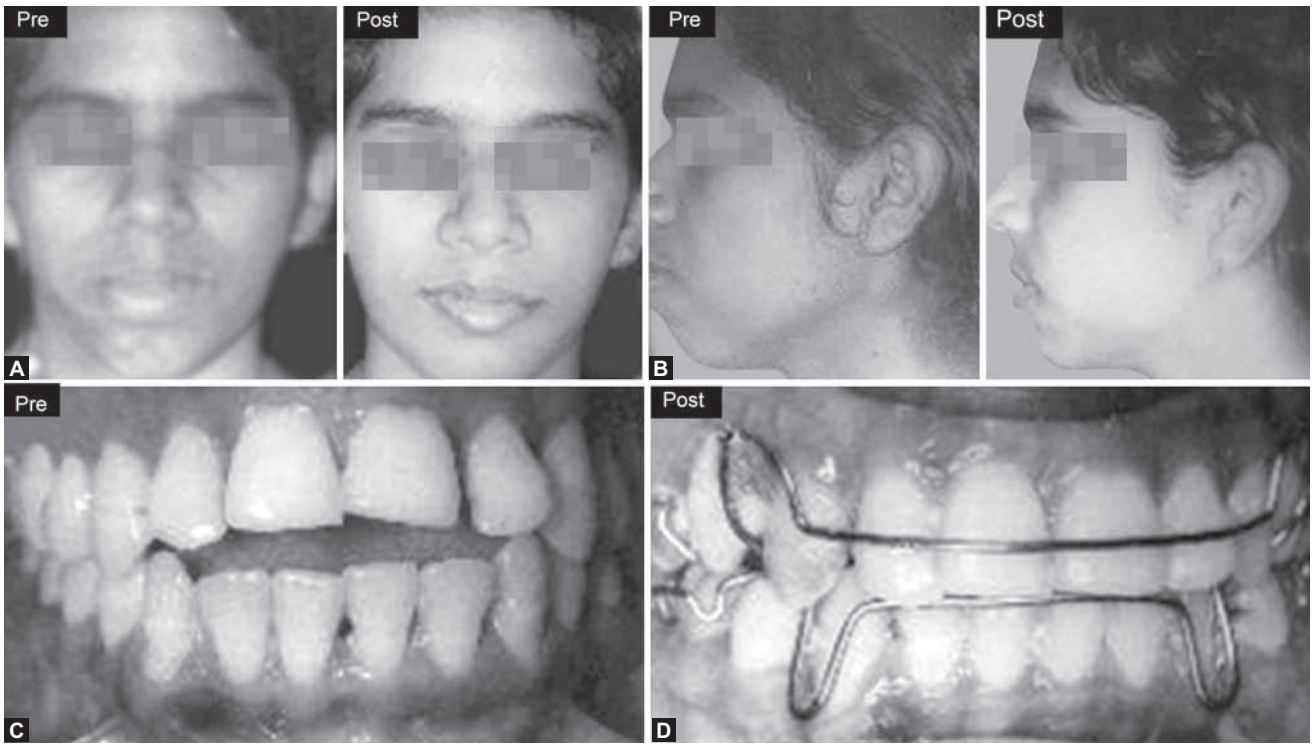
It was originally described by *Schuchardt* in 1959, as a two stage procedure. Now, it is always done as a single stage procedure. The unilateral or bilateral posterior maxillary osteotomy can be used for correction of a wide variety of occlusal and dentofacial discrepancies, which are as follows **(Fig. 27.48A and B)**:



Figs 27.46A to F: A case of bimaxillary protrusion treated with anterior maxillary and lower anterior subapical osteotomy procedures. (A and B) Preoperative front and profile view; (C and D) Postoperative front and profile view; (E and F) Preoperative and postoperative dental occlusion



Figs 27.46G to I: (G) Occlusal splints *in situ*; (H and I) Preoperative and postoperative cephalograms

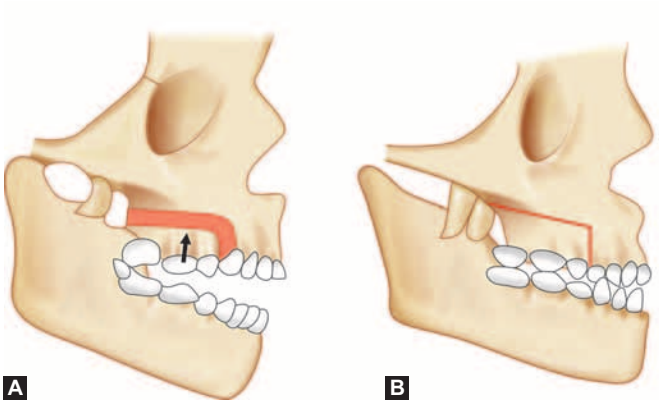


Figs 27.47A to D: Bimaxillary protrusion treated with surgery

- To correct crossbite.
- To superiorly reposition a supraerupted posterior segment.
- To close the posterior open bite by placing it inferiorly, etc.

Access to the osteotomy cuts is taken via a horizontal buccal vestibular incision from the canine to first molar region. The tunneling of the mucoperiosteal flap is done superiorly and inferiorly. By reflecting the mucoperiosteum, lateral maxillary wall and region posterior to the pterygoid plates is exposed.

The level of horizontal osteotomy is marked by scratching with the bur at least 5 mm above the apices of the posterior teeth. The vertical osteotomy cut is done either between the adjoining teeth (interdentally) or by using the extraction site as predetermined. As the



Figs 27.48A and B: Posterior maxillary osteotomy: Schuchardt technique

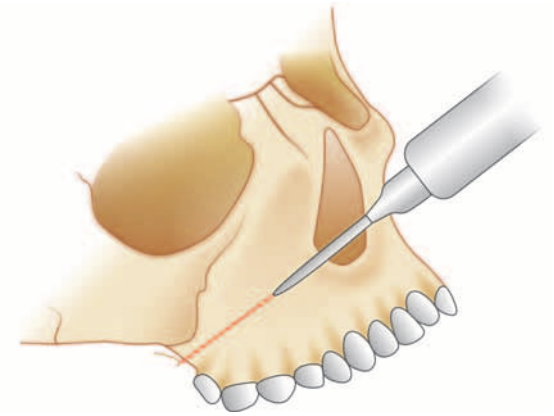


Fig. 27.49: LeFort I osteotomy

horizontal osteotomy extends distal to the second molar, it is tapered inferiorly toward the pterygomaxillary fissure behind the tuberosity region. The horizontal and vertical osteotomy cuts are completed through the palatal cortex by keeping the palpating finger constantly on the palatal mucosa to prevent laceration. Small curved osteotome is used to separate the pterygomaxillary junction and entire posterior segment can be downfractured pedicled on the palatal mucosa. Now the palatal bone can be removed sufficiently under direct vision. After the segment is well mobilized and the planned osteotomies completed, the prefabricated occlusal splint is fitted and wired to the teeth. Direct wire or bone plate fixation can also be done.

LeFort I Osteotomy

The LeFort I osteotomy is another versatile procedure, used frequently to resolve many functional and esthetic problems. This is a very dependable, predictable procedure with low complication rate. Understanding the biological basis of bony osteotomies is very critical. *The revascularization studies of Bell* indicate that the maxilla can be mobilized and repositioned and the healing continues, as long as the mobilized maxilla is pedicled on broad soft tissue base. Excellent healing is observed, even if the maxilla is segmented into multiple pieces. The soft tissues of the palate, lateral pharyngeal walls, buccal mucosa provide the vascular channels for healing. There is a rich, anastomosing collateral vasculature present in the facial area which results in excellent repair and healing **(Figs 27.49 to 27.61)**.

Indications

The deformities of the maxilla coexist in the multiple planes. Therefore, LeFort I osteotomy can be used to tackle the multifold problems either as a single procedure or in conjunction with mandibular osteotomy procedures.

Whenever required, multiple segmentalization of the maxilla, also can be done.

This procedure is used for surgical repositioning of the entire dentoalveolar segment of the maxilla superiorly, inferiorly, anteriorly and posteriorly, while simultaneously segmentalizing it to widen, narrow, level or improve arch symmetry.

Maxillary Advancement

Indications: Post-trauma patients, cleft lip and palate patients, nasomaxillary hypoplasia, in severe mandibular prognathism to reduce the amount of severe mandibular setback.

This can be done along with simultaneous expansion of the maxilla or narrowing of the maxilla by doing additional midpalatal split of the maxilla.

Inferior Positioning of Maxilla

Indications: In cases of vertically deficient maxilla (VMD cases), cleft palate cases, bone grafting is necessary after downfracturing of the maxilla. Bone grafts are secured with circumferential wiring or bone plates **(Fig. 27.50)**.

Leveling of Maxilla

Vertical maxillary asymmetry may be idiopathic, but can be also seen associated with hemifacial microsomia, Romberg's disease, unilateral condylar hyperplasia, TMJ ankylosis, etc. The occlusal plane in these conditions is canted transversely, because of either a lack of vertical growth on one side or excessive vertical growth on the opposite side.

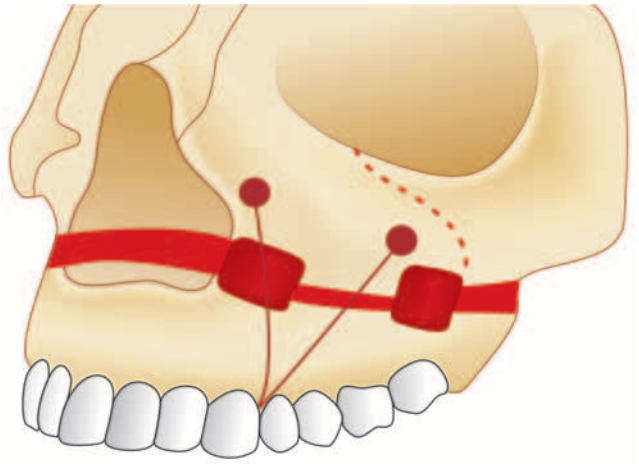


Fig. 27.50: Inferior positioning of maxilla with LeFort I osteotomy, downfracturing and sandwich bone grafts

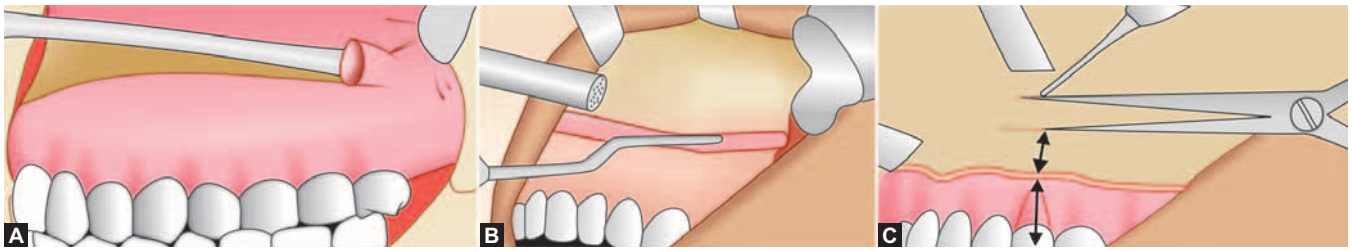
The leveling of the maxilla can be done by:

- Raising up of one side of the maxilla
- Lowering one side of the maxilla
- Simultaneously lowering one side and raising the other side of the maxilla.

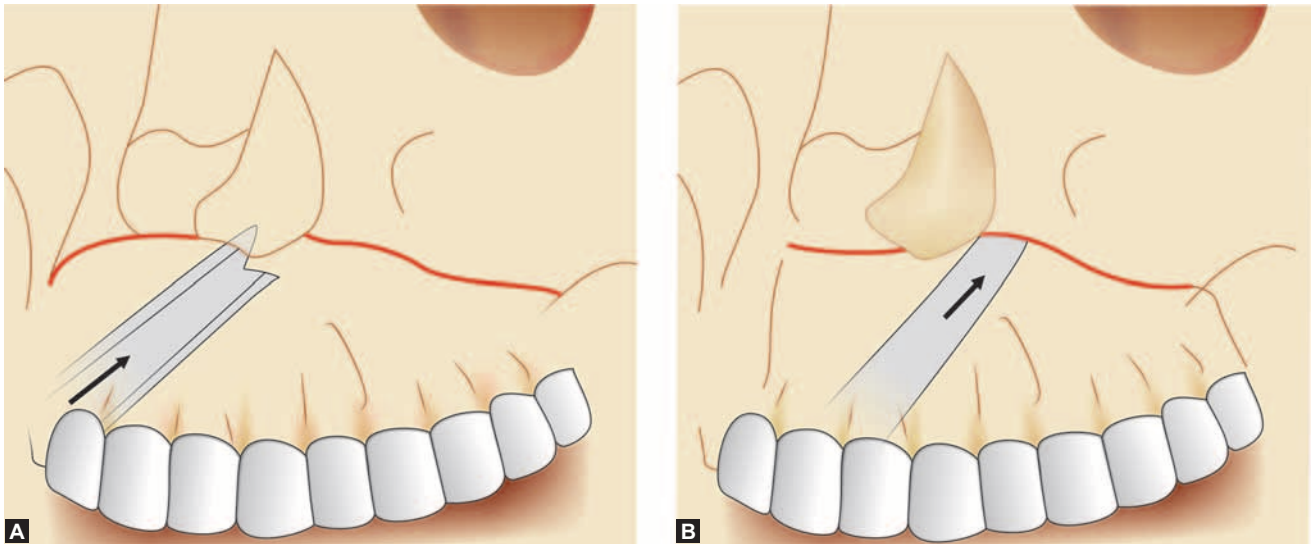
The degree of leveling necessary is determined by the clinical evaluation and the posterior, anterior and lateral cephalometric analysis. In adults, it is always necessary to simultaneously reposition the mandible, when the maxilla is being leveled.

Superior Repositioning of the Maxilla

Vertical maxillary excess (VME) cases with typical "gummy smile" and overexposure of anterior teeth will require superior repositioning of the maxillary dentoalveolar segment **(Figs 27.51 to 27.54)**. VME cases are usually



Figs 27.51A to C: LeFort I osteotomy with superior repositioning of maxilla: (A) After vestibular incision subperiosteal tunneling is done; (B) Visualization of the lateral maxillary wall; (C) Reference marks are scored on the bone



Figs 27.52A and B: Separation of nasal attachments to the maxilla. The septum and vomer are separated from the nasal floor by use of a septal chisel

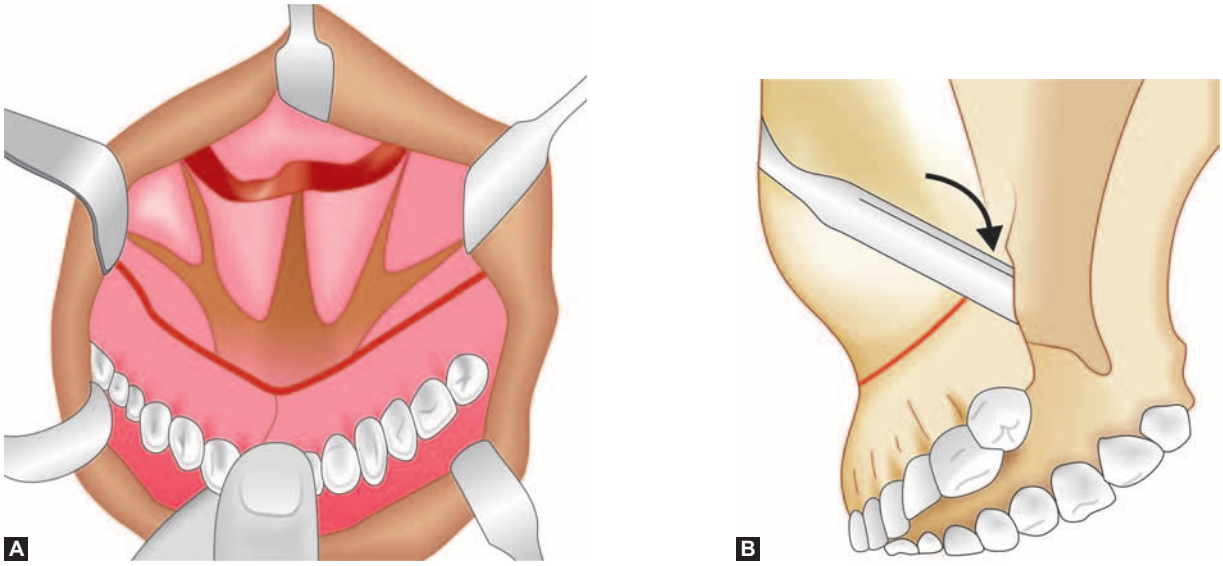
presented with coexisting other deformities of the maxilla or mandible or both, including AP (class II malocclusion), transverse (posterior crossbite) and a vertical (open bite) component. The unique feature of total maxillary surgery or LeFort I osteotomy is that, it permits the simultaneous correction of the vertical, AP and transverse deformities via appropriate repositioning and segmentalization of the maxilla.

Two basic surgical approaches for superior positioning of maxilla:

Superior Positioning of the Entire Maxilla: LeFort I Osteotomy

Indications (Figs 27.51 to 27.56)

- Superior movement less than 5 mm (minor movement)
- Existing functional nasal septal deviation or excessively large inferior turbinates
- Movement of the maxilla as a single unit or minor movement of multiple segments.



Figs 27.53A and B: (A) Downfracture of the osteotomized maxillary dentoalveolar segment; (B) Osteotome at the pterygomaxillary fissure for disjunction or separation of maxilla from the pterygoid plates

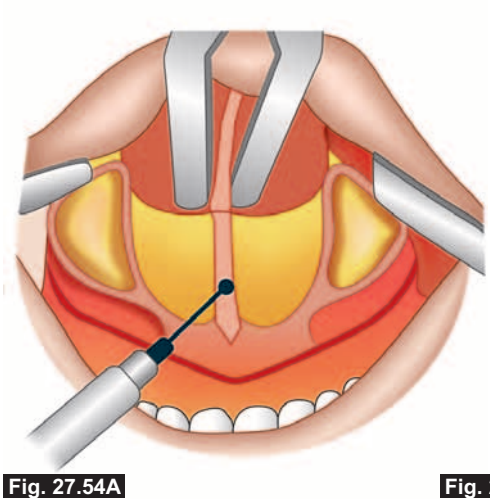


Fig. 27.54A

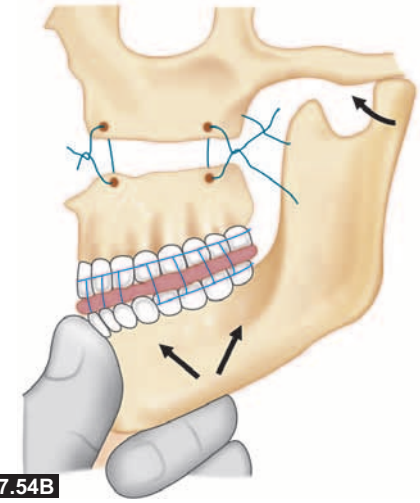


Fig. 27.54B

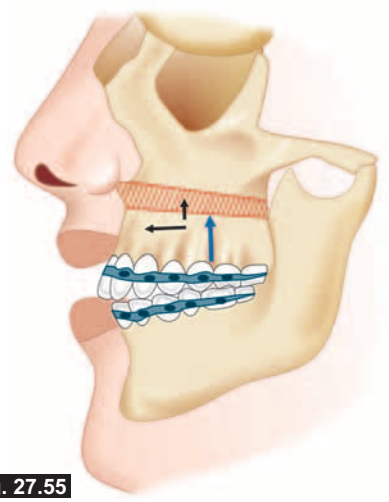


Fig. 27.55

Figs 27.54A and B: (A) LeFort I downfracture. A deep groove is made to accommodate the nasal septum; (B) Guiding the mandible, against the occlusal splint passively and then fixing the fragments with intraosseous wiring. **Fig. 27.55:** Superior positioning of maxilla. Double LeFort I osteotomy

Superior Positioning of the Maxilla Leaving the Nasal Floor Intact

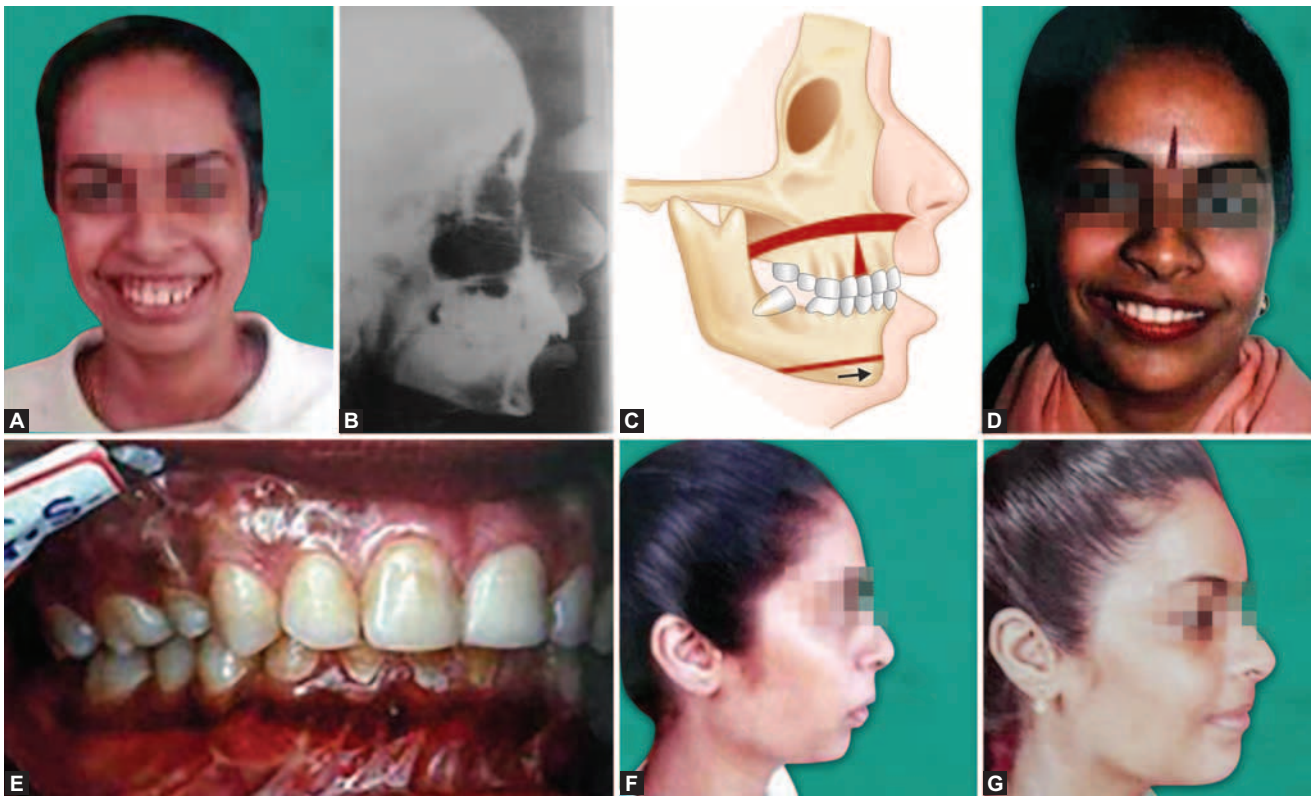
Horseshoe-shaped osteotomy: Modification of LeFort I osteotomy **(Figs 27.57 to 27.61)**.

Indications

- Superior repositioning of 5–15 mm (major movement)
- Pre-existing decreased nasal airway function not related to nasal septum deviation
- Segmentalization of the maxilla into 3–4 pieces with considerable movement of the individual segments.

Surgical procedure—LeFort I osteotomy (Figs 27.51 to 27.55): Whenever the vertical changes are planned, it is critical to place an external reference pin and measure to the reproducible point on the maxillary incisors. This is done by placing a Kirschner wire through the skin and into the bone of the nasal bridge.

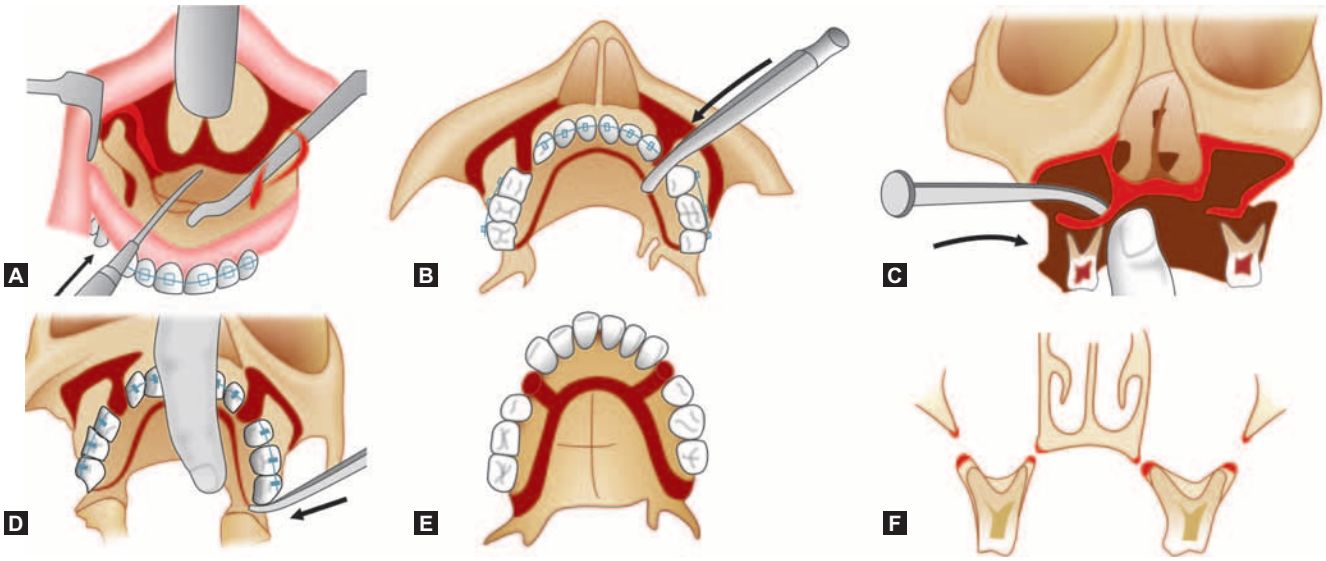
Intraoral circumvestibular incision is placed high in the buccal vestibule and it extends from the zygomaticomaxillary buttress region anteriorly across the midline. At the midline the incision level is lowered than the posterior region. The incision should be through and through from the mucosa till the periosteum. After completion of the incision bilaterally, the mucoperiosteum is elevated from the anterior aspect of the nasal floor and the anterior aspect of the nasal septum is reflected from the vomerine groove with a periosteal elevator, exposing the anterior floor of the nose. The lateral walls of the maxilla are exposed superiorly and posteriorly, tunneling is carried out till the tuberosity region. No tissue is elevated on the inferior aspect of the circumvestibular incision. The nasal mucoperiosteum is then elevated from the lateral nasal wall beginning at the piriform aperture and extending 10–15 mm posteriorly. Once the dissection of the soft tissue is completed, vertical reference points are scratched with the bur at the piriform aperture region, in the canine area and at the zygomaticomaxillary buttress region. Calipers are used to mark a point about 4 mm above the apices of the canine and first molar. These points determine the



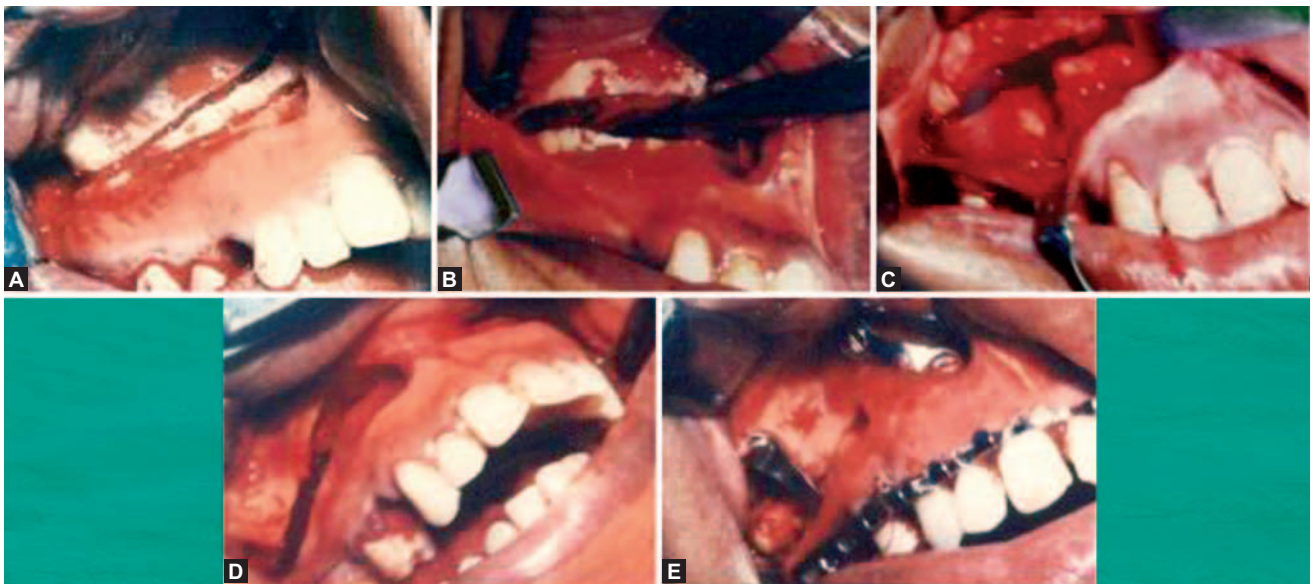
Figs 27.56A to G: LeFort I osteotomy with superior positioning of maxilla for a 27 years old girl with VME, over exposure of gingiva and teeth: (A) Gummy smile; (B) Preoperative ceph. showing VME plus Class II occlusion; (C) Preoperative ceph. planning for superior positioning of maxilla with LeForte I osteotomy along with genioplasty to augment the chin; (D) Postoperative front face. Note the improvement in smile (No gummy smile); (E) postoperative occlusion; (F) preoperative profile; and (G) postoperative improved profile with competent lips

position of the first osteotomy line. If superior positioning is to be done then another line is drawn above the first line at a distance equivalent to predetermined superior repositioning.

The periosteal elevator is inserted submucosally at the depth of the piriform aperture and then the osteotomy cut is started from the lateral wall of the nose, going over the lateral wall of the maxilla, towards zygomaticomaxillary buttress, as the cut extends posteriorly it descends downwards towards the pterygomaxillary fissure. Cut should extend from buccal to palatal bone. After finishing the inferior cut, an identical cut is made superiorly at the predetermined level. The bone in between these two cuts should be removed with the osteotome.



Figs 27.57A to F: Superior positioning of the maxilla leaving the nasal floor intact. Horseshoe-shaped osteotomy. Modification of LeFort I osteotomy



Figs 27.58A to E: A modified LeFort I horseshoe-shaped osteotomy with segmentalization: (A) Double LeFort-I osteotomy cuts only on the buccal cortex; (B) Horseshoe osteotomy being completed with osteotome after bur cutting, leaving nasal floor intact; (C) After upper first premolars were extracted, anterior segmental osteotomy was carried out; (D) Telescoping of maxillary osteotomized segments and anterior segment pushback; (E) Final fixation with bone plating

The same procedure is repeated on the opposite side. Finally, pterygomaxillary dysjunction is done by using a curved osteotome, placed behind the tuberosity. The osteotome should be directed downward and inferiorly and light tapping over it will separate the maxillary segment from the ptergygoid plates. Care should be taken that during this procedure the palpating finger is guiding the separation without laceration of the palatal mucosa. The nasal septum osteotome is used to separate nasal septum. A straight osteotome is used to cut the lateral nasal wall posteriorly. The entire maxilla is then downfractured with either manual manipulation or maxillary mobilization forceps. A deep groove is made in the midline with round bur to accommodate nasal septum or alternatively, the inferior portion of the nasal septum is resected to avoid deviation of the nasal septum. Bony interferences at the lateral wall of the nose, posterior tuberosity area should

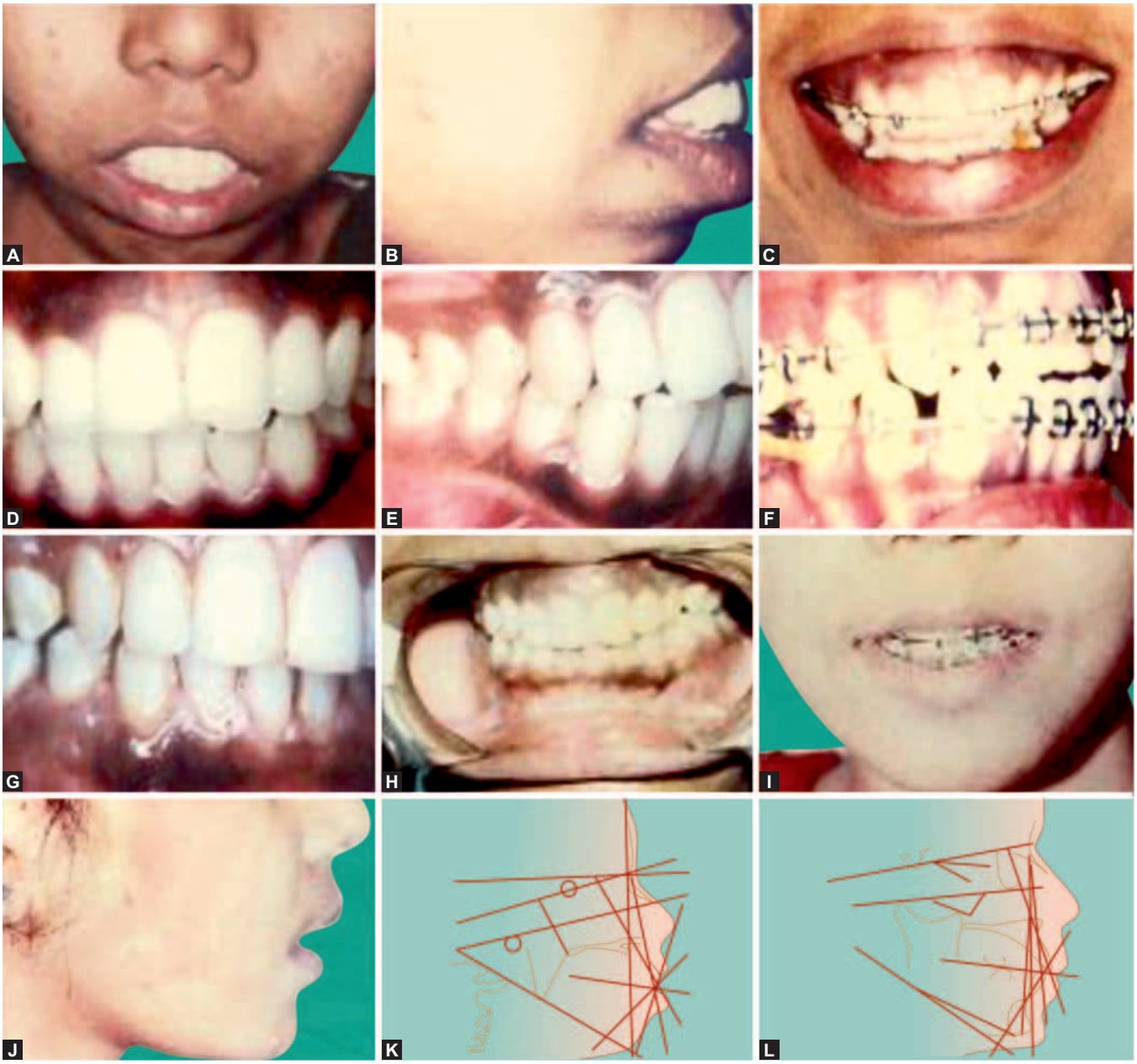


Fig. 27.59: LeFort I osteotomy with segmentalization. Fixation of the fragments is done with L-shaped bone plate and screws



Figs 27.60A to K: Vertical maxillary excess (VME) with open bite case: (A) A 21-year-old female, front face; (B) Incompetent lips; (C) Preoperative profile view; (D) Preoperative occlusion with anterior open bite with spaces; (E) Presurgical orthodontics. No attempt was made to treat the open bite. Spaces closed and gathered behind canine teeth; (F and G) Postoperative front face after LeFort I osteotomy with superior positioning with horseshoe-shaped modification and with anterior maxillary osteotomy; (H) Postoperative profile; (I) Postoperative occlusion; (J) Preoperative cephalogram; (K) Postoperative cephalogram

be trimmed with rongeur and superior positioning of the maxilla is checked. If the maxilla is to be segmentalized, then the vertical interdental osteotomies or osteotomies through the extraction sockets are completed first. The transverse palatal osteotomy can be easily done under direct vision by downfracturing the maxilla inferiorly. After complete mobilization of the maxilla, an occlusal splint is fixed to the osteotomized segment and mandible should be guided passively against the splint, with condyles seated in the fossa. Temporary IMF is done and vertical



Figs 27.61A to L: Vertical maxillary excess (VME) without open bite case. LeFort I osteotomy—horseshoe with anterior maxillary osteotomy. (A and B) Preoperative front and profile views; (C) Gummy smile; (D and E) Preoperative occlusion; (F) Presurgical orthodontics; (G and H) Postoperative occlusion; (I and J) Postoperative front and profile views; (K and L) Preoperative and postoperative cephalograms

correction of the maxilla is checked by measuring the calipers. If required, additional bone can be removed by downfracturing the maxilla and pushing it up superiorly after that. The final fixation is done by means of intraosseous wiring or small bone plates at piriform aperture and at zygomaticomaxillary buttress.

Superior Positioning of Maxilla: Leaving the Nasal Floor Intact (Horseshoe-shaped Osteotomy)

Whenever more than 5–6 mm of superior positioning of the maxilla is required, the nasal cavity size will be reduced and flaring of the alar bases of the nose will be seen with highly unesthetic results. In order to prevent this undesirable outcome, whenever large amount of superior positioning is required, modified LeFort I osteotomy is carried out **(Figs 27.57 and 27.59)**.

Horseshoe-shaped osteotomy of the palatal vault, including the dentoalveolar segment and sparing the central palatal vault intact, will allow maximum amount of superior positioning of the maxilla. Here, telescoping of the posterior segments of the maxilla into the maxillary sinus can be done. The nasal floor is kept intact in spite of maximum superior positioning of the maxilla.

The soft tissue incision and lateral bony wall cuts are same as described earlier. Only after finishing the LeFort I horizontal osteotomy cut through the buccal cortex, vertical interdental or segmental cuts through the extraction sockets are completed. A fissure bur is used to begin the transnasal osteotomy through the palate. A finger is kept on the palate to detect the bur as it perforates the palatal cortex. The transpalatal cut is made systematically beginning anterior to the nasal floor and progressing in a lateral and posterior direction into the medial aspect of the antral floor. The transantral cut is usually extended only till the first molar area, thus avoiding injury to the greater palatine neurovascular bundle. Posterior to the first molar, the palatal bone is relatively thin and it can be easily fractured along the palatomaxillary and pterygomaxillary suture areas with curved osteotome with gentle tapping. The maxilla is thus downfractured excluding the nasal floor. This can be achieved by inserting one or two osteotomes into the transnasal portion of the palatal osteotomy between the stable nasal floor and osteotomized dentoalveolar maxillary segment. Whenever excess superior positioning is required, usually large amount of bone is present vertically between the apices of anterior teeth and the nasal floor. After finishing the anterior segmentalization sparing the nasal floor, a horizontal bony wedge can be removed 5 mm above the canine roots. This will allow maximum vertical superior repositioning of the anterior segment without encroaching the nasal cavity. The rest of the procedure will remain the same as described earlier.

Surgical planning for VME cases: Depending on the severity of the deformity, the surgical planning of VME cases needs different procedures to be carried out. They are as follows:

- – Superior positioning of the maxilla via total maxillary osteotomy.
  - Superior positioning of the maxilla via segmental maxillary osteotomy. Autorotation of the mandible brings the chin forward and upward (no need for mandibular surgery).
- Superior positioning of the maxilla, combined with advancement of the mandible via a ramus osteotomy.
- Same as (2) plus anterior mandibular subapical osteotomy and segmentalization of maxilla.
- Additional genioplasty procedure.

Points to Remember

- Historical development of orthognathic surgery
- Protocol for osteotomies
- Osteotomy procedures
- Mandibular osteotomy procedures
- Maxillary osteotomy procedures.

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CHAPTER 28 Distraction Osteogenesis in Oral and Maxillofacial Surgery

DEFINITION

Distraction osteogenesis (DO) is the technique of bone lengthening in which osteotomized bone is moved apart and there is neo bone regenerate between the two separated bony ends. As defined by Ilizarov, the technique of osteodistraction utilizes body's own repair mechanism for generation of new bone. Along with new bone formation there is regeneration of soft tissues, which includes skin, mucosa, muscle and neurovascular tissues. Therefore, sometimes it is labeled as distraction histogenesis.

PHASES OF DISTRACTION OSTEOGENESIS

There are three phases of DO after the osteotomy of the bone and fixation of suitable distraction device. These are:

- Latency phase
- Distraction phase
- Consolidation phase.

Latency Phase

It allows the initiation of repair cells to form callus at the site of osteotomy. This usually lasts for 3–5 days. In infants and younger patients sometimes it can be started after 1 day and in older patients and after radiotherapy, there may be a waiting period up to 7 days after osteotomy.

Distraction Phase

In this phase, callus formed during latency period is distracted apart with the help of suitable distraction device. The frequency of activation of device is known as rhythm. Rate and rhythm of distraction is important to get good quality regenerate. It is desirable to achieve slow continuous distraction force, which will move bones apart, usually 1 mm in 24 hours. (Rate) The rate can vary from 0.5 mm. to 1.3 mm/day depending on the age of the patient and clinical judgment of a surgeon. Usually, this rate is achieved by activating the distraction device in 2–4 increments of 0.5 to 0.25 mm each. If the process of distraction is too slow, it can lead to early consolidation and if it is done too fast, it can lead to fibrous union.

Consolidation Phase

In this phase of osteodistraction, the callus is allowed to mineralize and gain strength. This may vary from 6 weeks to 12 weeks depending on the length of the regenerate. Once the new regenerate has gained sufficient strength, then the distraction device can be removed and bone is slowly loaded to normal routine activity and physiologic forces.

HISTORICAL BACKGROUND

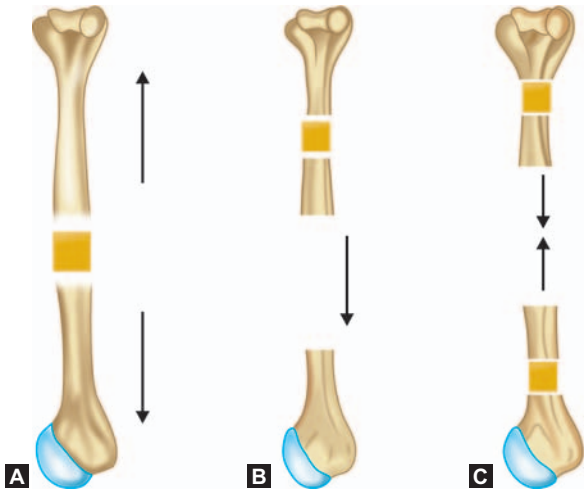
The technique of osteodistraction is not new and it began with the old technique of repositioning and stabilization of bone fractures as used by Hippocrates. Codvilla, in 1905, first published the case report of femoral extension using forces of osteodistraction. The Russian orthopedic surgeon Gavric Abramovitech Ilizarov is known as pioneer in the field of DO, who developed various skeletal fixation devices, techniques and scientific basis for the DO procedure. His basic technical protocols and scientific studies are used as references for DO. Snyder, in 1973, applied the technique of DO in the maxillofacial complex in dogs. Joseph McCarthy of New York University, USA, in 1992, was the first to report the clinical application of DO on human mandible. Polley and Figueroa, in 1997, reported this technique in management of maxillary

hypoplasia with rigid external device. Currently DO is being used for regeneration of bone in craniomaxillofacial region for various indications.

TYPES OF DO

Monofocal Distraction

In this type of distraction, after surgical osteotomy, a distraction gap is created between the two bony ends. This is conventional approach for lengthening of the bones for example in severe mandibular hypoplasia; the mandible is lengthened in a sagittal plane **(Fig. 28.1A)**.



Figs 28.1A to C: Concept of monofocal, bifocal and trifocal distraction. Two segments of bone after osteotomy are separated with the help of distraction device. Callus (yellow colored) is converted into new bone during the consolidation period. (A) Monofocal distraction and callus' (B) bifocal; and (C) Trifocal type of distraction

Bifocal Distraction

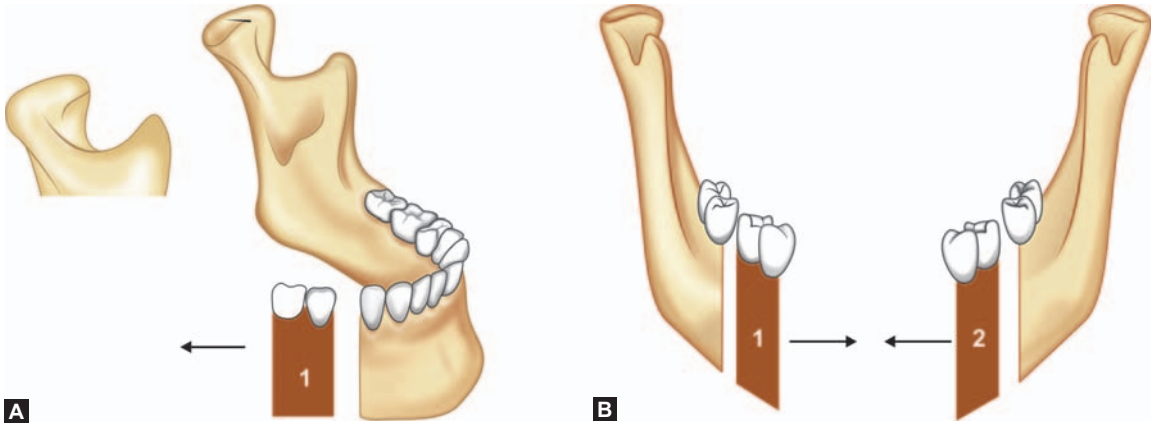
In this type of distraction, a continuity bony defect in a bone is managed by filling the defect with moving a piece of bone from one end of the defect. This moving segment of bone is called transport disk. This approach is used for mandibular reconstruction after tumor ablation **(Figs 28.1B and 28.2A)**.

Trifocal Distraction

In this type of distraction, two transport disks are moved from two sides of bony defect, until these meet in the center. This technique is used for reconstruction of midline mandibular defect after tumor removal **(Figs 28.1C and 28.2B)**.

BIOLOGICAL ASPECTS

After basic osteotomy procedure at the desired site, the appearance of hematoma at the site of osteotomy site with red blood cells, inflammatory cells, fibroblasts, undifferentiated mesenchymal cells and platelets start the healing process. Healing process in DO differs from fracture repair, that there is controlled microtrauma at surgery site and ossification mechanism is truly membranous without any endochondral component. The zones of regeneration are primary mineralization fronts adjacent to osteotomy sites and the fibrous interzone centrally. At the molecular level, there is high concentration of fibroblasts-like growth factors (FGFs)

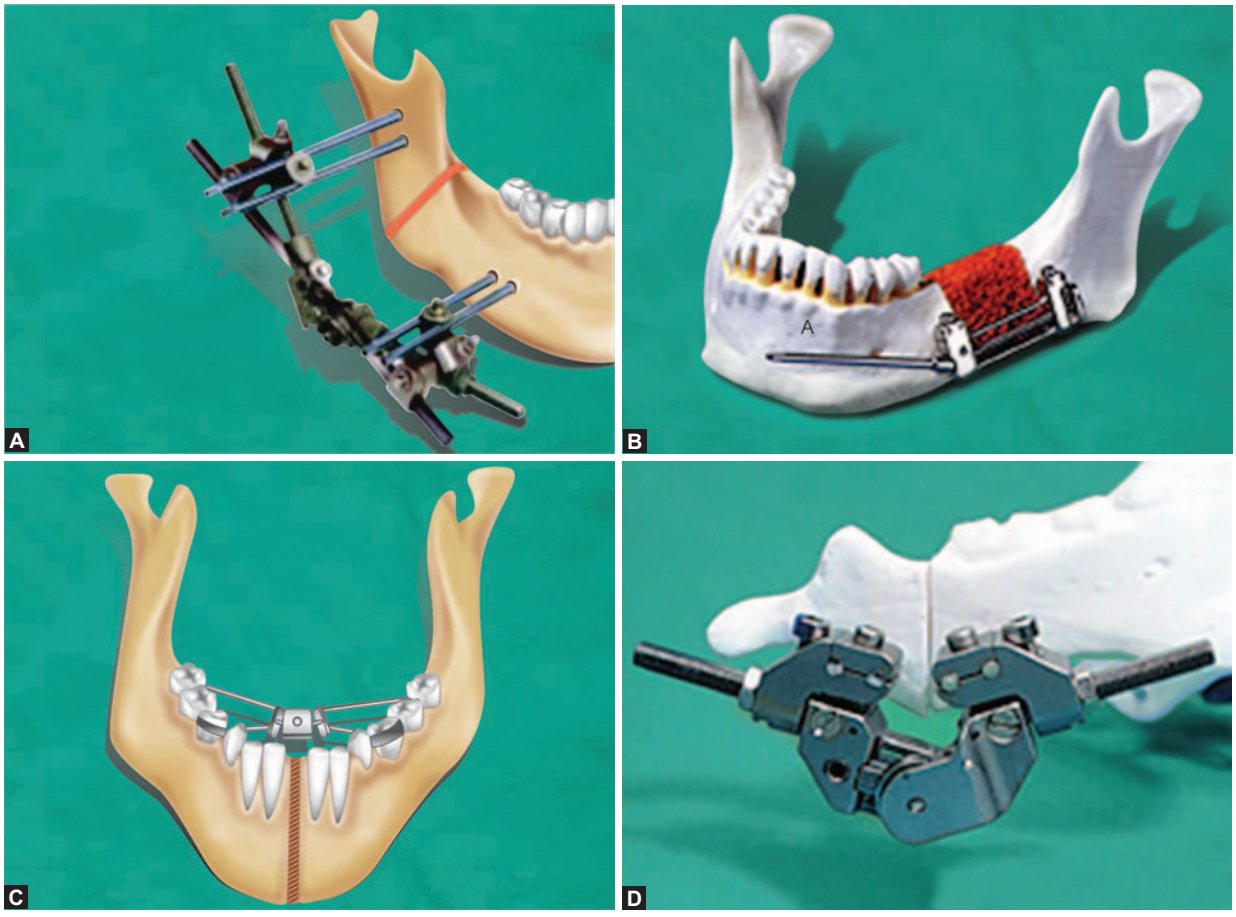


Figs 28.2A and B: Bifocal and trifocal types of distraction as applied to the mandible. Transport disk is pushed to fill the bony defect with new regenerate. (A) In bifocal distraction, there is one transport disk on one end of defect, whereas; (B) in trifocal distraction, there are two transport disks on either side of bone defect

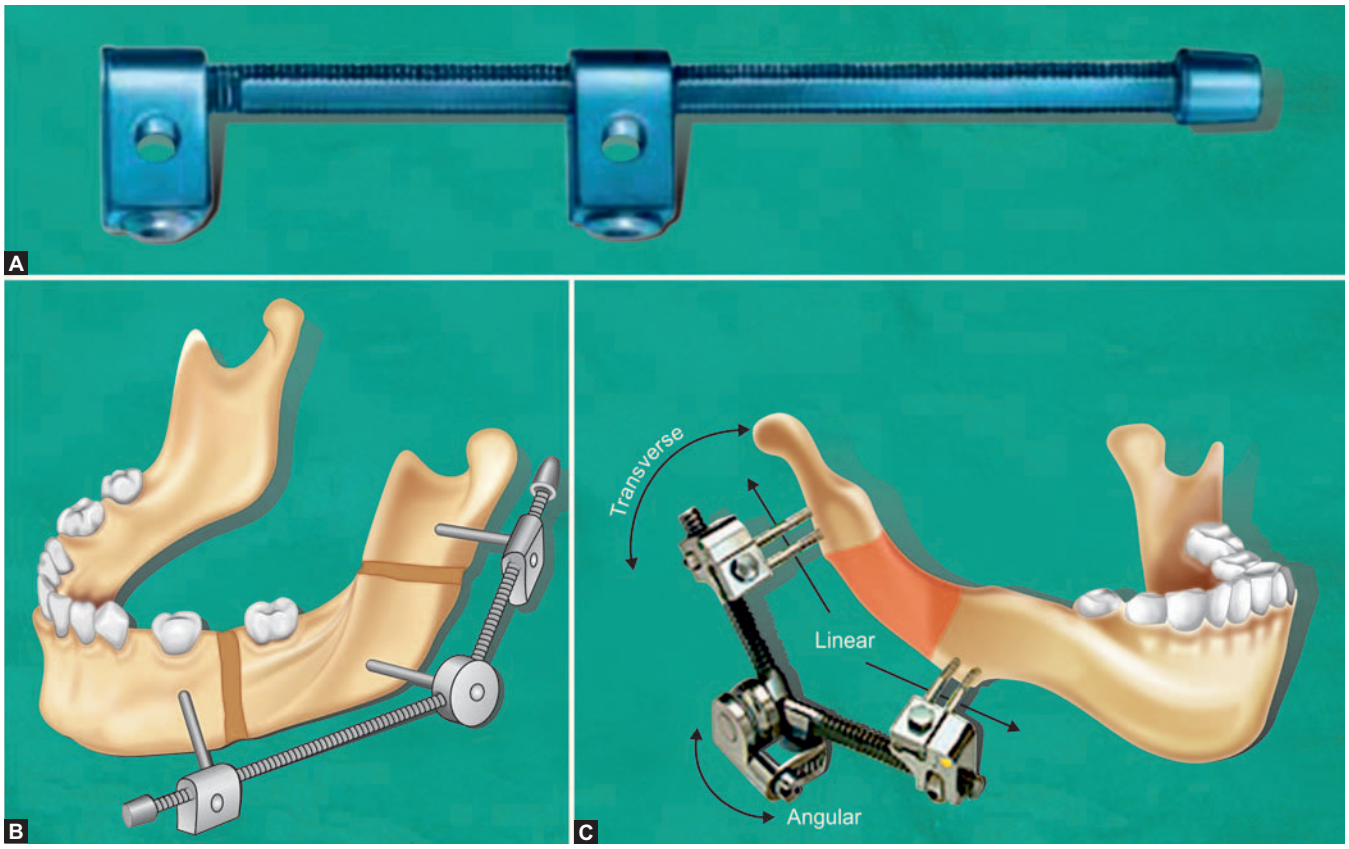
which include FGF1 (acidic FGF), FGF2 (basic FGF) and FGF3 to FGF8, and insulin-like growth factors (IGFs-1) which are important for neoangiogenesis. Transforming growth factors, bone morphogenic proteins (BMP), and platelet derived growth factors (PDGF) and vascular endothelial growth factors (VEGF) are also expressed at the site of osteotomy, due to the tension stress zone caused by process of osteodistraction. These various growth factors, cytokines and intercellular matrix proteins are involved in synthesis, mineralization and maturation of osseous tissues at distraction gap. Their concentration and expression vary during various phases and controls the entire process of tissue histogenesis. Blood flow during the process of distraction increases 8–10 times the normal level, and later it decreases during the consolidation phase. Apart from atraumatic osteotomy technique and vascular supply, other physical factors such as stability of fixation device and rate and rhythm of osteodistraction are very important. Poor stability of the device and greater rate of distraction than 1 mm per day has shown fibrous tissue formation. Peripheral nerves also regenerate at 1–3 mm per day; therefore, it is best to stay at lower limit for distraction. High rigidity and stability at distraction device results in best bone healing.

Devices for M/F Distraction Osteogenesis

Device for distraction known as distractor usually consists of nut and bolt mechanism with a distraction rod, which can be fixed on both ends of the osteotomy. Distraction rod has mechanism by which its length can be increased by activation of device usually by opening the screw. Design of distractor varies depending on the purpose, site, requirement and tissues available for anchorage. These devices can be stock devices made by various manufacturers and chosen by the surgeon or can be custom made piece for a particular patient.



Figs 28.3A to D: (A) showing external (3D External Distraction System KLS Martin Group); (B) Internal distraction device (Submerged intraoral device for mandibular lengthening); (C) Tooth-borne Hyrax device for midsymphysis region; (D) Bone-borne external distraction device (Multivector distractor)



Figs 28.4A to C: (A) Unidirectional mandibular distraction device and (B) bidirectional mandible distraction device, which allows two independent sites of distraction. (C) Multivector device, in which trajectory of regenerate bone formation can be manipulated during the distraction process—Linear distraction (sagittal plane), angular distraction (vertical plane), transverse distraction (coronal plane)

Distraction Devices Classification

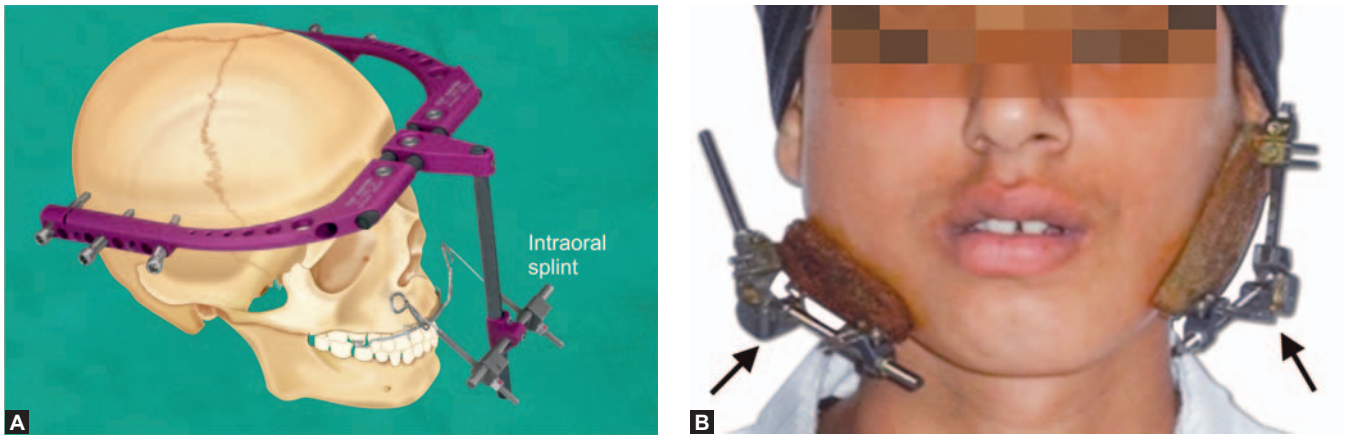
- *Depending on the relation with skin surface—Internal or external devices* **(Figs 28.3A and B and Figs 28.5 and 6)**.
- *Depending upon type of anchoring tissues—Tooth borne or bone born or hybrid* **(Figs 28.3C and D)**.
- *Depending on the vector/direction—Unidirectional or bidirectional or multivector* **(Figs 28.4A to C)**.
- *Depending upon the purpose and site of distraction—Maxillary/mandibular/alveolar distracters etc.* **(Fig. 28.6)**.

External distraction devices: When distractor is placed outside the skin surface and is visible **(Figs 28.5A and B)**. Advantages are: large movements can be achieved, multivector movements can be done and vector can be changed easily. Distraction rods can be replaced and these can be easily removed as outpatient procedure under local anesthesia. However, these can be bulky, lead to facial scars and pin track infections, need for special care, particularly in children and a negative psychosocial impact.

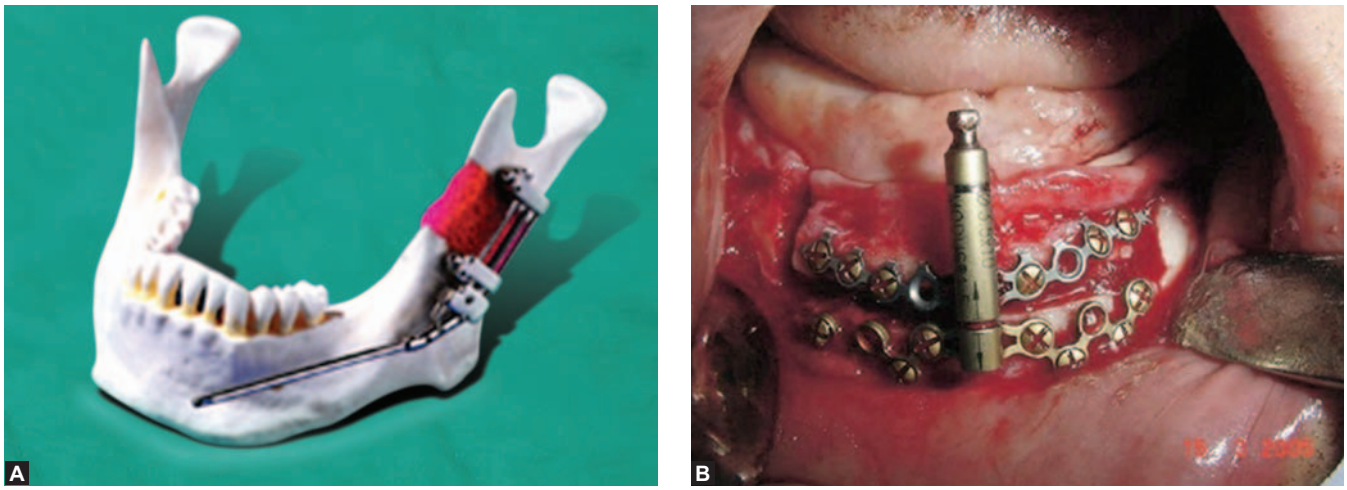
Internal devices: These are buried under skin or mucosa and not visible **(Figs 28.6A and B)**. Only distraction port for activation of device is brought out intraorally or through the skin and these are also known as semi-buried devices. This has got psychosocial advantage over external devices and there can be prolonged consolidation phase. Vector of distraction once fixed cannot be changed and these are difficult to remove and require admission and general anesthesia. Sometimes removal can be more difficult than placement because after activation, there is increase in length of the device and there can be fibrous tissue envelope around it.

INDICATIONS

The patients with large skeletal discrepancies which cannot be managed by conventional orthognathic surgery techniques, because movements required will



Figs 28.5A and B: (A) Rigid external distractor—RED (KLS Martin, Germany); (B) Mandible mutidirectional external distraction device (Depeys Synthes)



Figs 28.6A and B: (A) Submerged intraoral device for mandibular lengthening; and (B) semi-buried alveolar distraction device. Track distractor by KLS Martin (Tuttlingen, Germany)

be too large or will need additional bone grafts to fill the created gap. Large skeletal movements with conventional osteotomies are considered unstable, because of high chances of relapse; such cases can be safely managed by DO. Mandibular advancement beyond 10 mm by bilateral sagittal split osteotomy is considered unstable and there are high chances of relapse. Similarly, maxillary advancement, especially in cleft lip and palate patients, beyond 8 mm has high relapse rate and needs to be bone grafted. These cases can be safely managed with technique of osteodistraction with minimal relapse and without the need of bone grafts.

Similarly, height of ramus and length of body of mandible can be increased; maxilla and mandible can be widened, and alveolar bone before implant placement can be regenerated in height as well as width with the help of osteodistraction. Technique of transport distraction can be used to reconstruct mandibular as well maxillary continuity defects after tumor removal or post-traumatic defects. Similarly, DO technique when applied to cranium vault can be used to treat various patients suffering from syndromic and nonsyndromic craniosynostosis. It is now possible to move craniofacial bones three dimensionally with help of suitable osteotomy and distractor.

MANDIBULAR DISTRACTION OSTEOGENESIS

Technique of DO is being used extensively for regeneration of bone to treat various growth abnormalities in the



Fig. 28.7A: Patient with severe mandible hypoplasia treated with external bilateral unidirectional distraction osteogenesis. Large malocclusion was created by the skeletal movement. Orthodontic treatment was used to correct malocclusion. First row pictures—preoperative facial photos; second row—1 year 3 months postdistraction photos; third row—4 years postdistraction photos

mandible **(Figs 28.7 and 28.8),** which may be seen in syndromic **(Figs 28.9A to F)** and nonsyndromic patients. This technique is also useful for reconstruction of bone in mandibular continuity defects of symphysis, body, ramus and condyle region. Same principles are being used for alveolar bone regeneration before dental implant placement. There is availability of multivector devices by which there is ability to control the regenerate in all the three planes, i.e. horizontally, vertically and mediolaterally.

When there is associated canting of occlusal plane due to maxillary cant, such as in cases of unilateral or bilateral temporomandibular joint ankylosis deformity **(Figs 28.10 and 28.11)**, and hemifacial microsomia **(Fig. 28.12)**. Maxilla can be simultaneously distracted at Le forte 1 level to correct the occlusal cant. This can be achieved by placing separate distractor on the maxilla after osteotomy or by doing maxillomandibular fixation during the mandibular distraction phase. The vertical



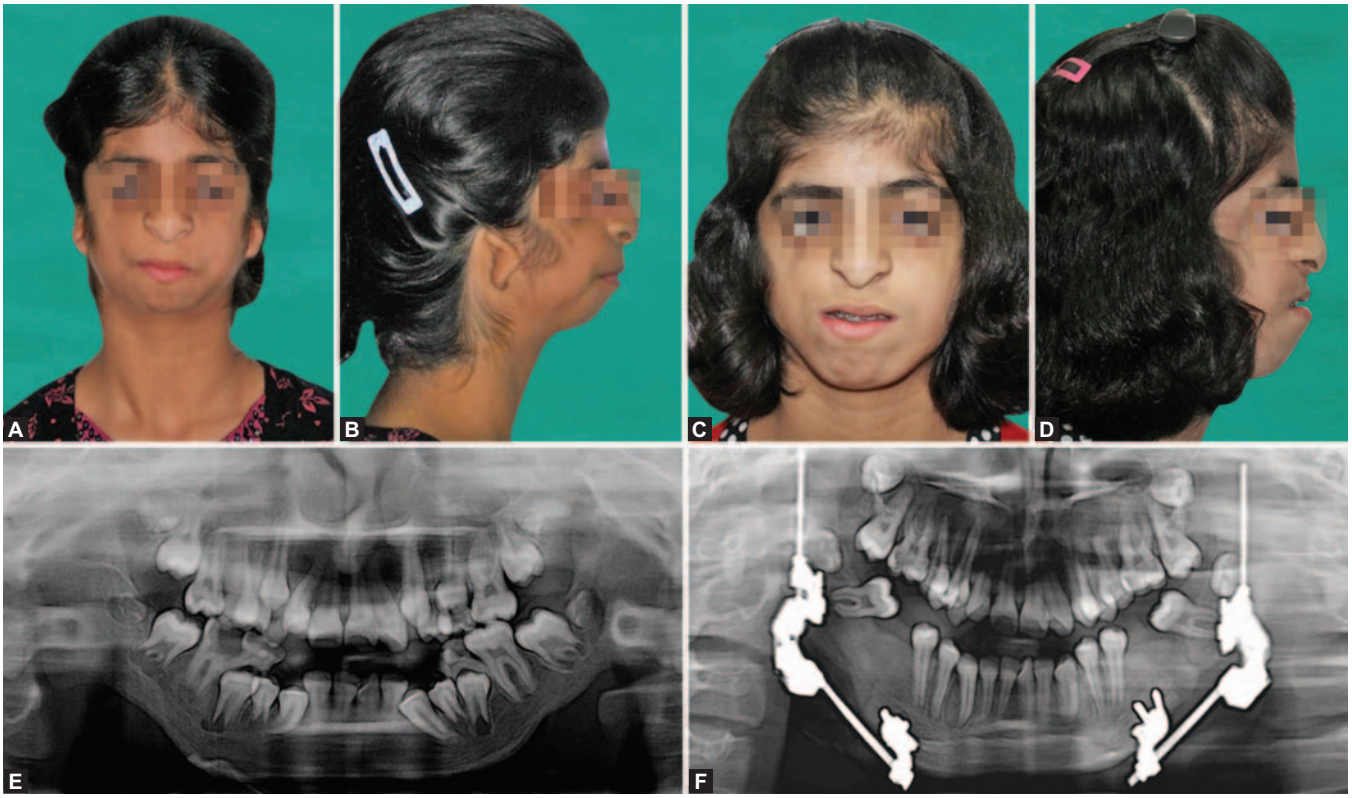
Fig. 28.7B: Intraoral dental occlusion photos of the same patient in Figure 28.7A. First vertical row—pretreatment photographs showing severe positive overjet due to severe retrognathia; second row—postdistraction, and third row—postorthodontic treatment photographs showing correction of retrognathia and malocclusion



Figs 28.8A to D: (A to C) A 12-year-old boy had unilateral mandibular distraction for correction of facial asymmetry due to hypoplastic left mandible; and (D) Reappearance of asymmetry after 18 months due to active growth of contralateral condyle



Figs 28.8E to H: (E) Second phase of distraction (vertical maxillomandibular) at 19 years of age and correction of facial asymmetry; and (F to H) dental malocclusion being corrected



Figs 28.9A to F: (A and B) Patient with Treacher Collins syndrome with severe retrognathia and malar deficiency treated with bilateral mandible distraction with multidirectional distraction device; (C and D) Post-treatment photographs; (E) Pretreatment OPG; and (F) OPG shows correction of mandible hypoplasia. Patient is waiting for maxillary distraction and zygoma reconstruction



Figs 28.10A and B: (A) Pretreatment—patient with post-temporomandibular joint ankylosis deformity treated with external unidirectional mandible distraction; (B) Post-treatment—post-treatment photographs show correction of mandibular asymmetry to great extent

movement on nonaffected maxilla is avoided by fixing the bone with wire or bone plate on nonaffected site. There is significant improvement in facial asymmetry **(Fig. 28.13)**. Advancement of mandible leads to significant increase in pharyngeal airway. Therefore, this technique is helpful in obstructive sleep apnea cases due to micrognathia. The DO has been used for relieving airway obstruction in Pierre Robin syndrome cases also in neonates and infants. Mandible can be widened to treat crowding of anterior teeth **(Fig. 28.14)**.

Large osseous movements during DO can lead to severe dental malocclusion. Therefore, these patients need long phase of active orthodontic treatment. The orthodontist has a great role to play in DO. The orthodontist should be involved from the very beginning at preoperative planning stage, when dental malocclusion is anticipated. Some patients also benefit from predistraction orthodontic treatment, in which dental arches are aligned and prepared as in orthognathic surgery cases.

MAXILLARY DISTRACTION OSTEOGENESIS

The maxillary DO has revolutionized the management of severe skeletal maxillary hypoplasia in cleft lip and palate deformities **(Fig. 28.15 and 16)** and various syndromic cases such as Crouzon **(Figs 28.17 and 28.18)** and Apert syndromes. Usually, there is sagittal maxillomandibular skeletal discrepancy in these cases due to poor growth potential of maxilla. When this discrepancy is more than 8 mm then results with distraction are more stable as compared to orthognathic surgery. Rigid external distractor is work horse for DO of midface at Le forte I, II, III and monoblock advancement **(Fig. 28.15)**. Many internal distraction devices are also gaining popularity **(Figs. 28.19 and 28.20)**.



Figs 28.11A to C: (A) Patient with history of bilateral surgical release of the temporomandibular joint ankylosis in February 2008, came with chief complaint of backwardly placed lower jaw and inability of the teeth to meet, is a case of Class II skeletal bases with hyperdivergence with anterior open-bite and proclined upper and lower incisors, constricted arches with posterior cross bite; (B) Post-treatment and postdistraction photographs; (C) Series of lateral cephalograms show correction of mandible hypoplasia and malocclusion



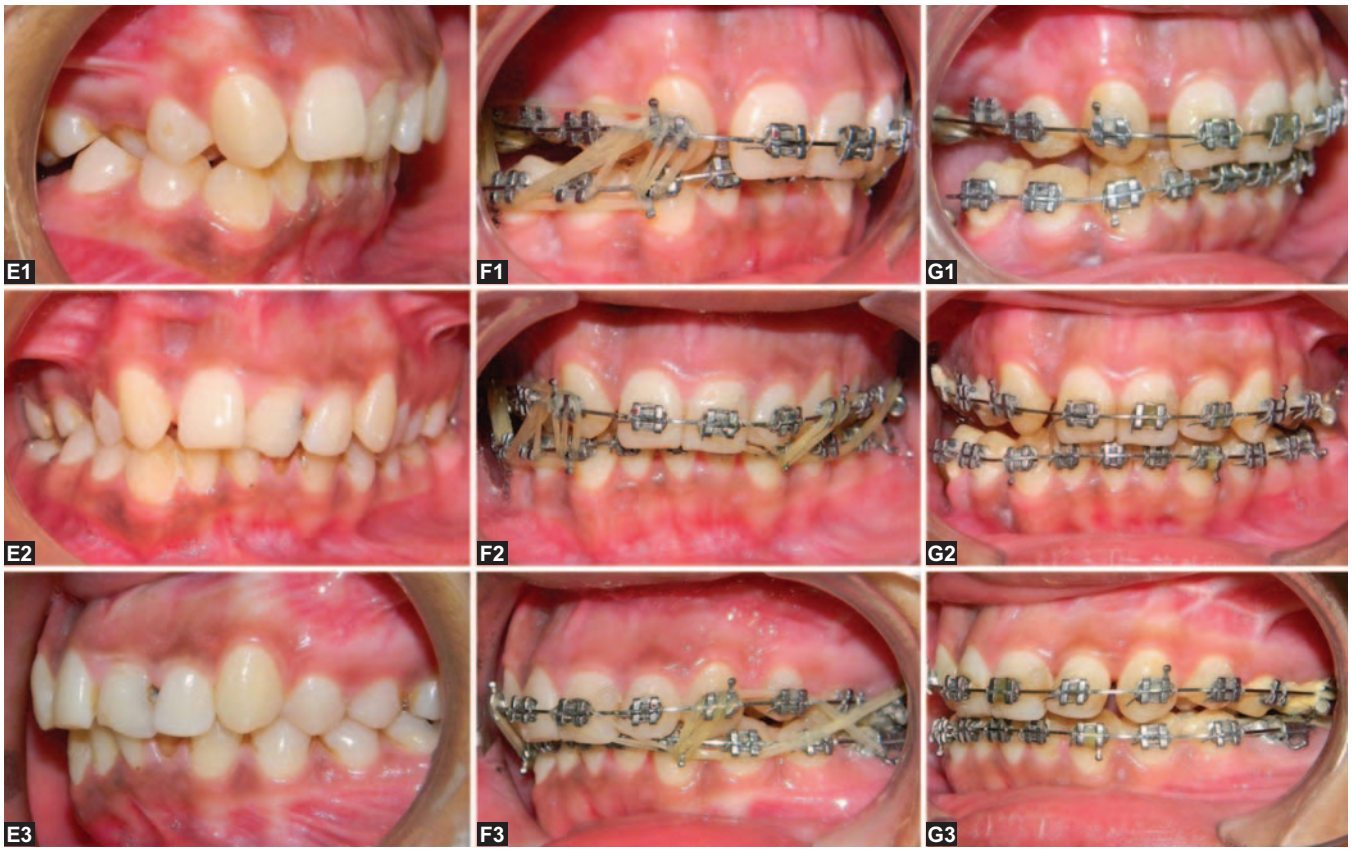
Figs 28.12A to C: Patient with hemifacial microsomia in Oct. 2009; (B) Patient`s photographs after two years watching growth; (C) Patient treated with unilateral distraction of the mandible



Fig. 28.12D and E: (D) Post-treatment and postdistraction photographs; and (E) Orthopantomograms show correction of mandible hypoplasia. She will need second phase of orthodontic treatment after growth completion



Figs 28.13A to D: Patient with post-temporomandibular joint ankylosis deformity treated with simultaneous distraction of the maxilla at Le fort I level and unilateral mandibular distraction to correct occlusal cant: (A) Preoperative facial asymmetry; (B) Mandibular distraction device; (C) Preoperative occlusal cant; and (D) Postoperative correction of occlusal cant and post treatment photograph shows correction of facial asymmetry



Figs 28.13E to G: (E1 to E3) Preoperative malocclusion; (F1 to F3) Midstream orthodontic treatment; and (G1 to G3) Occlusion correction after distraction and orthodontic treatment



Figs 28.14A to G: Mandible transverse deficiency can be corrected by osteotomy in symphysis region of mandible and placement of tooth born mandibular distraction device. Space gained with distraction was utilized to align crowded teeth orthodontically

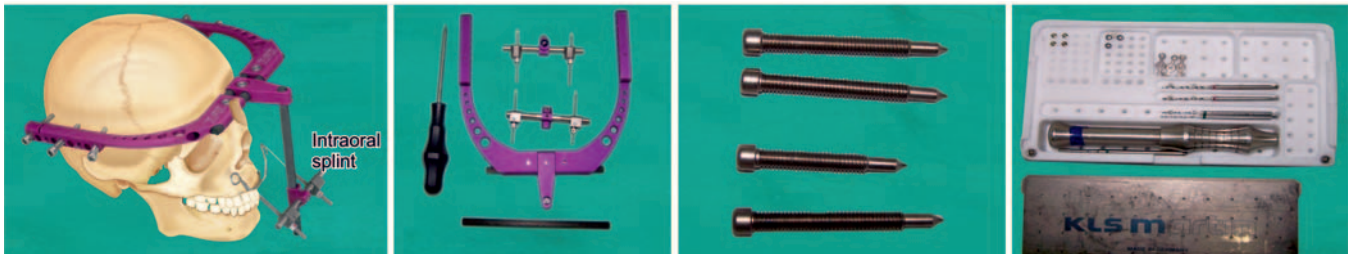
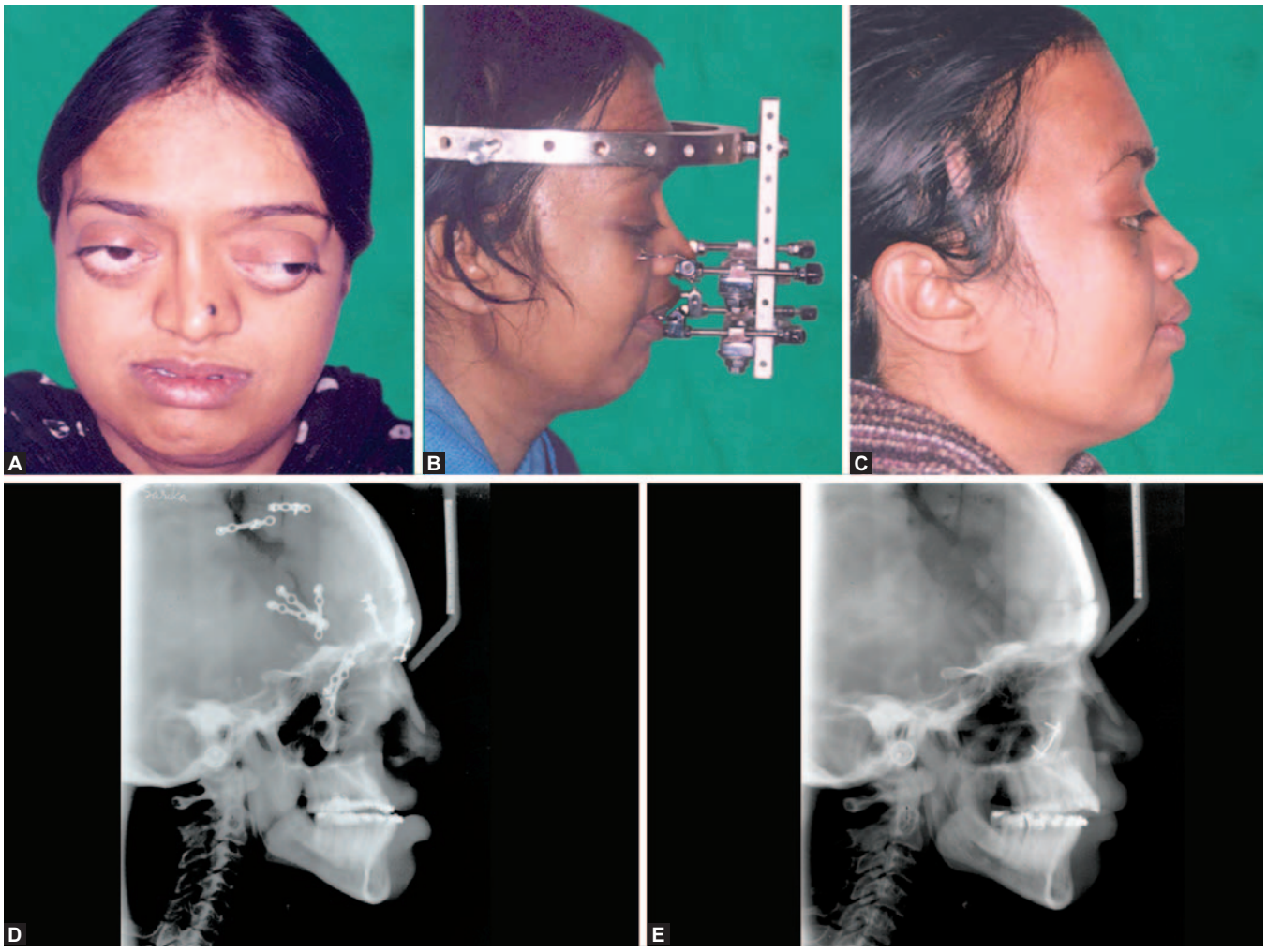


Fig. 28.15: Rigid external distractor (KLS Martin, Germany) can be used for distraction osteogenesis of midface performing Le forte I, II, III osteotomies, depending on the level of correction needed and monoblock advancement



Figs 28.17A to E: Technique for distraction for severely hypoplastic maxilla with RED: (A) Patient with crouzon syndrome with midface deficiency; (B) Treated by simultaneous distraction at Lefort I and III levels; (C) Postoperative photograph; and (D and E) Lateral cephalogram shows correction of midface deficiency

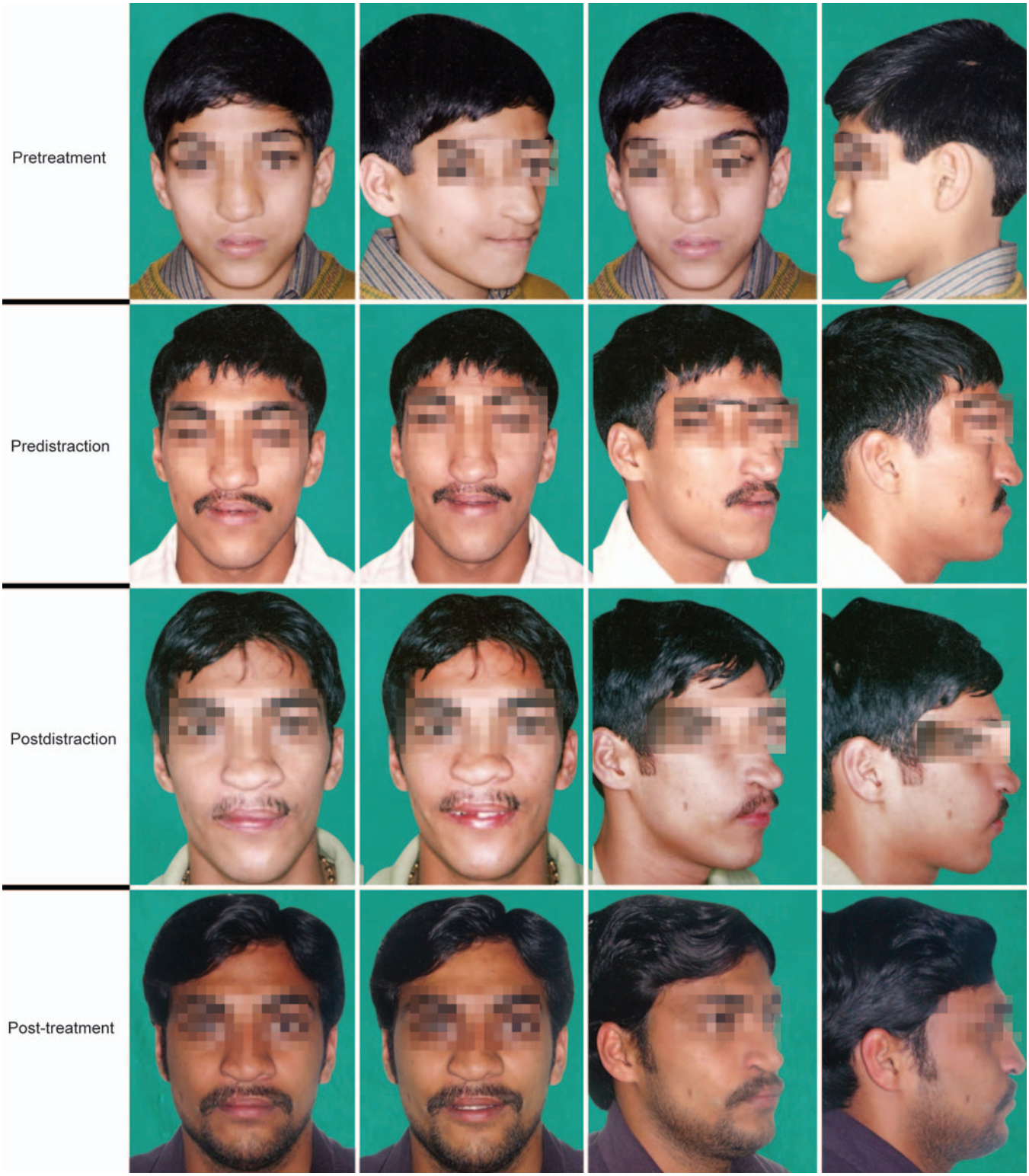


Fig. 28.16: Patient with hypoplastic maxilla due to unilateral cleft lip and palate deformity, treated by distraction at Le fort I level. Post-treatment photographs showing correction of maxillary hypoplasia stable result after 4 years

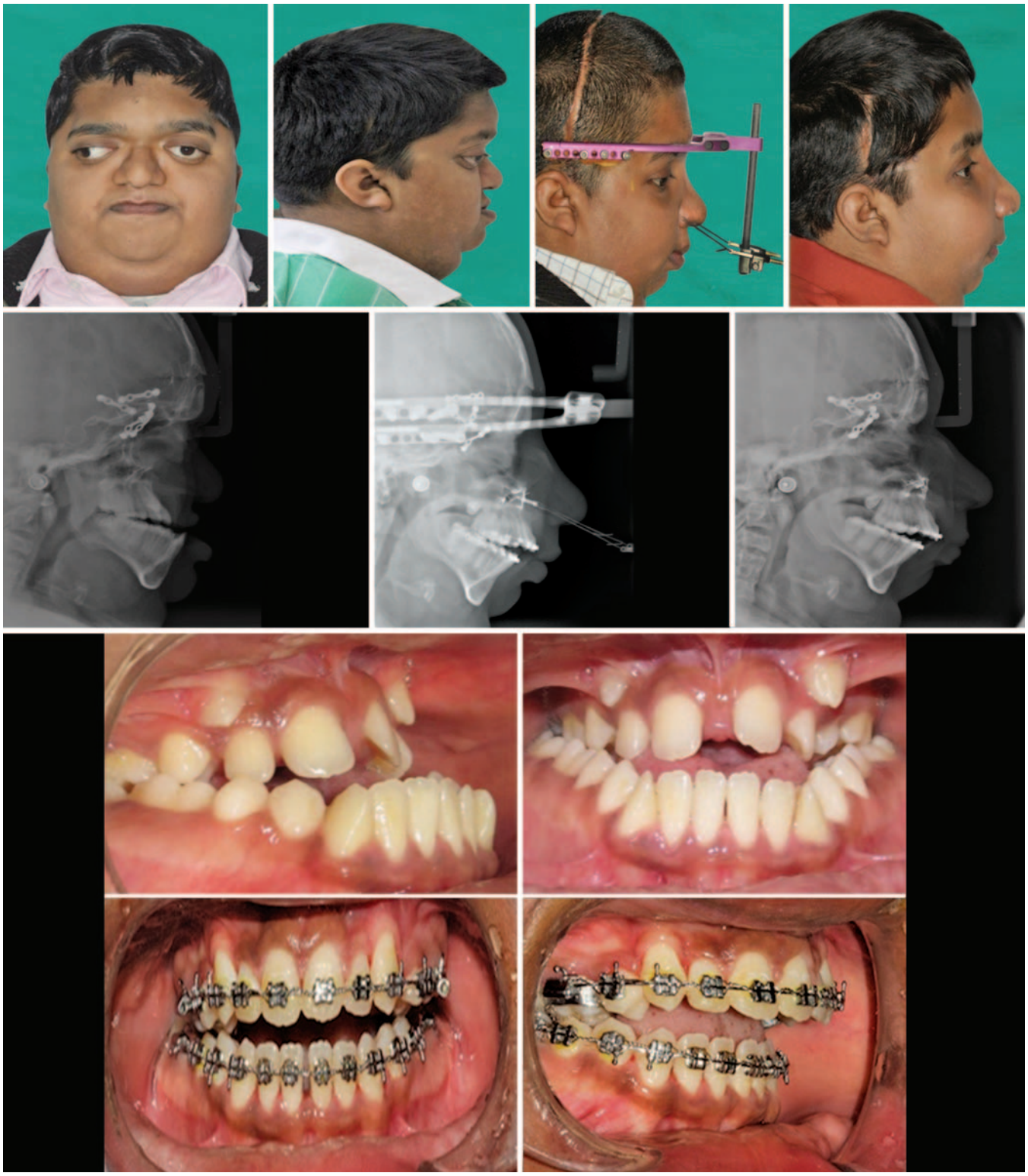


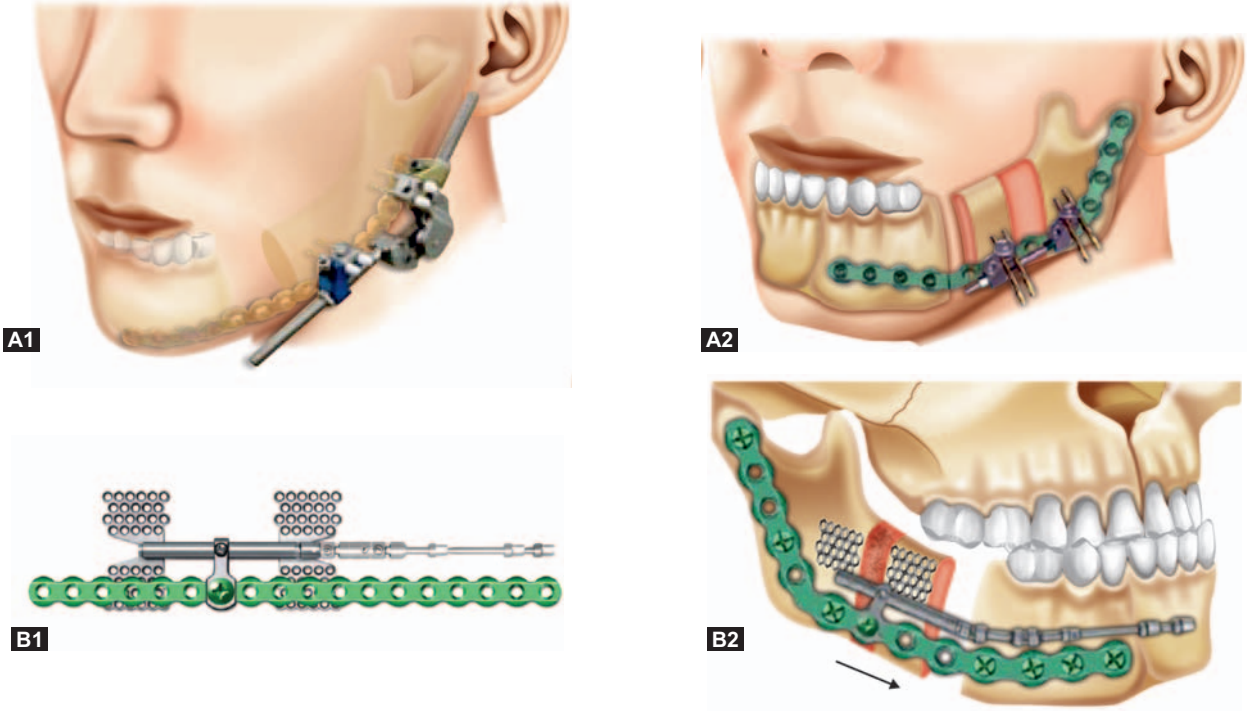
Fig. 28.18: A case of Crouzon's syndrome with proptosis, and midface retrusion and difficulty in breathing (severe obstructive sleep apnea). He had undergone fronto-orbital advancement in 2001. Tracheostomy was done in 2013 due to obstructive sleep apnea and severe chest infection. Le fort III osteotomy was done and distraction was carried out with RED device



Fig. 28.19: Patient with severe maxillary hypoplasia of more than 2.5 cm and treated by distraction of maxilla at Le fort I level and mandibular set back by sagittal split osteotomy



Fig. 28.20: Distraction of maxilla in post-traumatic midface deficiency and malpositioned maxilla due to poor management of trauma at initial phase of management. Distraction at Le Fort I level was done with external distractor to correct this post-traumatic deformity



Figs 28.21A and B: Distractors for mandibular transport disk distraction osteogenesis (TDDO). A-1 and A-2—External distractor by Depys Synthes for TDDO of mandible; B-1 and B-2—Internal distractor by KLS Martin for mandibular TDDO

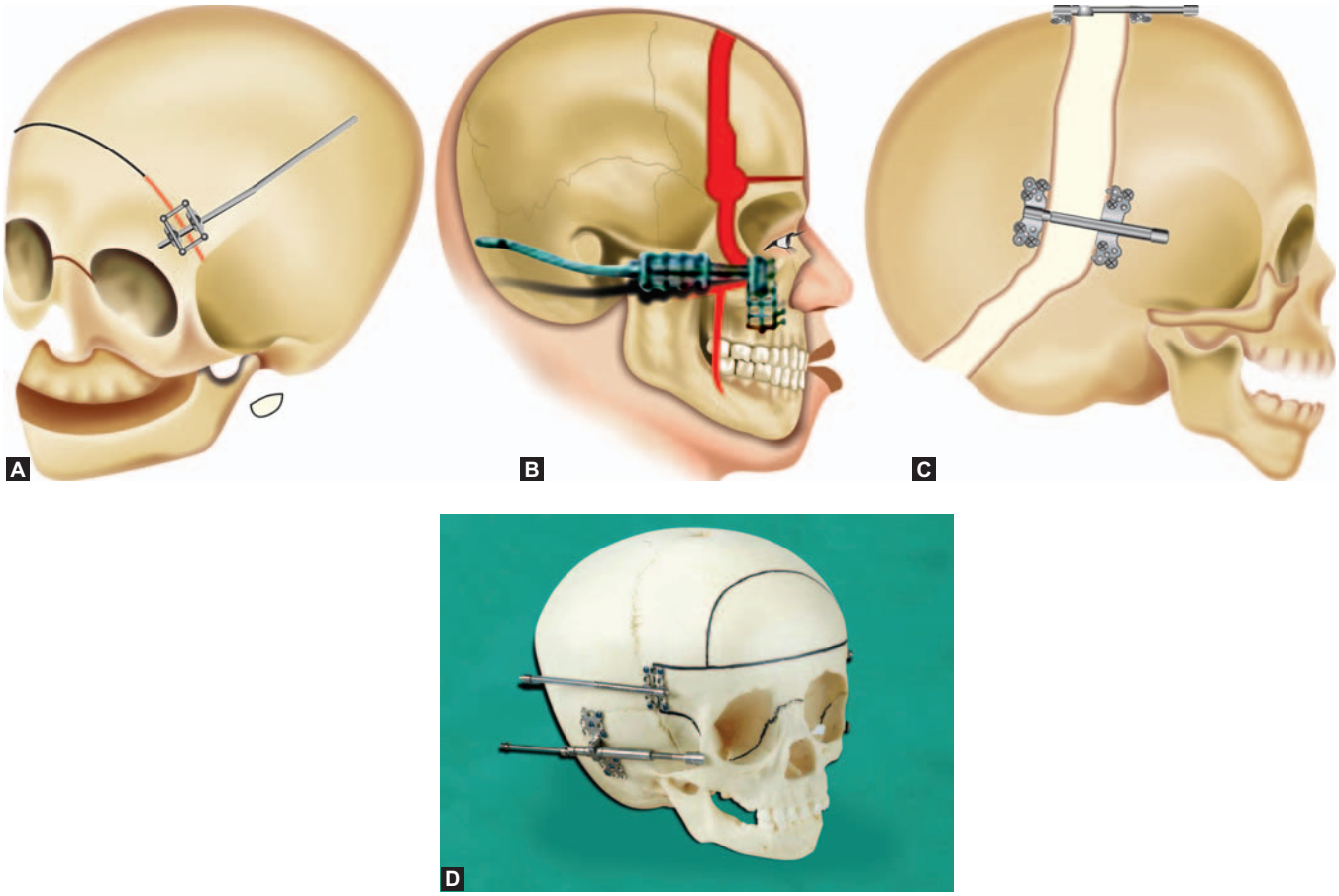


Courtesy: Dr Kumar Nilesh

Fig. 28.22: A 54-year-old patient with plexiform ameloblastoma in anterior mandible region was treated with excision of the lesion and creating a continuity defect from right second premolar to left first premolar. The transport disks were created on both sides, with right side containing first and second molar teeth, while left side of the transport disk contained second premolar tooth. Transport distraction was done for 40 days, at the rate of 0.75 mm/day. After consolidation period of 4 months, the distraction device was removed. Prosthetic rehabilitation was done by tooth supported overdenture

TRANSPORT DISK DISTRACTION OSTEOGENESIS

In transport disk distraction osteogenesis (TDDO) a small segment of bone is used as transport disk to get new bone formation. In maxillofacial region, technique of TDDO can be used to reconstruct mandibular continuity defects, maxillary and zygomatic defects. In cleft lip and palate deformity, it can be used to decrease alveolar cleft width. In mandibular continuity defects, DO can be used in bifocal and trifocal manner to regenerate the lost bone. Various devices are available based on taking guidance from mandibular reconstruction plate **(Figs 28.21A and B)**. **Figure 28.22** shows case of mandibular defect treated by TDDO. Customized distractor based on three-dimensional model of the patient can be also fabricated for patient specific needs.



Figs 28.23A to D: (A) Frontal distraction for coronal synostosis; (B) Monoblock advancement when midface is also retruded; (C) Posterior cranial distraction; and (D) Marchac temporal distractors (KLS Martin) Arnaud Cranio-orbital distracters

CRANIAL DISTRACTION

Volume of cranial vault can be increased by DO in syndromic and nonsyndromic craniosynostosis. There is increased intracranial pressure–IPC due to lack of growth of cranial vault caused by fusion of cranial sutures. Brain size increases rapidly in growing infants and due to fusion of sutures there is cranial deformation, copper beaten skull due to raised intracranial pressure, and herniation of brain through foramen magnum (known as Arnold Chiary malformation). These are life-threatening conditions and require urgent intervention. Technique of DO is quite handy in increasing the cranial vault volume. The osteotomies are made parallel to fused sutures and cranial distractors are applied across it to move the two segments apart **(Figs 28.23A to C)**. The technique of DO decreases the complexity of procedure, no bone grafts are required, requires less time and less blood replacement than conventional surgery. Therefore, DO may be preferred technique over conventional osteotomies in certain complex syndromic craniosynostosis cases.

Points to Remember

- Definition of distraction osteogenesis
- Phases of DO
- Types of distraction
- Biological aspects of DO
- Various devices for DO
- Indications for DO
- Clinical applications of DO.

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Section 7

Maxillofacial Trauma

29. Basic Principles for the Management of Maxillofacial Injuries
30. Injuries of the Maxillofacial Skeleton
31. Fractures of the Middle-third of the Facial Skeleton
32. Principles of Treatment of Midfacial Fractures
33. Applied Surgical Anatomy of the Mandible and Classification of Mandibular Fractures
34. Management of Mandibular Fractures
35. Fractures of the Condylar Process and Its Management

CHAPTER 29

Basic Principles for the Management of Maxillofacial Injuries

INTRODUCTION

In view of the large and ever increasing number of facial injuries, it is mandatory for each clinician to have at least some knowledge regarding the primary care and proper referral. Each person subjected to the ordinary risk of everyday life, is a potential candidate for trauma to the face. Various methods for handling maxillofacial trauma have been evolved after the mass casualties, which resulted from world wars.

No fixed protocol can govern the treatment of an injured individual, but fundamental principles of treatment with sound surgical basis should be always followed.

- Prompt and thorough assessment of injured patient
- Life-threatening situations should be quickly recognized and treated
- Acute trauma care involves many specialities, therefore, proper specialized consultations are asked for.

Treatment of a facial injury should be guided by the functions of the face and its components. *Facial trauma must be considered in a slightly different light than similar trauma elsewhere in the body; where function is the primary concern in a repair. In facial trauma, restoration of a function and esthetics is a must, otherwise a minor facial injury, if not treated properly can become serious problem due to psychological impact.* It is also important to note that properly executed initial repair of the facial injury often gives better results than multiple secondary procedures. Furthermore, prolonged hospitalization, disability and added expenses can be avoided. Inadequate primary treatment may result in severe deformities, which may be difficult to treat later on without good results. However, even after proper initial primary treatment, there may be need for secondary surgery. This possibility should be discussed with the patient and his/her family.

GENERAL CARE OF THE INJURED PATIENT

General Considerations

When a patient with a severe maxillofacial injury is first seen, an immediate general evaluation must be made to determine, if emergency treatment is necessary. Hemorrhage, shock, spinal cord injuries, cardiac arrest, airway obstruction can cause early fatality. Intracranial hemorrhage with associated skull fractures, fractured ribs with pneumothorax or hemothorax, rupture of the spleen or kidney can also pose an immediate danger.

After thorough systemic evaluation and emergency treatment, priorities for treating all injuries can be established. One should not rush into the treatment of an obvious facial injuries prior to complete evaluation. At the same time for some insignificant associated injury, the treatment for facial injury should not be delayed. Soft tissue injuries should be treated within 6–8 hours or sooner, whenever feasible. If possible, facial fractures should be treated at the time of the soft tissue repair with the fracture reduction and fixation being done first.

BASIC PRINCIPLES OF TREATMENT OF SEVERE MAXILLOFACIAL INJURIES

- Preservation of life
- Maintenance of function
- Restoration of appearance (esthetics).

In preservation of life, immediate prompt emergency treatment should be instituted by involving various specialities' care.

BASIC ABCs TO BE FOLLOWED FOR PRESERVATION OF LIFE

A: Maintenance of airway patency
B: Bleeding or hemorrhage control
C: Consciousness restoration, circulation maintenance. Otherwise,
D: Death will follow.

A: Maintenance of Patency of Airway

Maintenance of patency of airway must be given priority consideration, since adequate oxygenation is vital to life **(Fig. 29.1)**.

Maintenance of the airway is dependent on the following:

- The absence of any anatomical or mechanical barrier
- The preservation of the laryngeal reflex
- The existence of adequate pulmonary ventilation.
- The integrity of the respiratory center.

The tissue hypoxia or anoxia is related to the integrity of the respiratory center, the preservation of cough reflex, the efficiency of pulmonary ventilation and the oxygen carrying capacity of the blood. A simple persistent bleeding due to nasal fracture in an unconscious patient, who is lying supine and whose reflexes are depressed by alcohol or drugs, can easily prove to be fatal. Wounds involving tongue, larynx, pharynx with surgical emphysema can bring about airway obstruction. Patient with associated head injury with deterioration in the level of consciousness may be having depression of the respiratory center. Associated injuries to the lungs may produce 'flail chest' with paradoxical respiration. Pneumothorax, hemothorax, traumatic asphyxia may reduce the pulmonary efficiency.

Clinical Signs and Symptoms of Respiratory Distress (Obstruction)

- Initially there will be restlessness, apprehension, anxiety
- Tachypnea, tachycardia, pallor
- Rapid, labored breathing (gasping for breath)
- Rapid movement or fluttering of the alae of the nose
- Crowing sound, stridor, intercostals retraction
- Suprasternal indrawing of the tissues or supraclavicular retraction
- Decreasing ventilatory excursions, hypercarbia, hypertension
- Progressive cyanosis (may be present with Hb less than 5 g).

Causes of Respiratory Obstructions Related to Maxillofacial Injuries

- Inhalation of blood clot, vomit, saliva, thick mucus or portions of teeth, bone and dentures
- Inability to protrude the tongue, because of the posterior displacement of the anterior fragment of the mandible (bilateral parasymphysis mandibular fractures)
- Occlusion of the oropharynx by the soft palate after retroposition of the maxilla (fractured maxilla) **(Fig. 29.2)**.

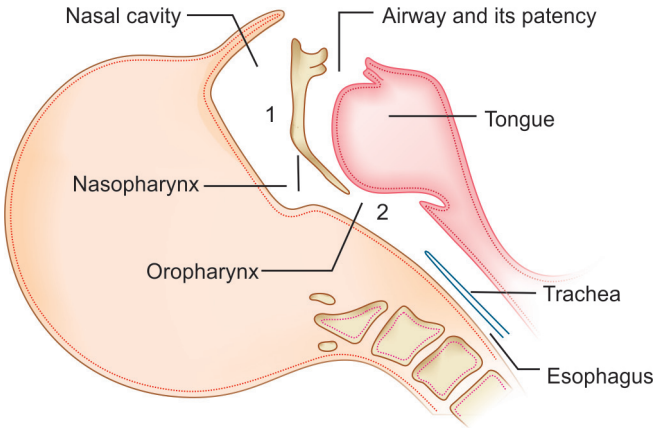


Fig. 29.1: Airway and its patency: 1. Nasopharyngeal airway; 2. Oropharyngeal airway

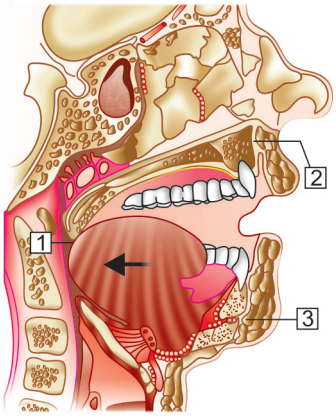


Fig. 29.2: 1. Critical airway obstruction may be seen due to; 2. Retroposition of the maxilla after severe maxillofacial injury; 3. Tongue fall after bilateral parasymphysis mandibular fracture

Treatment for Airway Maintenance (Nonsurgical)

Position of the patient: Supine with neck extended or head turned sideways or patient can be made prone with head down, so that the collection of saliva or blood in the mouth can be thrown out instead of aspiration **(Figs 29.3A and B)**.

Oropharyngeal toilet: All blood clot, saliva, thick mucus or foreign bodies, etc. should be cleared from the oral cavity and throat by digital exploration or by using cotton swabs, if available.

Suction: If the suction machine is available, then catheters should be used to clear the nose, oral cavity and throat.

Anterior traction of the tongue: Control the tongue by the proper positioning of the patient already described or the tongue can be pulled out and it can be maintained in the forward position by using tongue suture or towel clip attached to the patient's shirt collar.

Immediate restoration of the position of the soft palate: It can be brought about by doing disimpaction of the maxillary fracture. This is achieved by placing index and middle finger into the mouth hooking behind the soft palate and thumb placed on the alveolus in the incisor region. Head is stabilized by counter pressure with other hand over the forehead. Strong anterior and downwards traction will bring the maxilla in the normal position. Immediately one or two well-lubricated nasopharyngeal tubes should be inserted to maintain the airway.

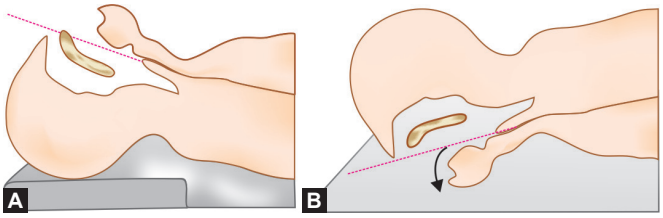
- Unfavorable mandibular fracture also should be reduced and temporary stabilization with dental wiring should be carried out to prevent the tongue fall
- Mouth-to-mouth breathing
- Oro- or nasopharyngeal airways can be used **(Figs 29.4A and B)**
- Endotracheal intubation as soon as possible.

Surgical Treatment

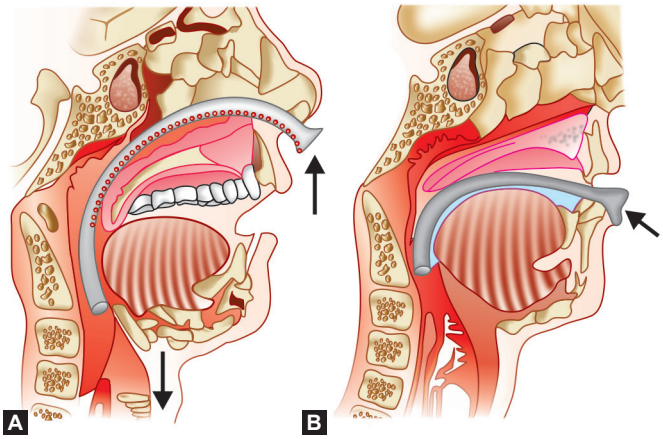
A tracheostomy may be indicated in extensive maxillofacial injuries **(Figs 29.5A to D)**.

Indications

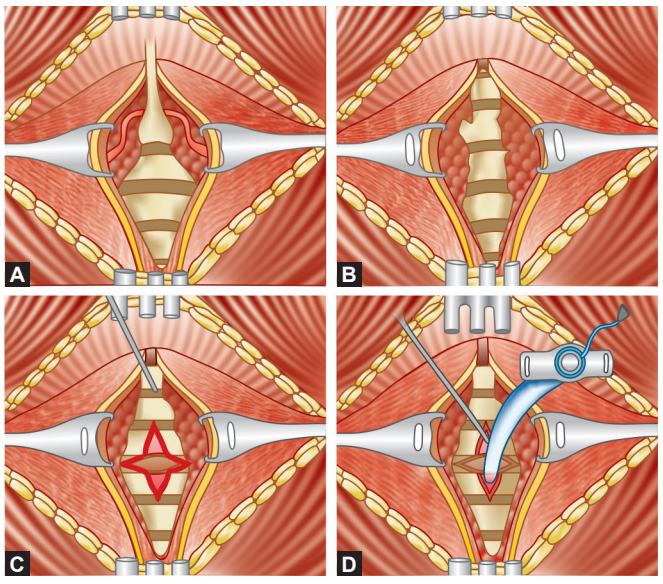
- Lack of tongue control
- Gross retroposition of middle-third of the facial skeleton
- Actual or potential edema of pharynx or glottis
- Uncontrollable oro-/nasopharyngeal bleeding
- Respiratory inadequacy—pulmonary or central nervous system—(CNS). In case of dire emergency,



Figs 29.3A and B: Position of the injured patient during transportation. (A) Supine position with head extended; (B) Head turned sideways or downwards



Figs 29.4A and B: Nonsurgical treatment for airway maintenance after severe maxillofacial trauma. (A) Nasopharyngeal airway tube in situ; (B) Oropharyngeal airway tube in situ



Figs 29.5A to D: Tracheostomy procedure

a lifesaving oxygen supply can be delivered by puncturing into the tracheal lumen with a 12-G or 14-G needle for a short time, till adequate airway management is done. In tracheostomized patient, the airway must be monitored carefully. Secretions should be sucked away frequently.

B: Bleeding or Hemorrhage Control

Prompt control of post-traumatic bleeding is a must. Initial digital compression should be given to control the bleeding. Compression dressings can be also used. Major vessels which are cut should be clamped or ligated. Soft tissue wounds which are deep and extensive should be sutured immediately. Deep wounds also can be packed with gauze till definite measures are taken.

Nasal bleeding can be stopped by using ribbon gauze packing soaked in 1:1,000 adrenaline. In some of the cases postnasal packing may be necessary. Anterior nasal packing can be done in addition to postnasal packing **(Figs 29.6A to C)**.

C: Consciousness Restoration/Circulation Maintenance

Initial assessment of the patient will reveal whether the loss of consciousness is due to intracranial injuries or because of hemorrhagic or neurogenic shock.

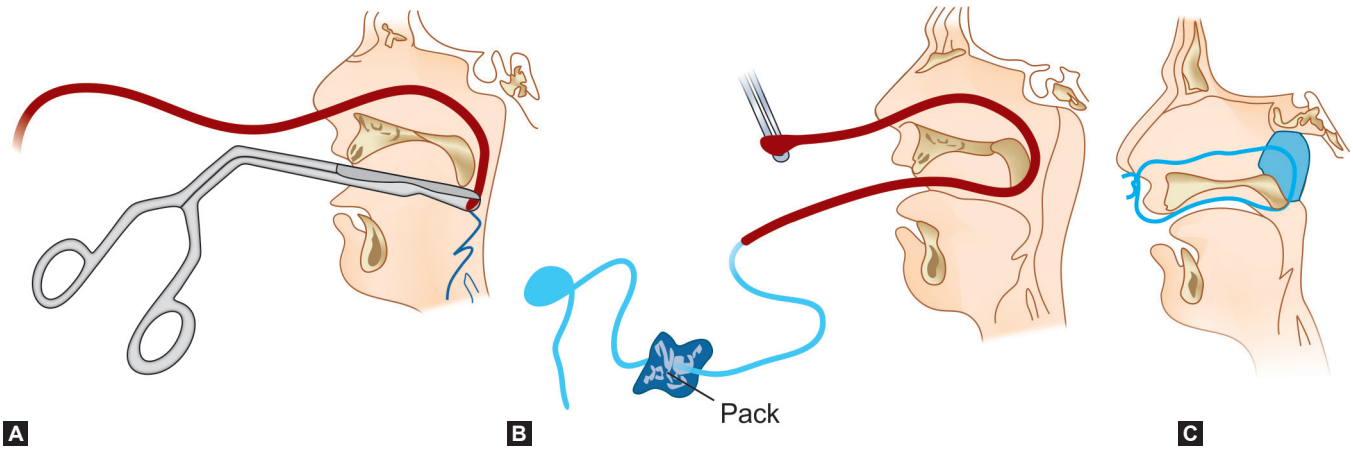
If the patient is in a state of shock, an immediate venipuncture or a cut down should be performed. A blood sample is sent for cross matching and intravenous (IV) fluids should be started to restore the circulating blood volumes. As soon as possible, blood transfusion can be started. Adjuvant measures like relieving the pain, making the patient comfortable, gentle handling and compression dressings and splinting of fractures can be done simultaneously. Close observation of a patient should be done. All vital parameters like pulse, respiration and blood pressure should be monitored. Control of infection and pain also should be done by administering adequate antibiotics and anti-inflammatory analgesics through IV route. Antitetanus protection should also be thought about. Tetanus antitoxin or toxoid be given immediately. Adequate nutrition should also be planned in order to have speedy recovery. High-calorie, high-protein diet is helpful. Nasogastric tube feeding may be necessary in severe maxillofacial injuries. Supplementary vitamin therapy should be given.

SOFT TISSUE INJURIES

- Thorough wound cleaning
- Gentle tissue handling.
- Meticulous repair.

  Will result into excellent healing of facial injury.

Facial lacerations should be repaired at the earliest time as soon as patient's general condition allows. Early wound repair lessens edema and prevents the formation of granulation tissue and infection. This will lead towards minimum scar formation. Preferably the facial wounds



Figs 29.6A to C: Technique for controlling bleeding from the nasal cavity. (A) Catheter passed through the nostril and brought out through oral cavity; (B) Gauze pack tied to the oral end of catheter and nostril end is pulled out to bring the pack upwards; (C) Nasal pack in situ

should be repaired within 6–8 hours. Because of excellent blood supply to the facial region, if necessary, safe primary repair can be done even after 1 or 2 days.

Wound Management

Prerequisites of wound repair are meticulous wound cleansing and hemostasis. A gauze piece moistened with betadine solution is initially spread over the wound to protect it further from contamination. Surrounding skin of the facial wound should be cleaned gently with liberal application of warm saline, dilute cetavlon or dilute hydrogen peroxide, taking care to swab away from the wound margins. A male patient should be cleanly shaven and female patients should have all cosmetics removed. *The eyebrows should never be shaved.* A careful wound examination including palpation should be carried out to detect foreign bodies (Blood clots, dirt, wooden splinters, broken teeth, denture pieces, glass pieces, tar, hair, bone splinters, etc.). Palpation of these foreign bodies should be done at the depth of the wound, as well as by bimanual palpation. In automobile accidents the dirt or road tar can be embedded in the tissue depth. Solvents, such as ether or benzene, may be needed to remove tar, oil, grease or paint from a wound. Tissue-holding forceps or scalpel can be used to remove the embedded foreign matter. To prevent fibrosis or traumatic tattooing of the skin, it is absolutely mandatory to remove these foreign particles.

After the surrounding skin is cleaned and wound palpation and removal of foreign particles is over, then the wound should be irrigated with copious amount of saline solution. Gentle handling of the wound is absolutely necessary. Intraoral wounds should also be thoroughly cleaned with copious saline solution with suction. The eyes should also be carefully irrigated with warm normal saline and inspection should be done for any ocular damage. Laceration of the scalp may be masked due to blood crust, entangled hair, etc. Washing of the area and careful inspection should be done. Conservative approach is chosen as far as debridement of the facial wound is concerned. Hemostasis is also essential for good wound healing. Atraumatic instruments should be used to handle the facial wounds. Fine skin hooks and Adson's tissue holding forceps are very helpful in handling the tissue with a minimum degree of trauma. Gentle sponging of tissues should be done. Approximation of the tissues should be done using the finest suture material.

Types of Soft Tissue Wounds and Management

Abrasions

Abrasions caused by the frictional violence, due to friction between an object and surface of the soft tissue. It is presented as raw bleeding areas. The wound is superficial and it denudes the epidermis, occasionally involves deeper layers. Abrasion involves the terminal nerve endings of many nerve fibers and it can be quite painful. Commonly seen as scraps and re-epithelialization occurs without scarring. While deep abrasions may require skin grafting. Abrasions may be contaminated depending on the surroundings. Foreign matter embedding contributes to traumatic tattooing of the skin, foreign body reaction or fibrosis and infection, with delayed wound healing **(Figs 29.7 and 29.8)**.

Thorough cleaning with profuse saline irrigation, removal of the foreign material, gentle scrubbing with the soft brush to remove sticky material to prevent tattooing, use of surgical soap is required to be done prior to dressing. Topical application of antibiotic ointment with compression dressing promotes good healing. Superficial abrasions can be covered with topical antibiotic application and left open. Slowly the crust of dried blood and serum will form a scab and it will fall off as the healing takes place.

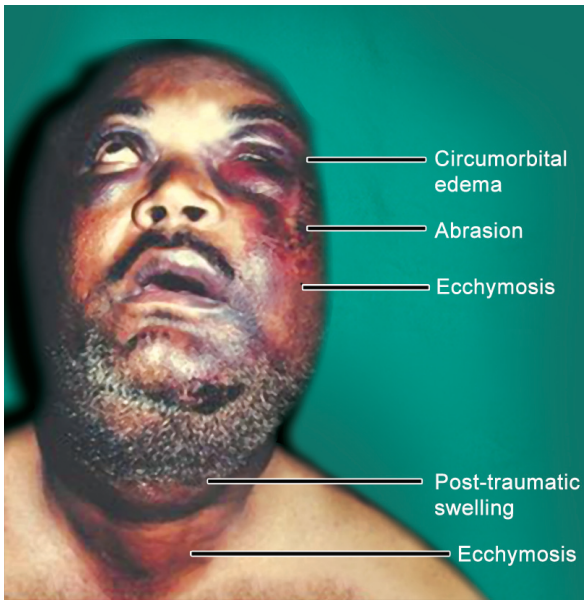


Fig. 29.7A: Clinical picture of a patient, who has sustained a maxillofacial trauma



Fig. 29.7B: Different soft tissue wounds in the orofacial region: A. Abrasion; B. Contused lacerated wounds (CLW) sutured; C. Circumorbital ecchymosis; D. Lingual hematoma; E. Intraoral ecchymosis; F. Subconjunctival hemorrhage; CE. Circumorbital edema

Contusion

Contusion is caused by a blow or fall against a hard or blunt object. Blood extravasates in the subcutaneous or submucous tissue leading to bluish area or bruise. Subcutaneous bleeding is self-limiting. This is without break into the soft tissue surface. Discoloration of the skin or mucosa causes ecchymosis. Important for diagnosis and search for an osseous trauma/fracture is mandatory. Application of ice pack will help to stop further extravasation of blood.

Areas of *ecchymosis* which becomes evident in 48 hours will be seen as bluish black marks and these fade away with change in variety of colors as blue, green, yellow, etc.

Hematomas

Hematomas are localized collection of blood in the subcutaneous or intramuscular or submucosal space. It may be deeply seated or superficial. Contusions and hematomas may be associated with a fracture or rupture of a vessel or vessels. Careful examination may be repeated and X-ray examination is essential for proper diagnosis and treatment. Most hematomas are reabsorbed. Persistent hematoma may require incision and drainage. It cannot be aspirated as blood is partly clotted. Antibiotic cover should be given to prevent hematoma from getting infected.

Lacerated Wounds

Lacerated wounds are most frequent type of soft-tissue injuries. Here the tearing of mucosal tissue or skin is seen due to vehicular accidents, low-velocity missiles (pistol) or bomb splinters. The margins are contused and lacerated in deep wounds, the muscles are also lacerated and devitalized. There may be associated injury to the underlying vessels, nerves and bone. These wounds are usually highly contaminated with dust, mud, greasy



Figs 29.8A to G: Multiple soft tissue wounds on the facial region

material, tar, glass pieces, bone splinters, etc. *Thorough cleaning, minimum debridement, removal of foreign bodies and proper suturing* (as early as possible) are the steps in the management. Closure should be done in multiple layers (muscle, dermis, epidermis and submucosa and mucosal closure). These may be superficial or deep. CLW means contused lacerated wounds.

Incised Wounds

Incised wounds are caused by sharp-cutting objects such as knife, dagger, glass piece, tin edge, etc. These are clear cut, gaping, bleeding wounds with minimum contamination. Deep wounds can bring about damage to the vital organs leading towards major complications. The wound should be taken care as early as possible. The wound is cleaned, explored and the bleeding arrested. The wound is closed by primary intention.

Penetrating and Punctured Wounds

Punctured wounds are caused by pointed objects like a knife, bullet, bomb splinter, etc. These wounds are highly deceptive as externally they may appear small, but may be deep penetrating endangering vital organs. Careful clinical examination, X-ray examination and other special investigation may be required.

Crushed Wounds

Crushed wound is caused by road accidents, or a machinery accidents. Crushing of the parts with lacerated skin, devitalization or crushing of the musculature is seen. Damage to blood vessels and nerves with associated profuse bleeding is also observed. The bone/bones are shattered. The wound is highly contaminated. There can be loss of soft/hard tissue.

Gunshot Injuries (High Velocity Missile)

Gunshot injuries are in reality penetrating wounds, but are classified separately, because of the extensiveness of the wounds and the special problems which arise during their management. They are subclassified as: (1) penetrating wounds, when the missile is retained in the wound, (2) perforating wounds, when the missile produces another wound of exit, (3) avulsive wounds, when large portion of the soft or osseous structures are destroyed. These wounds

are produced by projectiles fired from a gun or fragments of a shell. They may be seen in civilian life or war injuries. Depending upon the speed, shape and striking angle of the projectile, the character of the wound will vary.

High velocity bullets: Small wound of entry and large, ragged wounds of exit. Fragmentation of teeth, bone may serve as secondary missiles, causing extensive internal trauma.

Low velocity projectiles: They become distorted upon meeting resistance and cause comminution and internal damage. Crushing of tissues due to its direct pressure effect around a small area of the track. The necrosed tissues, particularly the devitalized muscles are good nidus for infection.

Multiple metallic foreign bodies are retained in these wounds. The pellets of a gunshot are sterile and they can splinter further, and are seen embedded in the soft and hard tissues at various levels. If usual wound care is not sufficient, then after primary treatment, extensive reconstructive surgery is needed to restore the facial contour.

Treatment of Lacerated Wounds

- Cleaning of wound
- Removal of foreign bodies
- Debridement
- Hemostasis
- Closure in layers—primary closure
- Dressing
- Prevention of infection
- Pain control
- Follow-up.

Supportive Therapy

Drains: Superficial wounds do not require drainage. Deeper wounds, particularly, those involving oral cavity, require insertion of penrose or rubber drain. Drains may be placed between the sutures or through dependent stab incision. Drains should be removed after 2–4 days.

Dressings: Sofra-tulle or antibiotic ointment along with dry gauze dressing should be changed in 48 hours. Large wounds need pressure dressing. Sutures can be removed on 5–7th day.

Prevention of infection: Strict adherence to sterile technique, wound closure by eliminating all dead spaces and adequate supportive antibiotic therapy and follow-up is necessary.

Prophylaxis against tetanus: Whenever there is an inclusion of dirt and debris in the wound, protection against infection by the *Clostridium tetani* organism must be provided. In a person who has been immunized with previous inoculation with the tetanus toxoid, a 'booster' dose of 1 mL of tetanus toxoid should be given as soon as possible. Passive immunity can be produced by administering 1,500 units of tetanus antitoxin at weekly intervals, until three doses have been given.

Factors Modifying Wound Healing or Leading towards Failure

- Too tight suturing without adequate drainage, may lead towards wound breakdown
- Inadequate pressure dressing—collection of hematoma
- Oral contamination of the wound, with inadequate closure on the oral mucosa side
- Secondary hemorrhage
- Inadequate antibiotic therapy
- Improper asepsis
- Secondary rough handling of the wound.

Inaccurate skin repair, dead tissue, foreign bodies inclusion, compromised vascularity, infection, lack of rest and constant movement and irradiation, delays can hamper the wound healing. General factors like old age, anemia, lack of vitamin C, systemic diseases like diabetes, hepatitis, steroid therapy may delay healing.

Points to Remember

- General care of the injured patient
- Basic principles of treatment of a severe maxillofacial injuries
- Basic abcs to be followed for preservation of life
- Soft tissue injuries.

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CHAPTER 30 Injuries of the Maxillofacial Skeleton

INTRODUCTION

Because of the complex bony structure of the maxillofacial region, any treatment for the extensive injury is quite challenging. Proper attention should be paid towards the restoration of function as well as esthetics.

The facial skeleton is divided into three parts:

1. Upper-third—formed by the frontal bone.
2. Middle-third—from the frontal bone to the level of upper teeth, or upper alveolus, if patient is edentulous.
3. Lower-third—the mandible.

Fractures of the middle-third of the facial skeleton and/or the mandible are known as "maxillofacial skeletal injuries" and they can be associated with varying degrees of injuries of the soft tissues. The injuries can vary in severity from simple crack to major fractures of the entire facial skeleton. Incidence of occurrence of maxillofacial injuries is ever increasing due to the fast pace of life and increased violence in addition to the advent of rapid modes of transportations.

ETIOLOGY OF MAXILLOFACIAL INJURIES

- Typical causes
  - Direct violence
  - Indirect violence
- Crush injuries
  - Automobile accidents/road traffic accidents (RTA)
  - Aeroplane crashes
  - Mining accidents
- High velocity missiles injuries
- Predisposing causes:
  - *Local causes:* Presence of cysts, osteomyelitis, tumors, presence of third molars, etc.
  - *Systemic causes:* Systemic diseases affecting the formation of the structure of the bone **(Table 30.1)**.

Table 30.1: Typical causes of maxillofacial injuries

Due to direct violence
1. Altercation, battery, interpersonal fights
2. Fist fight, blows due to stick, metal rods, bricks, etc.
3. Fall
4. Road traffic accidents
5. Occupation hazards (Athletic injury, industrial mishaps)
6. Iatrogenic causes—during dental treatment. Fracture of a tooth, alveolus, maxillary tuberosity, fracture of mandible, etc.
Indirect violence
1. Fall from a height
2. Counter coup fractures
Due to excessive muscle contraction (fracture of coronoid process).

Most of the severe injuries are caused by RTA, when the vehicle driver suddenly puts the break, the head hits the dashboard, steering wheel or the windshield. The various safety measures to be used are seat belts, dashboard padding, telescoping steering wheel, push-away wind shield and dashboards with recessed or absent knobs. Now the seat belts are available for all the passengers, whether front seat or back seat. There is legislation for the compulsory wearing of seat belts in cars, and compulsory wearing of crash helmets for motorcyclists.

Preliminary Examination

After initial steps for preservation of life are taken satisfactorily and patient has been stabilized, then a full examination of the patient is carried out to detect the presence of associated important injuries.

Head injury: To assess the level of consciousness "Glasgow coma scale" is used. This scale relates clinical observations for motor response, verbal response and

Table 30.2: Glasgow coma scale
Eye opening— (E)
4— Opens eyes spontaneously
3— Opens eyes to voice
2— Opens eyes to pain
1— No eye opening
Best motor response— (M)
6— Obeys commands
5— Localizes to pain
4— Withdraws to pain
3— Abnormal flexor response
2— Abnormal extensor response
1— No movement
Best verbal response— (V)
5— Appropriate and oriented
4— Confused conversation
3— Inappropriate words
2— Incomprehensible sounds
1— No sounds

eye examination and its responses **(Table 30.2)**. The skull or cranium examination should be carried out for any obvious lacerations or fractures. Level of consciousness should also be assessed:

- Fully conscious
- Drowsy patient with disorientation, but responds rationally to spoken questions
- Semiconscious patient, responding irrationally to spoken questions
- Unconscious patient, but responds to painful stimuli (semi coma)
- Unconscious with no response to painful stimuli (coma). The degree and duration of loss of consciousness is an important indication for the severity of the cerebral damage.

Retrograde amnesia: It is an inability to recall events leading up to the accident.

Anterograde amnesia: It is the failure to remember events immediately following the accident.

Whenever, patient is admitted in an unconscious state with maxillofacial injuries, it may not be due to head injury. Sudden loss of consciousness may be following epileptic fits or cerebral and cardiovascular disasters. The level of consciousness may be also influenced by the action of alcohol or other drugs intake, hypoglycemia or hyperglycemia. Eyes, the spine, the limbs, abdomen and chest should be checked properly. Specialist consultations from neurologist, ophthalmologist and general surgeon should be sought in cases of extensive injuries.

Trauma team: General, cardiothoracic, vascular, orthopedic surgeons, neurosurgeon, anesthesiologist, ophthalmologist, urologists, ENT surgeons, plastic surgeons and maxillofacial surgeons and paramedical staff.

The complete record of the detailed examination for maxillofacial injuries is considered under following steps and it should be preserved for evidence in medicolegal cases.

- History of the injury to the patient
- General condition on admission
- Extraoral examination
- Intraoral examination
- Radiological examination.

History of the Injury to the Patient

A proper history is mandatory for proper diagnosis of facial injuries. A detailed history of the injury should be obtained from the patient, provided he/she is rational and cooperative, otherwise it can be obtained from the relatives, accompanying person or witness at the time of injury.

- **Who**—The identity of the patient should be ascertained. Name, age, sex, address, phone number, etc. should be recorded.
- **When**—The date and time of injury should be noted. This will indicate whether it is fresh or old injury. If the patient comes for early treatment, then prognosis is better.
- **Where**—The surroundings of the injury place is important for knowing the possibility and degree of bacterial or chemical contamination of the wound. Here, the history of tetanus prophylaxis also should be asked and whether patient has received early care elsewhere also should be ascertained.
- **How**—The mode of injury—the type of violence and direction of the force may give some indication of the nature and extent of the injury. It is also important for medicolegal cases like child abuse, husband or relatives hitting a lady or RTA.

If patient gives history of epileptic fit and subsequent fall on the chin or soldier fainting on parade, then midline fracture of the mandible with possible fracture of condylar neck can be suspected.

- *What* type of treatment was provided earlier (if the patient comes from other center) should be known.

- *What* is the general health of the patient?

Obtaining pertinent medical history may be facilitated by using the AMPLE mnemonic.

A : Allergies
M : Medications
P : Past illness
L : Last meal
E : Events related to the injury.

History of drug allergy, bleeding disorders, pre-existing systemic bone diseases, neoplasia with potential metastases, arthritis, related collagen disorders, nutritional and metabolic disorders, endocrine diseases should be asked. Medical and psychiatric problems influencing the management should be ascertained.

- *Previous history of trauma* also should be recorded for medicolegal purpose.
- *Length of unconsciousness* also should be recorded for knowing the degree of head injury and proper referral. Prior to subjecting the patient for general anesthesia (GA), neurosurgical clearance should be obtained.
- *Any history of* pain, vomiting, unconsciousness, amnesia, headache, visual disturbances, confusion after the accident, malocclusion should be noted.
- *History of amount of bleeding* from various sites—Extraoral wound, intraoral wound, nose, ear, etc. should be asked for.
- *Information about patient's routine medication*—Whether patient used to receive insulin, steroids, anticoagulants, etc. prior to accident is also important to know.
- *Blood group of patient*—Whether patient's blood group is known to him?

LOCAL CLINICAL EXAMINATION OF MAXILLOFACIAL INJURIES

Extraoral Examination

Prior to examination, patient's face should be gently washed with warm saline or water and cotton wool swabs should be used to clean dried blood clots or scabs. Oral cavity should be irrigated thoroughly and cleaned with cotton swabs. Mouthwashes can also be used. Evaluation of the facial area should be done in an organized and sequential fashion.

Inspection

Inspection reveals the presence of edema, ecchymosis and deformity. Associated soft tissue injuries should be noted. Length, breadth and depth of the soft tissue wound should be measured and written. Inspect the nose and ear for the presence of bleeding or cerebrospinal fluid leak. Periorbital edema, ecchymosis, subconjunctival hemorrhage can be noticed (Bruises behind the ear or battle's sign, suggest a skull fracture). A neurological assessment should include careful evaluation of all cranial nerves. Vision, ocular level, extraocular movements, pupillary reaction to light should be carefully evaluated. Visual or pupillary changes may suggest intracranial (cranial nerves II, III, IV and VI) or orbital trauma. Abnormalities of ocular movements may also indicate other central neurologic problems or mechanical obstruction to the movements of the eye muscles resulting from fractures around the orbital area. The eyes, if they are closed due to edema, then the eyelids should be gently separated. If the patient is conscious, the vision is tested in each eye. Then the patient is asked to follow the clinician's finger with his eyes, without moving the head and asked to report if diplopia or double vision is noticed. A note is made of alteration in the size of two pupils and the light reflex is tested. The extent of the subconjunctival ecchymosis and its limits are also confirmed. Motor function of the facial muscles (VII cranial nerve) and muscles of mastication and sensation over the facial area (V cranial nerve) should be evaluated.

Anesthesia, paresthesia or dysesthesia of the lower lip, eyelids, nose, infraorbital areas should be noted.

The nasal complex should be inspected with a speculum and good illumination, for intranasal laceration, septum deviation and hematomas, tip and dorsal contour changes, epistaxis and cerebral spinal fluid (CSF) rhinorrhea.

Palpation

Palpation of the extraoral areas should be started with both the hands, simultaneously on each half of the external face, with gentle but firm pressure. This helps to detect the abnormalities and one can compare the normal side with the abnormal region **(Figs 30.1A to H)**.

Gentle palpation should start at the back of the head, and the cranium should be explored for wounds and bony injuries. Then the fingers should run over the forehead palpating for any depression. The palpating fingers should be kept in the midline and go sideways over supraorbital rims and infraorbital rims, zygomatic bones and arch. Areas of tenderness, step deformities or abnormal mobility should be noted. The nasal bridge palpation should start from the top till the nasal tip in the center and then sideways. Any crackling if felt, should be noted.



Figs 30.1A to H: Systematic palpation for maxillofacial injuries: Palpation for— (A) Supraorbital ridge; (B) Infraorbital ridge; (C) Lateral margins of orbit; (D) Zygomatic bone and arch; (E) Nasal bones; (F) Temporomandibular (TM) joints; (G) Intraoral palpation in the buccal vestibule for zygomatic buttress; (H) Intraoral palpation for checking the mobility of the maxilla

Firm digital pressure over these areas, is used to evaluate the bony contours and may be difficult when these areas are grossly edematous. After intranasal cleaning, fresh bleeding or CSF leak should be ascertained.

The cerebrospinal fluid rhinorrhea can be seen in LeFort II and III maxillary fractures (fracture of the ethmoid, sphenoid, frontal bones with dural tear). Here the escape of CSF into the nose is the result of a dural tear associated with the fracture of the cribriform plate of the ethmoid bone. This leak can get arrested in the first few days spontaneously or after the reduction of the fracture. In case of dural tear, there is always a risk of meningitis in early days, after injury or even after some time lapse. Antibiotic cover is important in such cases. Penicillin does not cross the blood-brain barrier. Other group of antibiotics are continued for at least 48 hours after CSF leak has ceased.

Detection of CSF leak may be difficult with associated bleeding in the nose. The mixed blood and CSF leak from the nose produces a classic "tram line pattern" on the face and a "halo" effect on the pillow or the bed sheets. This is also known as the ring test. The more viscous CSF forms a central circle rimmed on either side by blood, which diffuses to the edge. CSF will not stiffen a handkerchief, while secretions will do so. Characteristic salty taste of CSF in the nasopharynx is experienced by the patient. Patient should be placed in semirecumbent position and instructed not to strain, sneeze or blow the nose. This is to minimize the risk of increasing intracranial pressure.

Biochemical tests to detect the presence of glucose can be done using Dextrostix, as CSF has higher glucose content. Determination of the protein content also can be done, if clear fluid (CSF or serum from the blood clot) is seen passing through the nose. CSF contains little protein. Similarly, the nasal secretion contains mucin, but no sugar, whereas CSF contains sugar, but no mucin.

The nose should be evaluated for symmetry. Intercanthal distance between the innermost portions of left and right medial canthus is measured. Frequently naso-orbitoethmoid injuries cause spreading of the nasal bones and detachment of the medial canthal ligaments, resulting in traumatic telecanthus (widening of the medial intercanthal distance).

The temporomandibular joint (TMJ) function evaluation should be done by placing index fingers on preauricular area or in the external auditory meatus. All the movements

should be checked. Then the palpation of the posterior and the inferior border of the mandible should be carried out. Any areas of tenderness and step deformity should be noted.

Intraoral Inspection

Restriction of oral opening, gagging of the occlusion, lacerations, ecchymosis and damage to the teeth and/or alveolus are noted.

There may be presence of blood clots with foetid odor. Buccal and lingual sulci are inspected for wound, ecchymosis or a sublingual hematoma. The loose teeth and gross disturbed alignment of the teeth also should be noted. Occlusion should be checked. Any break or step deformity in the dental arches are found. Palatal mucosa also should be inspected for tear or bleeding areas.

Intraoral Palpation

The buccal and lingual sulci should be palpated for the presence of areas of tenderness, alteration in contour, crepitus, mobility of the teeth, etc. The mandible should be palpated bimanually and the abnormal mobility should be elicited. To assess the maxillary mobility, the patient's head should be stabilized using pressure over the forehead with one hand, and with the thumb and forefinger of the other hand, the maxilla is grasped, firm pressure should be used to elicit maxillary mobility. "Rock" the maxillary alveolar segments to detect fractures of the alveolus or split in the palate.

Radiological Examination

After a careful clinical examination, patient should be referred for necessary radiological examination. It can be also supplemented by computerized tomography (CT) scan examinations, whenever the facilities are available.

Minimum X-rays required for the following:

- **For fractures of middle-third of the face**
  - 15° and 30° occipitomental view
  - Submentovertex view
  - Cranial posteroanterior (PA) view (skull)
  - Lateral skull view
  - Posteroanterior view—Water's position
- **For zygomaticomaxillary complex**
  - Occipitomental view 15° and 30°
  - Posteroanterior view—Water's position
  - Submentovertex projection
  - Tomography/CT scan of the orbit
- **For mandibular fractures**
  - Orthopantomogram—OPG
  - Right and left lateral oblique views of the mandible
  - Posteroanterior view of the mandible
  - Towne's view for fractured condyles

The occlusal view for mandible or maxilla, intraoral periapical views for individual tooth may be required to be taken.

Fractures of the Jaw Bones

A fracture may be defined as a sudden break in the continuity of bone and it may be complete or incomplete.

Principal factors in fracture are (1) the dynamic factor (blow or impact), and (2) stationary or static factor (jaw). Dynamic factor is characterized by the intensity of the blow and its direction.

Light blow: Simple fracture or incomplete fracture.

Heavy impact: Compound, comminuted fractures with displacement. Direction decides the location of the fracture.

Static factor (Physiological age): In younger children, the bone is resilient, the trauma may lead to incomplete fracture. In athletes, the heavily calcified bones resist trauma to some extent. In the static factor physical condition, predisposing causes, anatomical weakness and presence of muscle pull on the fragments are the important considerations.

Classical Clinical Signs and Symptoms of Fracture of the Jaws

- *A history of injury to the area*
- **Pain:** If the patient complaints of pain upon movement either at the site of, or remote from the site of injury, then a fracture should be suspected.
- **Abnormal mobility:** Presence of abnormal mobility in the dental arches/jaw bones may be detected manually or observed during the movements of the jaws or patient may complaint of abnormal mobility at certain site.
- **Bleeding:** Active hemorrhage may be present or presence of hematoma or ecchymosis may follow a fracture process. In fresh injury, bleeding areas can be inspected by the clinician. Later on, patient should be asked for history of bleeding from oral cavity, nose (epistaxis), and ear, etc.
- **Crepitus:** Crackling, grating sound can be detected during the palpation of the wound due to the friction of the broken bones over each other.
- **Deformity:** Obvious facial deformity will be seen depending on degree and direction of the impact. It

will also depend on the direction of the fracture line and muscle pull acting on.

- **Ecchymosis and edema (Swelling):** These signs will be seen within few hours after the trauma. It may be seen extraorally or intraorally depending on the site of fracture and impact.
- **Loss of function or interference with function:** Mastication of food is interfered. In case of condylar fracture, loss of transmitted movements will be noticed. Speech problems, swallowing difficulty also may arise.
- **Radiographic evidence:** All cases of suspected fracture must be radiographed. It helps as a diagnostic aid plus provides additional confirmation. It is also important for medicolegal purpose to produce as an evidence.

The general classification of fracture, which is discussed in the mandibular fracture section, can be applied to any fracture of the jaw bones.

Basic Principles of Treatment of a Fracture

- Reduction—for reestablishment of form, function and occlusion with minimum morbidity
- Fixation
- Immobilization.

Aims

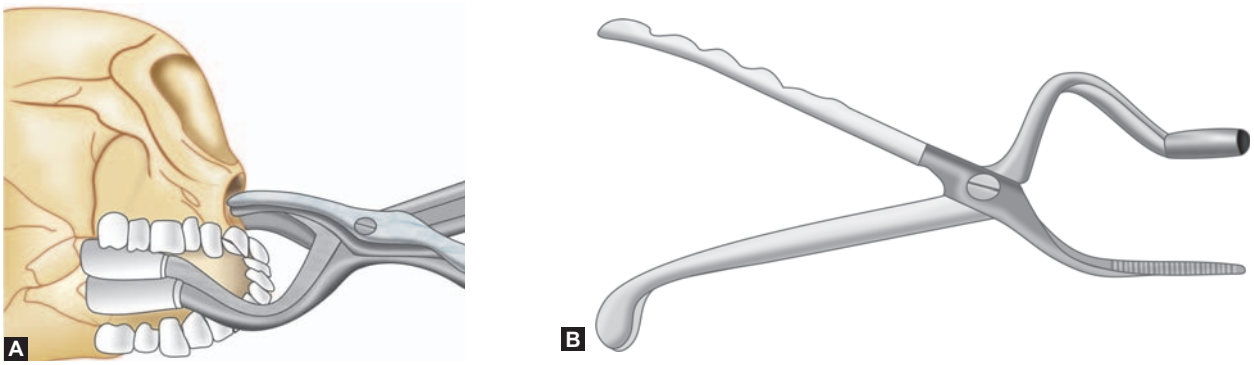
- Satisfactory facial form
- Satisfactory functional occlusion
- Satisfactory post-treatment range of movements of the jaw
- No second surgery for facial recontouring or malocclusion
- No bone grafting.
- **Reduction:** Restoration of the fractured fragments to their original anatomical position. The restoration of the fragments to their correct position may be brought about by:
  - *Closed reduction* (Alignment without visualization of the fracture line) **(Table 30.3)**.
    - Reduction by manipulation.
    - Reduction by traction.

    No surgical intervention is needed in closed reduction. Alignment of fractured fragments can be done without surgery. Occlusion of the teeth is used as a guiding factor. Fractures in the tooth bearing areas of the jaws are reduced satisfactorily by checking the final occlusion of the teeth.

    The closed reduction can be achieved either by manipulation or by traction method.
  - **Reduction by manipulation**—when the fractured fragments are adequately mobile without much overriding or impaction and the patient comes for treatment immediately after trauma (fresh fractures), then the digital or hand manipulation for reduction can be used. Specially designed instruments for grasping the fragments are available (Disimpaction forceps, bone-holding forceps). It can be done under LA with sedation or under GA depending on the need of the patient **(Figs 30.2A and B)**.
  - **Reduction by traction**
    - Intraoral traction method.
    - Extraoral traction method.

Table 30.3: Advantages and disadvantages of closed reduction

Advantages
• Inexpensive
• Only stainless steel wires needed (usually arch bars also)
• Easy availability, convenient
• Short procedure, stable
• Gives occlusion some "leeway" to adjust itself
• Generally easy, no great operator skill needed
• Conservative, no need for surgical tissue damage
• No foreign object or material left in the body
• No operating room needed in most cases, outpatient treatment
• Callus formation (secondary bone healing) allows bridging of small bony gaps
Disadvantages
• Cannot obtain absolute stability (contributing to nonunion and infection)
• Noncompliance from patient due to long period of IMF
• Difficult (liquid) nutrition
• Complete oral hygiene impossible
• Possible temporomandibular joint sequelae (MPDS)
• Muscular atrophy and stiffness
• Denervation of muscles; alteration in fiber types
• Myofibrosis
• Changes in temporomandibular joint cartilage
• Weight loss
• Irreversible loss of bite force
• Decrease range of motion of mandible
• Impaired pulmonary function, may be problematic for patient with premorbid pulmonary condition
• Risks of wounds to operators manipulating wires



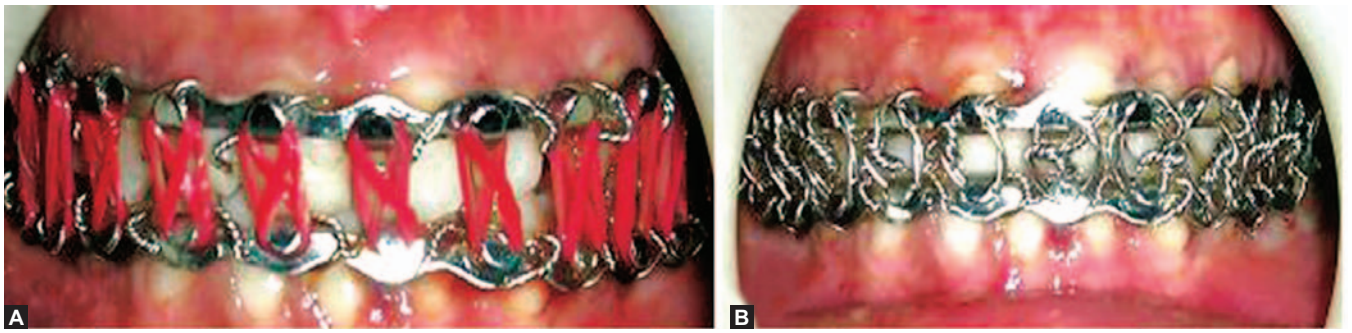
Figs 30.2A and B: (A) Reduction of maxillary fracture using disimpaction forceps; (B) Walsham's disimpaction forceps

- In intraoral traction method, prefabricated arch bars are attached to maxillary and mandibular dental arches by means of interdental wiring. Here, the fractured fragments are subjected to gradual elastic traction by placing the elastics, from upper to lower arch bars in a definite manner and direction depending on the fracture line **(Figs 30.3A and B)**. In extraoral traction method, anchorage is taken usually from the intact skull of the patient and different types of head gears are used for various attachments, coming down over the face and connected to the arch bars by elastics and wires. Whenever the traction method is used, patient is encouraged to open and close the mouth slowly, so that the elastic traction starts functioning. Patient should be kept on analgesics for pain control, so that the elastic traction can be smooth. Once the proper occlusion is achieved, then the elastics are replaced by wires to carry out intermaxillary fixation or intermaxillay ligation (IMF or IML). It is also known as maxillomandibular fixation (MMF). After the elastic traction is given, then the patient should be observed for a period of 12–24 hours. At the end of 48 hours, if satisfactory occlusion is not achieved, then open reduction is opted for:

Open Reduction

Surgical reduction allows visual identification of fractured fragments **(Table 30.4)**.

- **Fixation:** In this phase the fractured fragments (after reduction) are fixed, in their normal anatomical relationship to prevent displacement and achieve proper approximation. Fixation devices can be placed internally or externally.
  - **Direct skeletal fixation**: Consists of: (i) *Direct external skeletal fixation,* where the device is outside the tissues, but inserted into the bone percutaneously or (ii) *Direct internal skeletal fixation*— by devices which are totally enclosed within the tissues and uniting the bone ends by direct approximation. In direct external fixation, bone clamps or pin fixation can be used, while direct internal skeletal fixation is carried out with transosseous or intraosseous wiring or using bone plating system.
  - **Indirect skeletal fixation**: Here, the control of bone fragments is done via the denture-bearing area. By means of arch bars and IML or gunning splint, if the patient is edentulous. It can be extraoral or intraoral method.



Figs 30.3A and B: (A) Intraoral traction; (B) Intraoral fixation (IMF)/intraoral ligation (IML) with wires

Table 30.4: Advantages and disadvantages of open reduction with rigid internal fixation

Advantages
• Early return to normal jaw function
• Normal nutrition
• Normal oral hygiene after a few days
• Avoidance of airway problem
• Can get absolute stability, promotes primary bone healing
• Bone fragments re-approximated exactly by visualization
• Avoids detrimental effects to muscles of mastication
• Does not require patient's compliance or supervision
• Permits the physical therapy early postsurgically
• Avoids IMF for patient with occupational benefits in avoiding mandible fixation, e.g. lawyers, teachers, sales people, seizure disorders
• Helpful in special nutritional requirements (diabetics, alcoholics, psychiatric disorders, pregnancy)
• Easy oral access (for example in intensive care unit patients)
• Decreased patient discomfort, greater patient satisfaction
• Less myoatrophy
• Decreased hospital time
• Substantial savings in overall cost of treatment
• Lower risk of major complications
• Lower infection rates, improved overall results
• Lower rate of malunion/nonunion
Disadvantages
• Most obvious; need for an open surgical procedure
• Significant operating room time
• Prolonged anesthesia
• Expensive hardware
• Some risk to neuromuscular structures and teeth
• Need for secondary procedure to remove hardware
• "Unforgiving procedure", the rigidity of the plate means no manipulation is permissible
• Needs much operator skill, meticulous technique needed
• Directly compared to maxillomandibular fixation
• Higher frequency of malocclusion
• Higher frequency of facial nerve palsy
• Scarring (extraoral and intraoral)
• Needs sophisticated material
• No bridging of small bone defect (absence of callus)

- **Immobilization:** During this phase, the fixation device is retained to stabilize the reduced fragments into their normal anatomical position, until clinical bony union takes place. The fixation device is utilized for a particular period to immobilize the fractured fragments. Immobilization period depends on the type of fracture and the bone involved. For maxillary fractures 3–4 weeks of immobilization period is sufficient, while for mandibular fracture it can vary from 4–6 weeks. In condylar fracture the recommended immobilization period is 2–3 weeks only, for prevention of ankylosis of TMJ.
- Next steps are prevention of infection and gradual rehabilitation of function.

In the teeth-bearing region of the jaws, any fracture reduction is guided by checking the occlusion of the teeth. Interdigitation of mandibular teeth against the maxillary teeth is checked and then fixation and immobilization is carried out.

The primary objective in reduction of facial bone fractures is to restore the structures to a normal position of function and contour. This means restoration of normal occlusal relations by proper positioning of the teeth and bony structures. The normal intermaxillary relation is significant as a guide to reposition the bones of the maxillary and zygomatic complex in multiple facial structures. In order to stabilize the reduced facial fractures, some type of anchoring device is applied to maxillary dental arch and mandibular dental arch and IMF is carried out by applying wires or elastic bands between the upper and lower dental arch anchoring devices. The main methods for such fixation are dental wiring, arch bars and splints.

Although reports of teeth being ligated to one another go back as far as 2500 years (Hippocrates), the practicable principle of IMF was formulated after 1887. Gilmer (1887) revived intermaxillary wiring as a method of fracture management. Till today this method can be used very effectively, as it is the simplest method to apply.

There are various methods available for anchoring the dental arches. The type of device to be chosen depends on the type of fracture, site of fracture, number of teeth present and their periodontal status and availability of the anchoring device.

The anchoring devices can be fitted on the dental arches under local anesthesia with or without sedation, prior to surgical procedure (if at all it is planned) to cut down the total operating time. In case of multiple fractures or extremely uncooperative patient, it can be done under GA at the time of surgery.

Different Types of Dental Wiring Techniques

- Essig's wiring
- Gilmer's wiring
- Risdon's wiring
- Ivy eyelet wiring
- Col. Stout's multiloop wiring **(Figs 30.4 to 30.8)**.

Armamentarium for Wiring

- Presterilized 26-G stainless steel wire spool or wires cut into lengths of 20 cm each. Wires are always cut on a bevel, so that the bevel can act as a needle point, to pass through the interdental areas. The wires should be prestretched about 10% to prevent loosening after fixing it to the teeth.
- Two needle holders or wire holders.
- Wire cutters.

Essig's Wiring

Essig's wiring can be used to stabilize the dentoalveolar fractures in individual dental arches, as well as it can be used as anchoring device for IMF. The luxated teeth can also be stabilized using this wiring **(Fig. 30.4)**.

Requirements for this type of wiring are that there should be sufficient number of teeth on either side of the fracture line to take the anchorage.

A 40 cm long, 26-G prestretched wire is used. The luxated teeth should be pushed back into their sockets and the stabilization area chosen should be at least three teeth away from the fracture line. The wire is passed around the necks of the chosen teeth, one end going from buccal to lingual and other end going lingual to buccal in each interdental space of the teeth (three teeth away from the fracture line). The buccal end of the wire is stretched to brace the buccal side of the necks of the teeth near the fracture line and on the opposite side of the fracture line again leaving at least three teeth on the other side from the fracture line. The same procedure is repeated with the lingual side wire and the ends are then brought out on the buccal side of the last anchoring tooth after lacing the necks of three teeth on the opposite side. Both buccal and lingual wires are brought together and twisted and cut short to be tucked into the interdental space. Now you have two base wires formed, one from buccal side and another from lingual side at the necks of the teeth. The additional small wires are passed interdentally around these base wires to secure them tightly beyond the cingulum. The individual interdental wires are also twisted, cut and adjusted in the interdental spaces, so that the sharp ends do not hurt the patient.

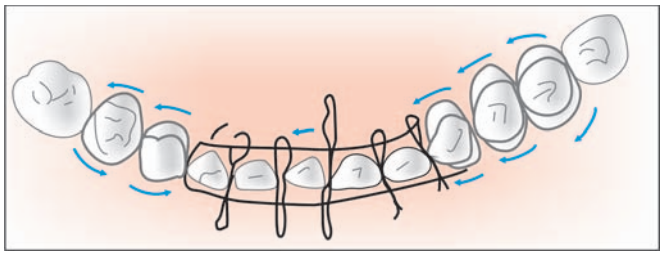


Fig. 30.4: Essig's wiring

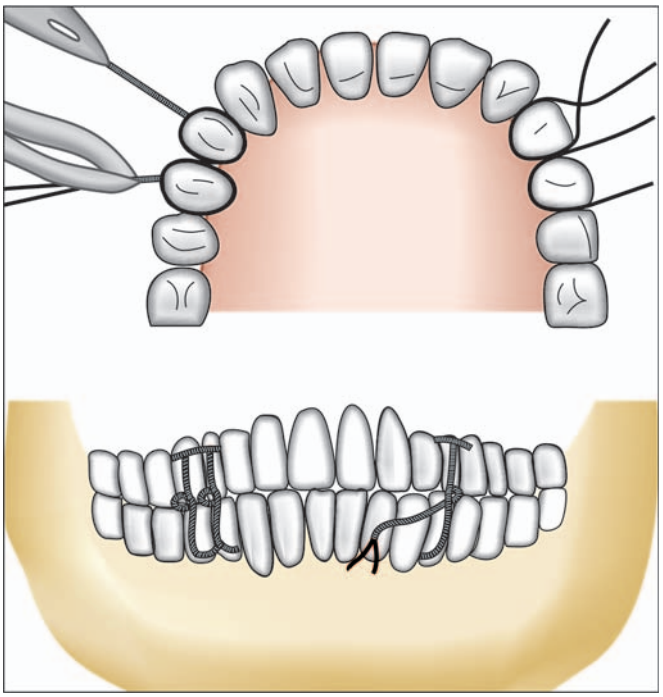


Fig. 30.5: Gilmer's wiring

Gilmer's Wiring

Gilmer's wiring is a direct wiring method of IMF between the maxillary and mandibular teeth **(Fig. 30.5)**. This is the most common, simple, and practical method, as it secures the teeth and stabilizes the jaw properly. Few firm teeth in the maxilla as well as in the mandible are chosen. At least one tooth anterior and one posterior to the fracture should be available for wiring to assure proper stabilization. It is best, however, to involve multiple teeth, lessening the strain and possible damage to any individual tooth. Wire should not be applied to a tooth directly adjacent to the fracture. A 20 cm long, 26-G stainless steel wire is passed around the neck of the chosen tooth. Both the ends are brought out on the buccal surface and manually twisted keeping the twists close to the tooth. Final twisting is completed by grasping both the ends with a wire holder, maintaining lateral traction while twisting, to avoid

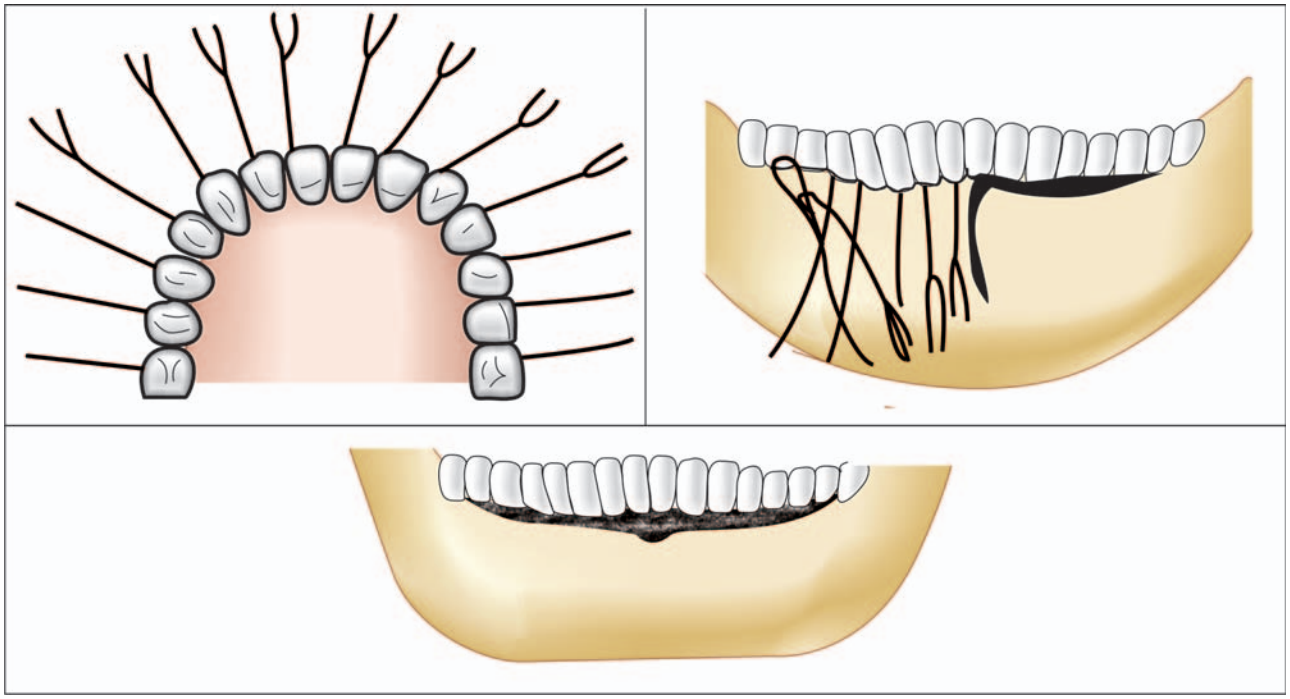


Fig. 30.6: Steps in forming a Risdon's wiring

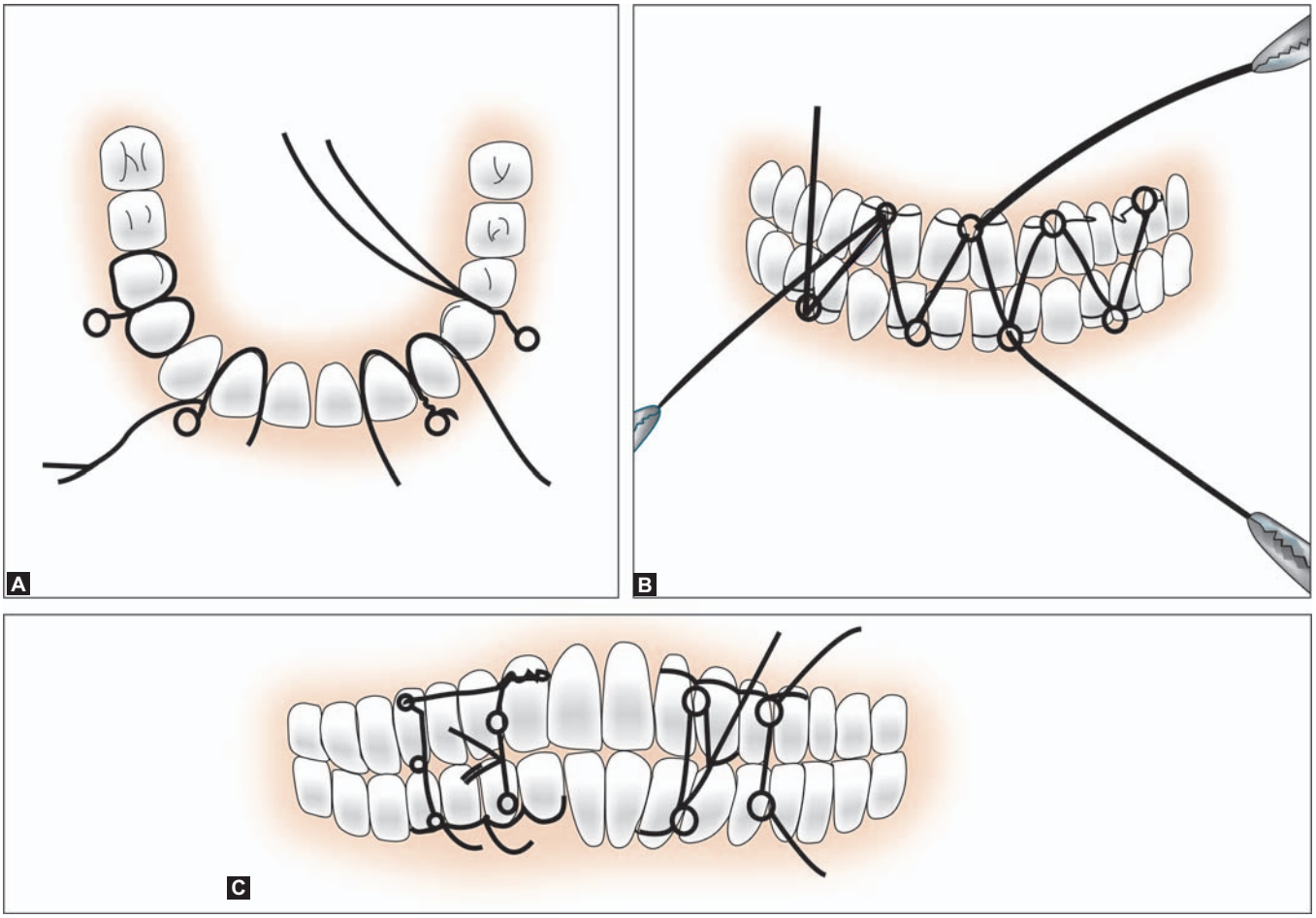
wire breakage. Couple of teeth are chosen in the individual arches and the twisted wires are left long clamped. After the reduction of the fracture is carried out, then the mandibular wires are twisted tightly together with their corresponding maxillary wires. The finally twisted wires are then cut short and the sharp ends turned into the interdental space. The main disadvantage of this wiring is of requiring complete removal of the wires to open the mouth in emergency situation. Another disadvantage may be the extrusion of the teeth as excess load is subjected, in case very few teeth are chosen for anchorage.

Risdon's Wiring

Risdon's wiring is a commonly utilized method of horizontal wire fixation. Certain fractures can be treated adequately by this method alone. However, in some cases, additional stabilization may be necessary. In this method usually second molars on either side are chosen for anchorage. A 26-G, 25 cm long wire is passed around the neck of the second molar on each side and both the ends are brought out on the buccal side. Then the ends of both wires twisted together for their entire length, so that the strong base wire is formed on either side, coming towards the midline from each second molar. The two twisted base wires are grasped and crossed at the midline by wire holder and final twisting is carried out adapting these base wires at the neck of the teeth on the buccal side. The excess wire is cut and the ends tucked in the interdental space. The base wire is secured to individual tooth by using additional interdental wires. Here small wires are cut and one end of the wire is passed from the distal surface of the tooth below the base wire and brought out towards the lingual side and then brought out on the buccal surface from the mesial interdental space above the base wire. Both these ends are again grasped together and twisted, cut and finished in the interdental space. Each tooth is engaged in the same manner to the base wire, so that the base wire is fully secured to the dental arch. This type of horizontal wiring offers strong fixation **(Fig. 30.6)**.

Ivy Eyelets Wiring

The Ivy loop embraces the two adjacent teeth. A 26-G stainless steel wires cut in 20 cm lengths are used. A loop is formed in the center of the wire around the beak of a towel clip or shank of a dental bur and twisted thrice with two tail ends. Such Ivy loops can be preformed and stored in cold sterilizing solution, so that they are available in emergency situation. The two tail ends of the eyelet are passed through the interdental space of the selected two teeth from buccal to lingual side. One end of the wire is passed around the distal tooth lingually and brought out from the distal interdental space over the buccal side and threaded through the previously formed loop. The other wire tail end is carried around the lingual surface of the

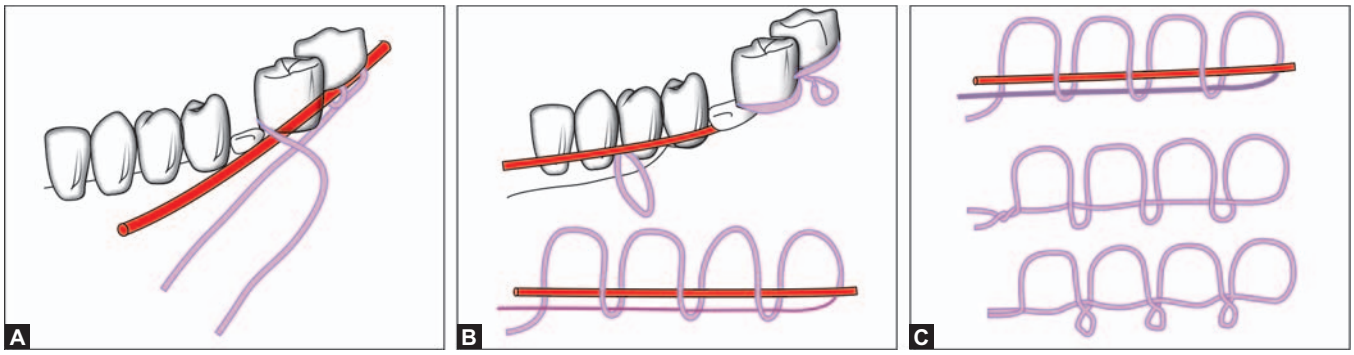


Figs 30.7A to C: Ivy eyelets wiring; (A) Eyelets formation; (B) The arrangement of tie wires in 'V' pattern; and (C) Intermaxillary ligation using eyelets wiring in a straight pattern

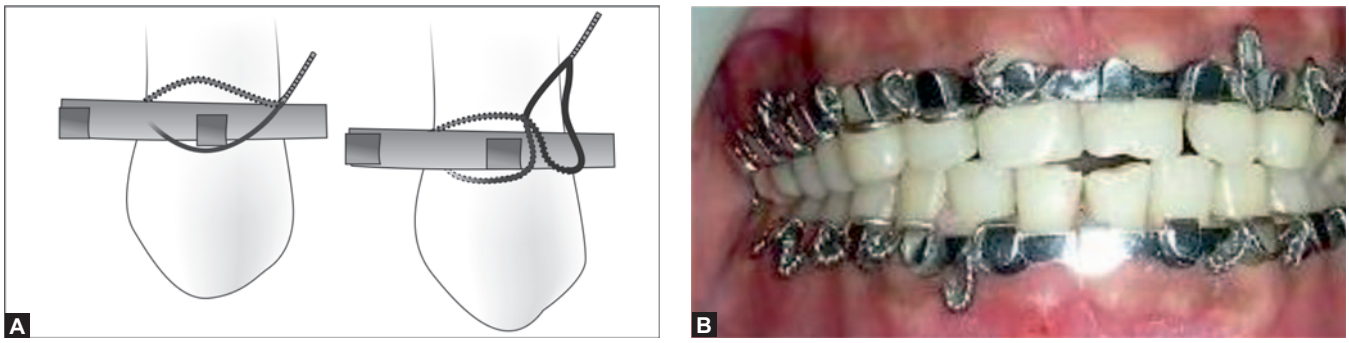
mesial tooth and brought out on the buccal surface from the mesial interdental space, where it meets the first tail end wire. The two wires are crossed and twisted together with the wire holder and cut short and finished in usual manner. The loop is then adjusted and bent towards the gingiva. The mandibular wire eyelets can be secured to maxillary eyelets by rubber bands or joining wires. One or two Ivy eyelets should be placed in each quadrant. Eyelet wiring is an asset. The rubber bands or bridging wires can be removed, whenever required without disturbing the main wiring and replaced. Even when there is breakage of a wire during fixation, only that eyelet can be removed and replaced **(Figs 30.7A to C)**.

Col. Stout's Multiloop Wiring

Here, the four posterior quadrants are used for wiring **(Figs 30.8A to C)**. Four pieces of 26-G, 20 cm long wires are required and piece of solder wire or any thick wire is required to make the loops. A piece of solder wire is adapted to the buccal surface of the teeth in the first quadrant, where the wiring is started. The 20 cm long prestretched wire is folded into equal parts, one part is known as stationary wire, to be adapted on the buccal side starting from midline going backward to second molar (or last existing tooth in the arch). The other end of the wire (working end) is then brought distal to the second molar and taken around it on the lingual side. This working end is threaded through the mesial interdental space of the second molar to the buccal side to emerge under the solder wire and the stationary wire. It is then looped around both the wires and back into the interdental space, this time from buccal to lingual side. From the lingual side it goes around the next tooth and the same procedure is repeated for each tooth till midline. The solder wire can be shifted ahead, once the loop is formed and the loop is twisted three times to form an eyelet. The final finishing is done by grasping both stationary and working ends together and twisting them and cutting short and pressing them in the interdental space. The same



Figs 30.8A to C: Col. Stout's multiloop wiring



Figs 30.9A and B: Arch bar fixation

procedure is followed in the other three quadrants of the dental arches. If the elastic traction is to be used, then the eyelets should be bent away from the occlusal plane, so that the hooks are formed. If wires are to be used, then the loops are bent towards the occlusal plane. It is desirable to use elastics in the initial recovery period instead of wires. In case of vomiting or emergency airway problem, these elastics can be removed easily.

Arch Bars

Many types of prefabricated arch bars are available. But the most popular one and commonly used is the *Erich's arch bar.* It is a prefabricated arch bar with hooks incorporated on the outer surface with flat malleable stainless steel metal strip. It provides an effective, quick and inexpensive method of fixation. The bar is available in spool form. The bar should be cut accurately to the length of the dental arch. Accuracy in this regard prevents injury to the adjacent soft tissues by protruding ends. Each arch bar is to be fixed to the upper and lower dental arches **(Figs 30.9A and B)**.

On the upper jaw, the hooks are arranged in an upwards direction. The bar is attached to the lower jaw with the hooks in a downwards direction. The arch bar should be adapted to the buccal surface of each arch by giving a shape of the arch by bending it. Bending of the arch bar should start at the buccal side of the last tooth progressing past the midline and finishing at the other end. The arch bar is fixed to each tooth, with 26-G stainless steel wire, which is passed from the mesial surface of a tooth to the lingual side and back on the buccal side from the distal surface of the tooth. One end of the wire is above the bar and the other below. By twisting the two ends of wire together, the bar is attached securely and firmly to the necks of the teeth on the buccal surface of the arch. The twisting of the wires should be always done in a clockwise manner, so that later on removal of wires can be done in anticlockwise manner. Improper adaptation of the bar, ligation of an insufficient number of teeth and inefficient tightening will result in inadequate stability of the arch bar. Advantages of the arch bar include less trauma because of the thin wire and greater stability in an arch, even if some teeth are missing, because the edentulous gaps can be spanned by this rigid appliance. If some wire is broken in between, the fixation generally not suffers and it can be replaced easily. The hooks are flat and do not irritate the tissue. In case of displaced mandibular body fractures, the arch bar can be divided and placed on either side of the fracture line. Elastic traction will reduce the fracture and

bring it into normal occlusion. Then the elastics can be replaced by wiring.

The use of Erich arch bar is accepted universally for its obvious advantages.

Custom Made Splints

Custom made appliances are fabricated for individual patient. The splints can be constructed using acrylic material or cast metal.

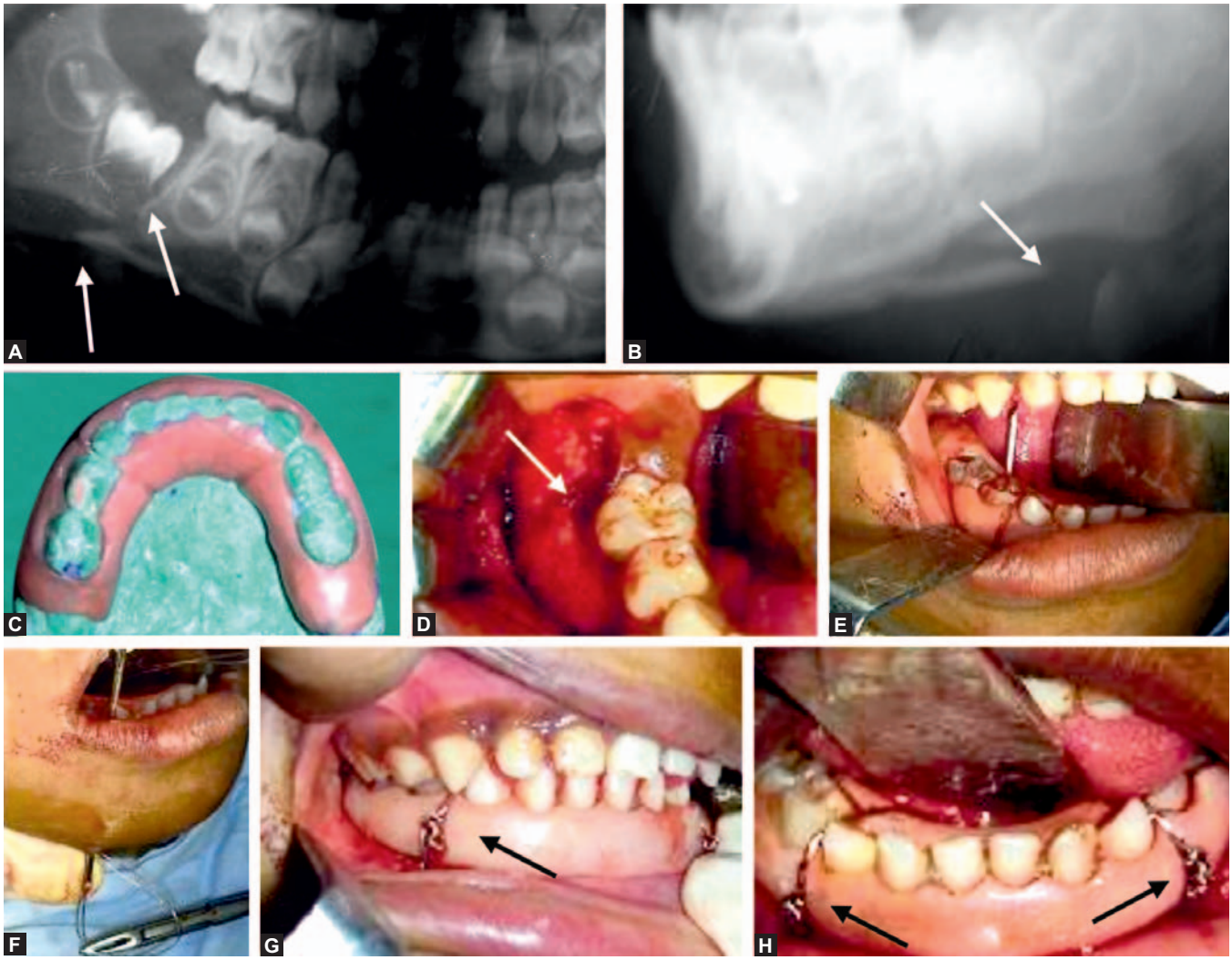
Indications

- When the wiring of the teeth will not provide adequate fixation.
- When horizontal splinting across the fracture zone is required without closing the patient's mouth.
- When both the jaws are edentulous
- In case of growing children, where mixed dentition is present and number of firm teeth for anchorage are not adequate
- In case of pregnant women and mentally challenged patients, where IML is not desirable.

Acrylic Splints

- Lateral compression splint
- Gunning splint

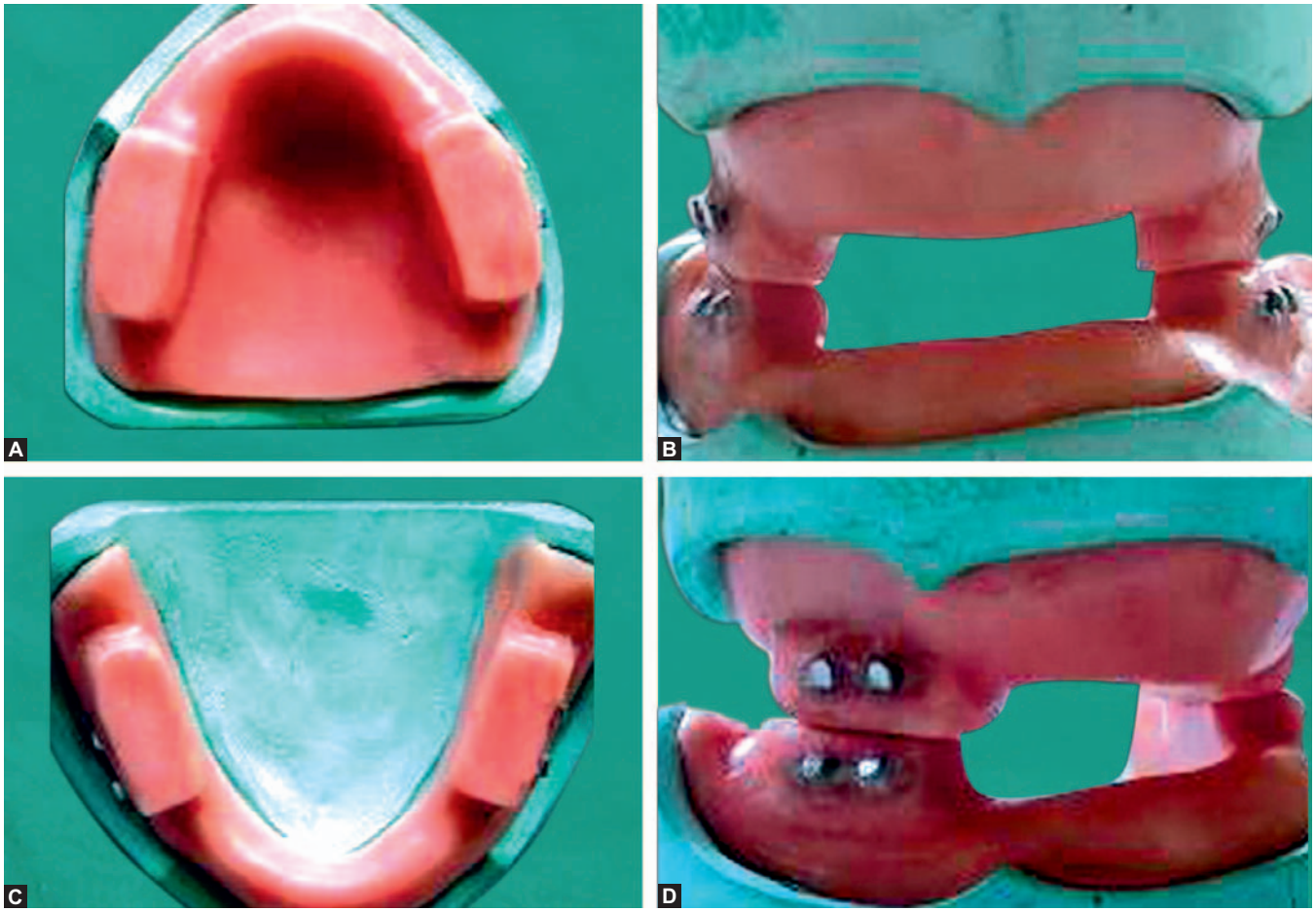
Lateral compression splint: It is made for the stabilization of mandibular arch **(Figs 30.10A to H)**. Mainly used in cases of children, where there is mixed dentition and presence of developing teeth buds (open reduction and direct fixation is contraindicated).



Figs 30.10A to H: (A and B) Orthopantomogram (OPG) and lateral X-ray showing fracture in the body mandible in 4-year-old child; (C) Lateral compression splint prepared on the cast; (D) Fractured site exposed and reduction done; (E and F) Splint in place and circummandibular wiring is being carried out; (G and H) Final fitting of the splint and occlusion checked

It can be also used in adult mandibular body fracture, where the stability cannot be obtained by means of other type of horizontal wiring methods. The splint can be made up of self-curing acrylic, so that the construction is quicker and easy. The first step in the construction is to obtain upper and lower impressions of the dental arches and preparing stone plaster models. On the mandibular plaster cast, the fracture line is marked and the cast is cut at the fracture line. Then the cut cast is assembled by checking the occlusion with maxillary cast and sealed in desired position using sticky wax. Then the 19-G wire is adapted to the entire circumference of the mandibular arch at the necks of the teeth, both on the buccal as well as on the lingual side. The bending of this wire should be started on the buccal surface in the midline and taken on the lingual side from distal aspect of last existing molar. On the lingual side, the shape of the wire will be concave adapting to each tooth surface and the end will be brought on the buccal surface going around the last existing molar on the opposite side. The wire will be adapted and brought towards the midline to meet the first end of the wire. This wire will reinforce the acrylic splint, as well as, it will act as a connector to the lingual and buccal flanges of the splint. The acrylic splint is then fabricated from the cast by incorporating the previously bent wire in it. The occlusal surfaces of the teeth should be left open, while constructing buccal and lingual flanges. On the buccal surface of the splint hooks can be incorporated, if required. This splint can be fitted to the lower arch by means of interdental wiring or by means of circumferential wiring (circummandibular wiring).

Gunning splint: In edentulous jaws, patient's own dentures, suitably modified can be used or specially constructed gunning splint can be used. Circumferential wiring is used to fix the splint to the mandibular bone and upper denture or splint is fixed to the maxilla by means of peralveolar wiring **(Figs 30.11A to D)**.



Figs 30.11A to D: Construction of gunning splint on the cast. Note that the anterior area of the splint is kept open for feeding purpose

Construction of Gunning Splint

- Upper and lower impressions taken from the patient's mouth
- Plaster casts made
- Plaster cast cut and assembled (if there is lot of displacement)
- Upper and lower base plates adapted
- Bite blocks prepared in the posterior region only
- Upper and lower plates with bite blocks constructed using heat cure acrylic leaving the anterior region open for feeding
- Hooks are incorporated on the buccal side of the bite blocks
- Grooves must be made in the both the gunning splints, in the canine region to prevent the peralveolar and circumferential wires from slipping along the surface of the splint.

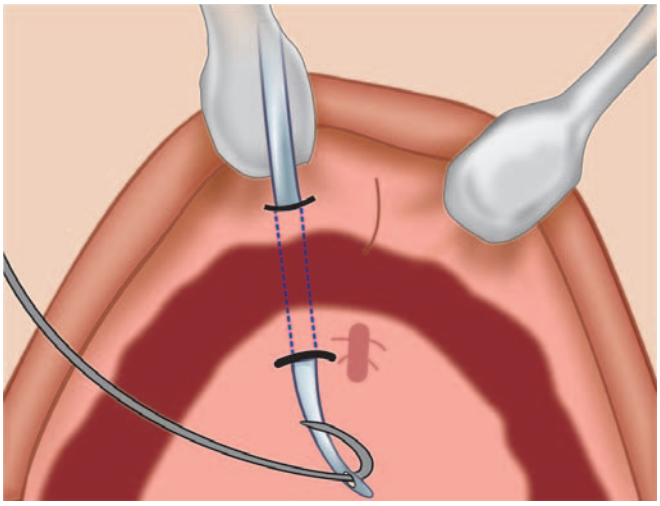


Fig. 30.12: Peralveolar wiring procedure for fitting the gunning splint to the maxillary edentulous ridge

Wiring Procedure

Peralveolar Wiring Procedure

Patient's own upper denture or upper gunning splint can be fitted to maxillary alveolar ridge by introducing two peralveolar wires in the canine region on either side. The procedure can be done under local anesthesia or GA, if required **(Fig. 30.12)**.

The splint is firmly placed in the position in the upper jaw and the mucous membrane of the buccal sulcus opposite to the groove in the canine region is pricked by a straight needle dipped in marking ink. This will be corresponding with the entry of the peralveolar wire introducer (Kelsey-Fry bone-awl introducer). A similar mark is made on the palatal aspect at the correct point of emergence of the introducer. With a boring action, the peralveolar introducer is pushed from the buccal to the palatal surface using the marking point as a guide. Once the tip comes on the palatal surface, then 26-G wire is threaded through the eye and then the introducer is withdrawn carrying with it the wire on the buccal surface. Both the wire ends are grasped with the wire holder. Same procedure is repeated on the opposite side. The splint is then replaced in the mouth and wires adjusted over it and twisted over the grooves. The twisted wires are cut and the end should be tucked inwards into the grooves.

Circumferential (Circummandibular) Wiring Procedure

Obwegeser's method (Fig. 30.13): This wiring can be utilized (after reduction of the mandibular fracture) for fixation of lateral compression splint or gunning splint to the mandibular bone. Two wires are passed in the canine region on either side. The procedure is carried out under GA after reduction of the fractured fragments **(Figs 30.13 and 30.14)**.

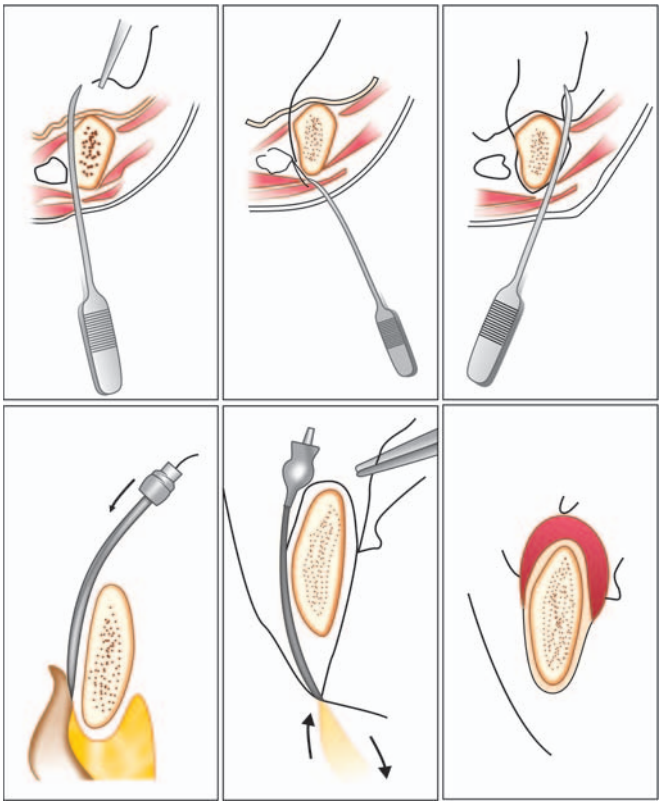
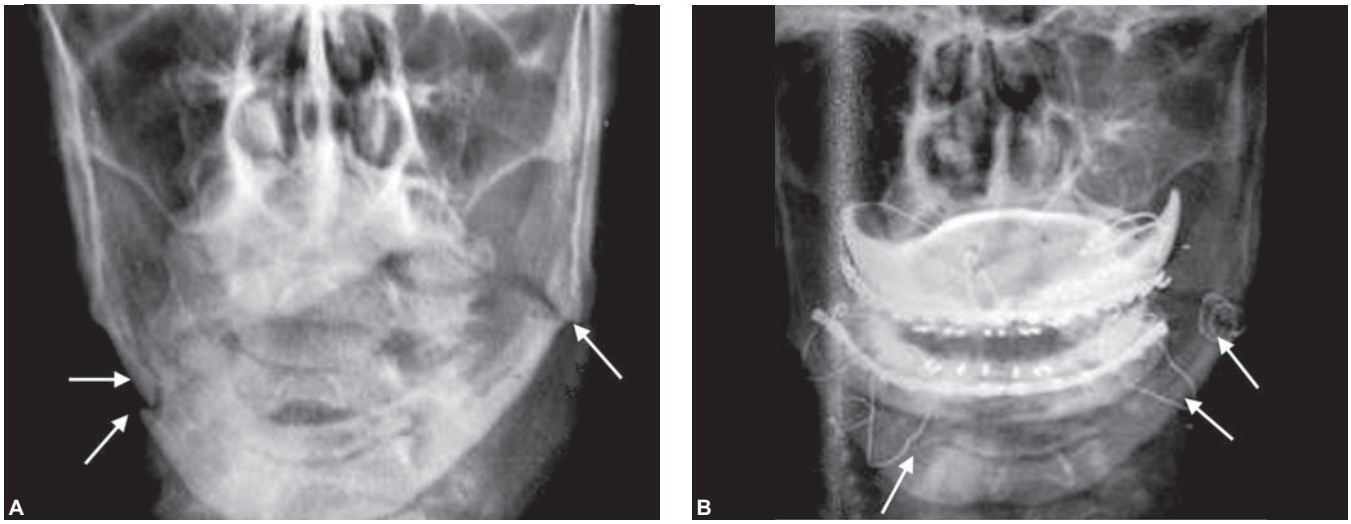


Fig. 30.13: Obwegeser's method of circummandibular wiring



Figs 30.14A and B: (A) Edentulous maxilla and mandible with bilateral fracture mandible; (B) Gunning splint fitted after reduction of fractures with peralveolar and circummandibular wiring. Intraosseous wiring seen at the inferior borders

One can use long, no. 18 hypodermic needle or Kelsey-Fry pattern curved bone awl or specially designed. Reverdine needle for passing the wire around the mandibular body.

The lower border of the mandible is palpated in the canine region and the skin is pierced beneath the lower border of the mandible, with the point of introducer, keeping in close contact with the lingual surface of bone, emerges through the floor of the mouth, close to the alveolar mucoperiosteum. A length of wire 26-G or 28-G is inserted through the eye of the introducer (or if needle is used through the lumen of the needle) and bent back upon itself. The introducer is then withdrawn along the same pathway, till the lower border is reached. Here, the tip is not withdrawn from the tissues, but is moved around the lower border and directed upwards along the buccal surface of the mandible to emerge through the sulcus. The wire is detached and the introducer withdrawn through the original point of entry. The two ends of the wire are then grasped with wire holder and using the to and fro sawing motion, the wires cut through the intervening tissues and brought in close contact with the lower border of the mandible. Then the splint is adjusted and the lingual and buccal wire ends are twisted together in the region of canine grooves, cut and finished inwards.

Cast metal splints (Fig. 30.15): These splints are fabricated in various metals in the laboratories. It requires impressions of both the arches. The lower cast is sawed through the line of fracture. The cast is reassembled in proper occlusion and fixed in position by pouring a base for the cast. The splint is formed till the gingival margins in 28-G sheet wax. Occlusal relations are established in the wax-up by checking the centric relation with the opposite cast, while the wax is soft. Then the wax-up is sent for casting procedure and the finished cast splint is obtained. This splint is used in adult patients with few firm teeth available and the splint is cemented to the reduced fractured jaw. These splints are expensive than the acrylic ones plus the construction is time consuming, hence not used routinely.

Methods of Fixation

Fixation is required in the majority of facial fractures.

Treatment without Any Form of Fixation

This method is reserved for the following:

- Fractures exhibiting minimal displacement and mobility; without occlusal discrepancy or with very minimal occlusal discrepancy
- Green stick fractures
- Elderly edentulous patients, who are in the high/poor risk category and who have no gross displacement.

Treatment with Intraoral Fixation Alone

This method can be employed for the treatment of the following:

- Dentoalveolar fractures

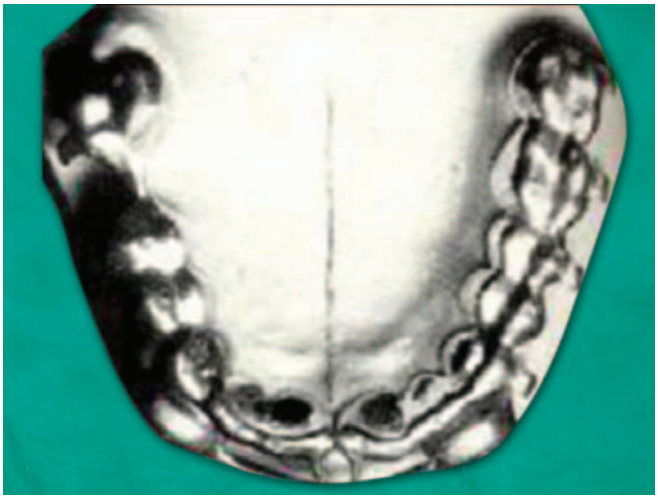


Fig. 30.15: Cast metal splint

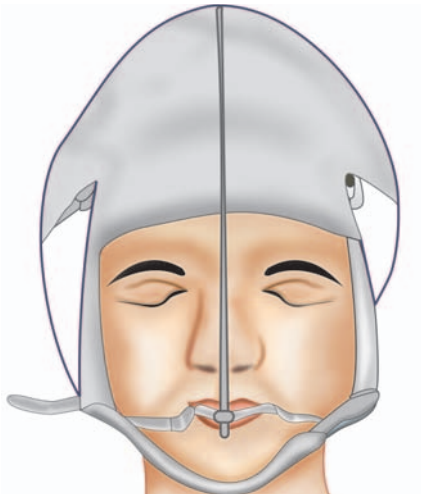


Fig. 30.16: External skeletal fixation with plaster of Paris skull cap

- Unilateral fracture— maxilla
- Dentulous mandibular body fracture with minimal displacement or no displacement
- Edentulous mandibular body fractures

This fixation can be achieved by the following:

- The use of an arch bar or suitable type of wiring methods described earlier.
- Cap splints with locking plates and a connecting bar.
- Acrylic splints—lateral compression or gunning type splint.
- Intermaxillary ligation (IML) or intermaxillary fixation (IMF)—whenever required the jaws are rigidly fixed to each other in centric occlusion. Both the jaws are united as a block, must be fixed to the skull in case of maxillary fractures.

External Fixation

The intact skull serves as a fixation point for the fixation of facial fractures. Usually a plaster of Paris head cap is applied for external skeletal fixation. Rigid connection to the head cap must follow by means of various connecting bars which are attached on both sides to the intraoral arch bars and that lead out of the oral cavity. Small cross-struts on the side bars are used for the application of the elastic traction **(Fig. 30.16)**. Instead of plaster of Paris skull cap, various prefabricated head frames can be used. These head frames can be made up of metal or leather straps. These are tiara-shaped head frames directly secured to the head. Head frames provide absolute stability and are more easily applied to an unconscious patient. They can also be used in conjunction with fractures of the frontal bone and cranial vault.

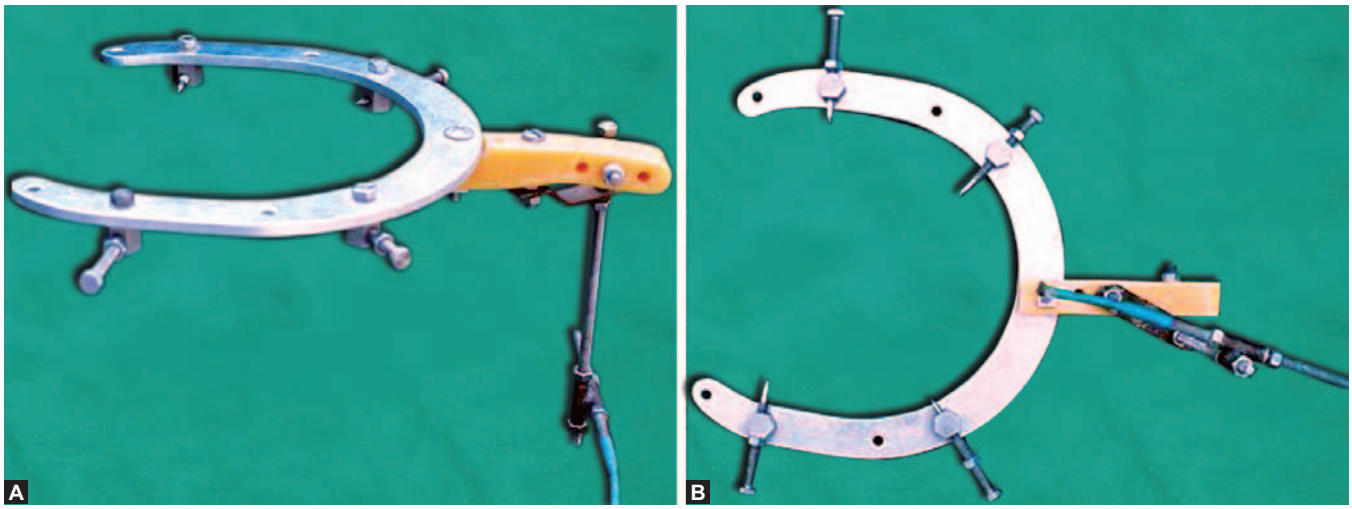
The metallic "Halo frame" devised by Crewe in 1943 is directly secured to the skull by multiple screw pins inserted into the external cortex of the skull. Vertical rods, bilateral check wires, side bars can be added to the central Halo frame, which is a versatile apparatus of great stability **(Figs 30.17 to 30.19)**.

Different Possibilities for External Skeletal Fixation

- Plaster of Paris head cap, intraoral arch bars, side bars fixed to the upper arch bar, connection between side bars and plaster head cap by:
  - Bilateral elastic bands.
  - Bilateral rods and universal joints.
  - Bilateral transbuccal cheek wires attached to the arch bars.
- Halo frame (instead of plaster of Paris head cap) with traction and fixation elements and intraoral splints.

The extraoral fixation may be of the following types:

- **Craniomaxillary:** Fixation between the skull and maxillary arch is termed as craniomaxillary fixation. This is a rigid direct suspension of the detached middle-third of the facial skeleton, which is achieved by connecting the maxillary arch bars to an external head gear. This can be achieved by means of a vertical rod, fixed via universal joints to a projecting bar screwed on the arch bars or splints.
- **Craniomandibular:** Fixation between the mandibular arch and skull is termed as craniomandibular fixation. Here the fractured area of the middle-third of the face is sandwiched between intact skull and rigid mandible. This can be achieved by:



Figs 30.17A and B: The metallic "Halo frame", devised by Crewe

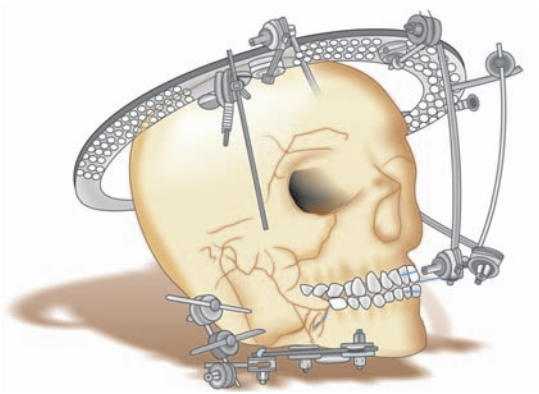
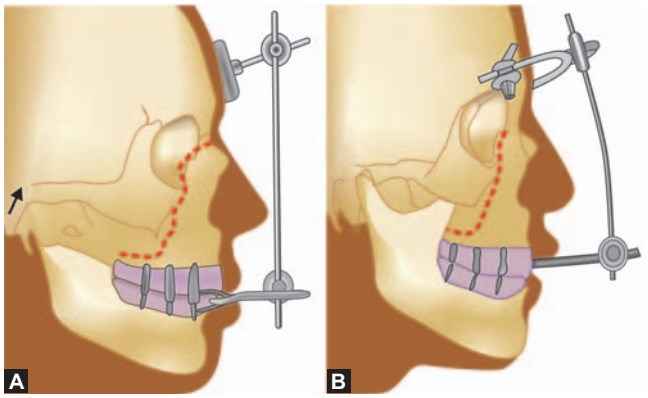


Fig. 30.18: Extraoral fixation device consisting of metallic halo frame, possible combination of rods and universal joints



Figs 30.19A and B: (A) Craniomandibular external fixation; (B) Craniomaxillary external fixation

- Connecting a mandibular splint to a plaster of Paris head cap via an anterior projecting bar and vertical rod, or
- Bilateral transbuccal wires from the head caps to a mandibular arch bar.
- Halo frame can be used as a fixed anchorage point in both craniomaxillary and craniomandibular fixation method **(Figs 30.19A and B)**.

Internal Fixation

This type of fixation is achieved entirely or primarily by passing wires within the tissues.

Direct suspension: In this method the same principle, as extraoral fixation is used except, the wires are passed subcutaneously from stable skeletal points into the oral cavity and are fixed on both sides to the arch bars under traction [craniofacial suspension **(Figs 30.20 and 30.21)**]. Depending on the type of fracture, the point of fixation may vary. The wires are always passed from a stable point above the fracture line. The various areas for direct suspension of wires can be chosen.

a. Pyriform fossa
b. Zygomatic buttress
c. Zygomatic arch
d. Infraorbital rim
e. Zygomatic process of the frontal bone.

Indirect support: Craniomandibular suspension is brought about by sandwiching the fractured areas between the mandible and some part of the facial skeleton above the fracture line through the medium of suspensory wires connected to a mandibular arch bar. The appropriate sites can be chosen as indicated in direct suspension procedure.

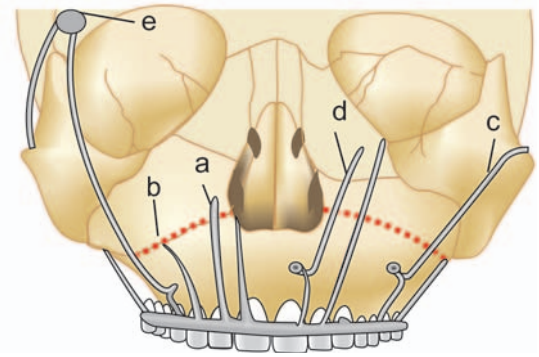
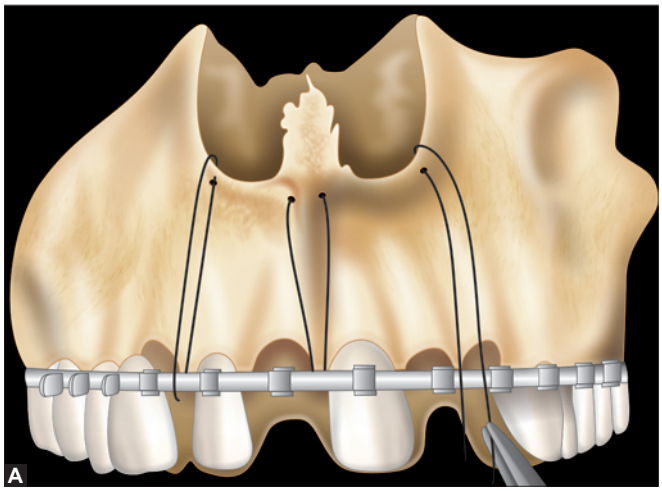
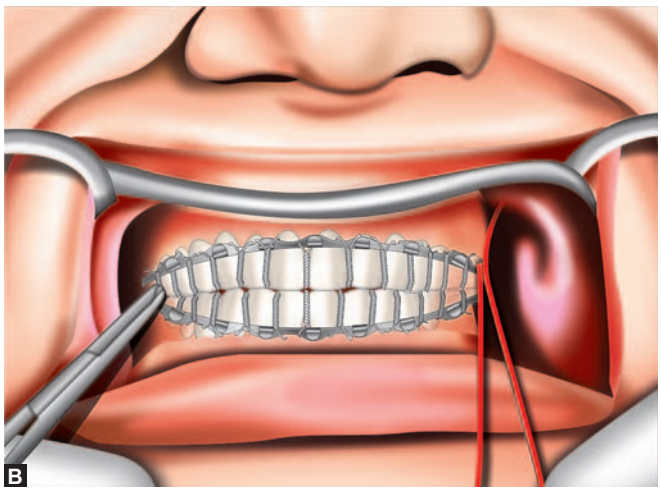


Fig. 30.20: Direct suspension wires at different locations: (a) Pyriform fossa; (b) Zygomatic buttress; (c) Zygomatic arch; (d)Infraorbital rim; (e) Zygomatic process of the frontal bone





Figs 30.21A and B: (A) Pyriform aperture suspension wiring along with wiring at anterior nasal spine; (B) Suspension wiring from the infraorbital rims on either side to arch bar

Transosseous or intraosseous wiring: It can be used at various sites **(Fig. 30.22)**. Open reduction is needed. Here the fractured fragments are approximated in their normal anatomical position after reduction and the holes are drilled on either side of the fracture line and 26-G or 28-G stainless steel wire is passed to interconnect the holes and both the ends of the wires are grasped on the outer cortex and twisted, cut and finished. This type of direct internal fixation offers semirigid stability. Most of the times, if occlusal discrepancy exists, then additional IMF is required during immobilization period.

Transosseous or intraosseous wiring can be done at the following sites:

- Zygomaticofrontal
- Zygomaticomaxillary
- Zygomatic bone (comminuted)
- Palatal processes
- Frontonasal
- Mandibular angle at superior border or inferior border
- Edentulous mandible at the site of fracture
- Condylar fractures—subcondylar or high condylar

Wire osteosynthesis is the oldest, simplest and most popular method for internal fixation.

Disadvantages

- Intermaxillary fixation is always needed
- There is no three-dimensional stability to the fragments
- Interfragmentary pressure cannot be controlled
- Under functional stress, the wire synthesis lacks adequate rigidity, direction control and surface contact
- Delayed healing as compared to bone plate system, because of micromovement at the fracture side.

Direct support: This may be employed in the case of a comminuted orbital floor by utilizing an antral pack or balloon. It can be also used for stabilizing zygomatic complex fractures **(Figs 30.23 and 30.24)**.

Transfixation: Kirschner wires or Steinmann pins may be inserted:

- From zygoma to zygoma
- From zygoma to the maxilla
- In mandibular edentulous fractures
- In mandibular fractures with extensive loss of bone.

Miniplate osteosynthesis: The extraordinarily good results with compression osteosynthesis with plates or lag screws in the mandible have led to the development of similar procedure for the midface. Champy and Michelet introduced miniplate osteosynthesis suitable for facial fracture fixation **(Fig. 30.25A and B)**.

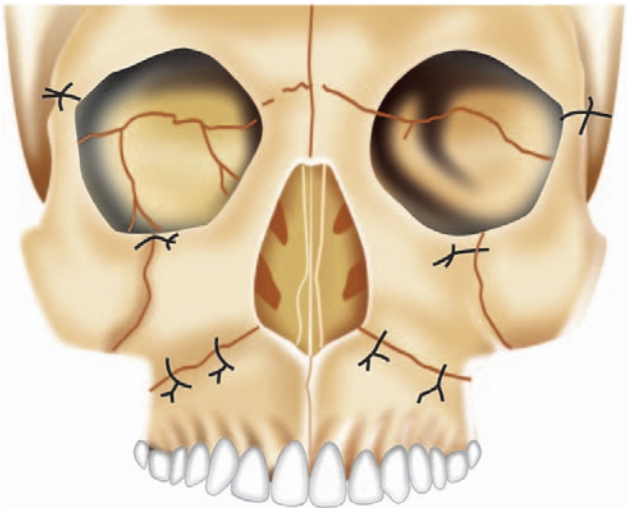
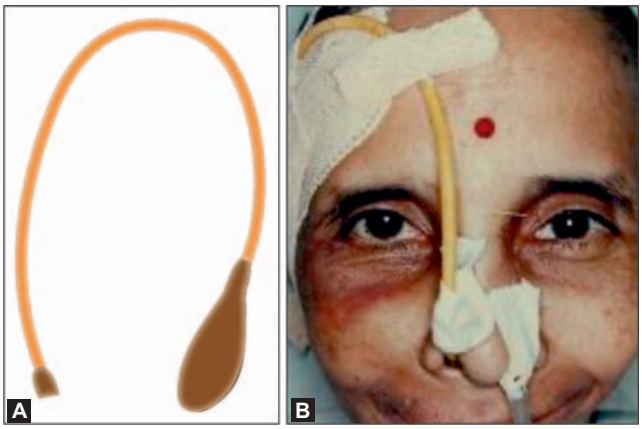


Fig. 30.22: Transosseous wiring at various sites in the facial area



Fig. 30.23: Antral pack



Figs 30.24A and B: Balloon catheter in situ

Construction of Plaster of Paris Headcap

Construction of an accurately fitting, firm, comfortable plaster of Paris skull cap is an art, ill fitting, loose headcap will be extremely uncomfortable for the patient and it will not offer desired stability. Patient may develop edema due to friction and complain of dull headache.

Armamentarium

- Twelve inches length, 6 inches width of stockinette
- A pair of heavy scissors
- Four to five 3 inches width plaster of Paris orthopedic bandage
- Various vertical bars, attachments, etc.

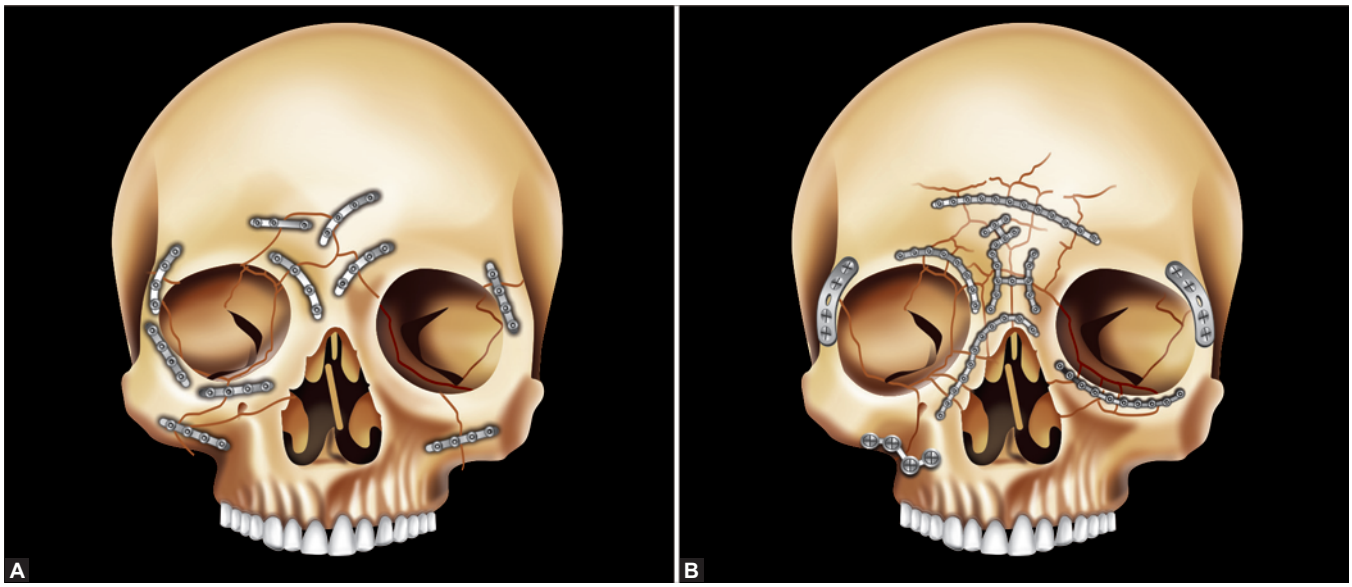
Procedure

Male patient's hair should be trimmed, females should have their hair tied up on top of the head with a ribbon. The stockinette sleeve is passed over the patient's head without disturbing the hair. The plaster of Paris bandage is immersed in cold water and first turn is taken round the head just above the supraorbital ridge by putting the bandage tight and shaping it properly. The second bandage is applied rather higher up the forehead than the first bandage and taken well down below the occiput posteriorly. After the first two bandages are in position then the retention ends of the headcap framework is adjusted until they lie accurately against the headcap surface. Then the third bandage is applied over the ends of the framework which are to be embedded in the plaster. The excess stockinette should be trimmed and turned over the wet plaster bandage. Once the plaster sets, then the plaster skull cap with its attachment is firmly secured to the cranium. Various additional attachments/wires are then incorporated and attached indirectly to the dental arch bars; either maxillary or mandibular.

Direct suspension: The principle of internal wire suspension was first described by Adams in 1943. That is the reason why these wires are also called as Adam's suspensory wires. It has got many advantages over external skeletal fixation.

- No cumbersome apparatus
- Can be used in cases of scalp injuries
- Patients cannot interfere with this type of fixation (mental derangement, cerebral irritation cases)
- Simple procedure with minimum armamentarium
- Elaborate laboratory facilities are not needed.

Direct suspension of the upper jaw is permissible, when precise articulation of the teeth is not required, e.g. when



Figs 30.25A and B: Miniplate osteosynthesis

one or both jaws are edentulous and when immobilization of the mandible is not needed. Fixation of the mandible with maxilla is contraindicated in the presence of severe associated nasal obstruction, unless a tracheostomy is performed.

The internal skeletal fixation of suspensory wires are secured to the arch bars by passing them through holes drilled at the bone by taking small incisions at one of the following sites:

- Margins of the pyriform fossa of the nasal cavity
- Zygomatic buttress
- Infraorbital margin—intraoral incision is taken for above three sites
- Zygomatic process of the frontal bone (extraoral incision)—after reduction of the fracture has been performed, one end of the wire is passed through the hole drilled in the bone and then returned to the point of origin on the splint or arch bar and the free ends twisted together, thus effecting stable fixation. All the suspensory wires are passed bilaterally on both the halves of the facial skeleton to maintain the balance. The fractured portion of the facial skeleton is in this manner suspended from the intact portion of the skeleton **(Figs 30.26A to C)**.
- Circumzygomatic wiring—here the wires are passed through the tissues over the zygomatic arches, both ends of the wire being secured to the splint or arch bar.

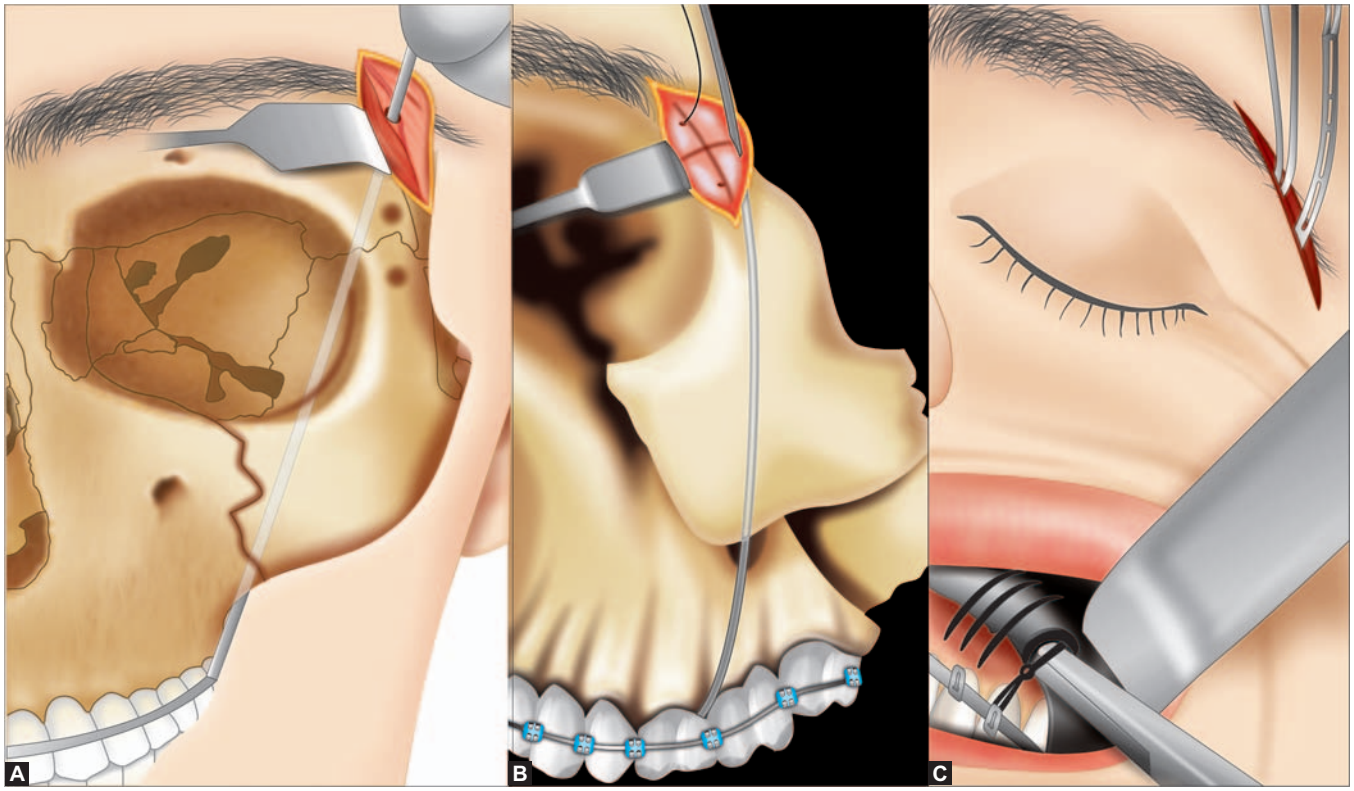
Procedure for wiring at the zygomatic process of the frontal bone: Incision along one of the upper 'Crow's foot' wrinkles overlying the zygomaticofrontal suture or an incision parallel to and within the hair of the outer third of the eyebrow may be employed **(Figs 30.26 and 30.27)**.

Direct transosseous wiring between the zygomatic process of the frontal bone and the frontal process of the zygomatic bone will have to be carried out as a preliminary measure in the case of fractures of LeFort III type.

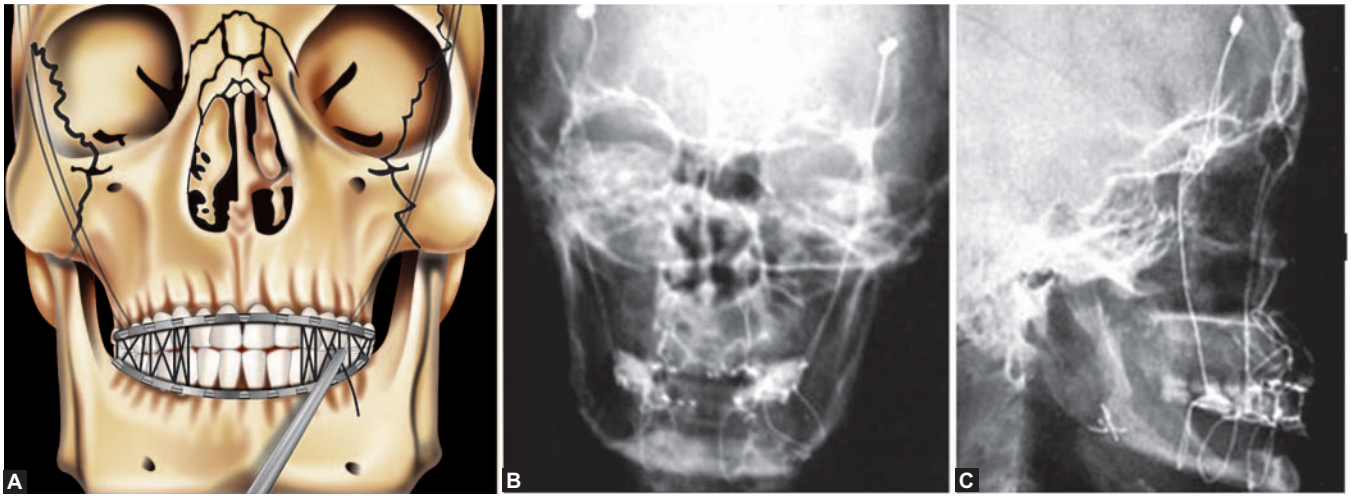
A 6 inches long, 26-G stainless steel wire is then threaded through the upper hole drilled in the zygomatic process of the frontal bone. The two ends of this wire are passed down the temporoposterior surface of the zygomatic bone to emerge into the buccal vestibule in maxillary second molar region. This passage of wire may be done by using a bone awl or a long, curved hypodermic 18-G needle. The attachment of the free ends of the wires is then carried out in the usual manner. Care should be taken that both the wires are not twisted/kinked at any point, so that the subsequent removal is easy.

Circumzygomatic wiring: This useful technique was described by Lesney in 1953 **(Figs 30.28A and B)**.

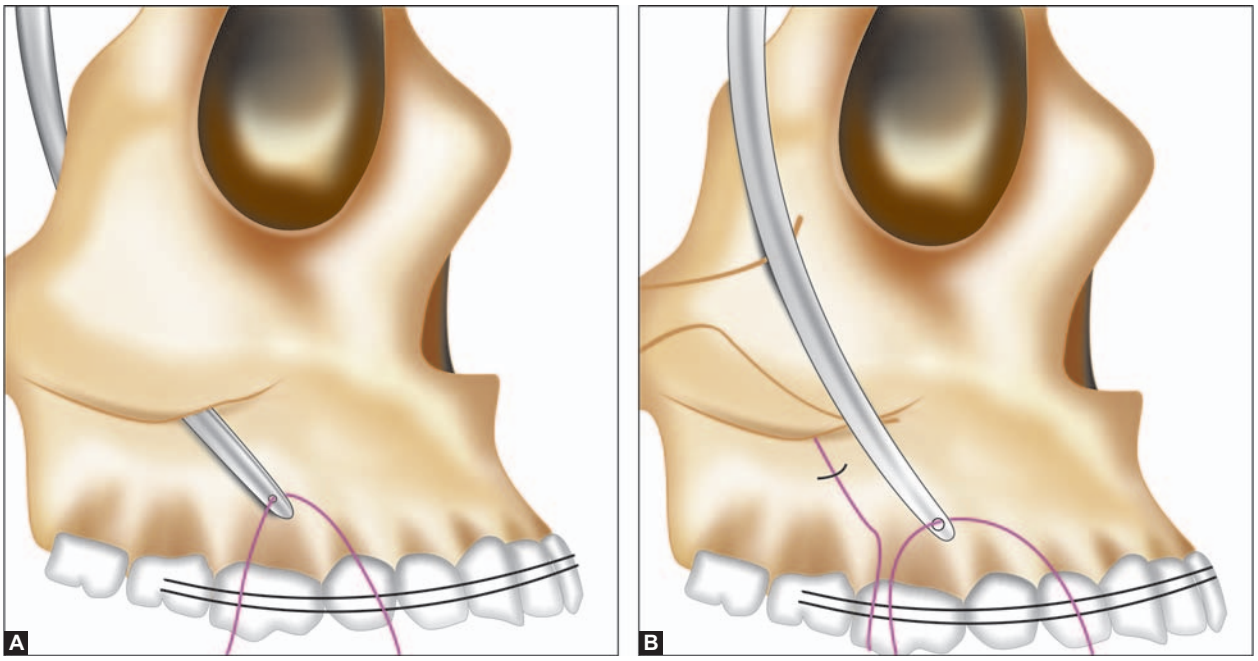
The entire length of the zygomatic arch is palpated and patient's head is turned sideways so the zygomatic arch becomes prominent. An introducer is then entered through small skin stab incision, at the upper border of the anterior aspect of the zygomatic arch, remaining on the medial aspect of it and is inserted within the tissues to emerge in



Figs 30.26A to C: Adam's internal suspension wiring at the zygomatic process of the frontal bone. (A) Incision is taken over lateral margin of the eyebrow. Small hole is drilled after exposing the zygomatic process of the frontal bone. Wire threaded through the hole, passing below the zygomatic arch; (B) Other end of the wire is passed over the zygomatic arch. Both the wire ends are brought out in the buccal vestibule; (C) Both the wire ends are tied to the maxillary arch bar for craniomaxillary suspension wiring



Figs 30.27A to C: (A) Adam's wiring; (B) Posteroanterior view X-ray showing the Adam's suspensory wiring bilaterally; (C) Lateral view X-ray showing the same with additional circummandibular wiring to secure the splint



Figs 30.28A and B: Circumzygomatic wiring

the buccal vestibule in maxillary second molar region. A 26-G 10 inches long wire is then threaded in the eye of an introducer and the introducer is pulled at the upper border of the zygomatic arch. At this point, the tip of the introducer is not taken out over the skin surface, but is manipulated back over the lateral surface of the arch and again passed through the tissues towards the buccal vestibule. This way the entire wire encircles around the zygomatic arch. The two loose ends of the wire in the buccal vestibules are pulled to and fro, so that wire cuts through the tissues and comes to lie on the zygomatic arch. Both the ends are then ligated to the dental arch bars as desired.

Direct support: This is mainly used in case of orbital floor fracture or zygomatic complex fracture displacement.

Intraorally, the direct support can be given via the maxillary sinus, with the objective of repositioning the fragments and supporting them in position by various means until union has occurred.

Extraorally, the orbital floor can be exposed and supported by using bone graft, cartilage graft or some alloplastic material as silastic sheet.

Antral Approach

The mucoperiosteum is reflected from the anterolateral wall of the maxillary antrum following an incision of the Caldwell Luc type. The bone may or may not be fragmented, but an opening is made, just above the canine roots, sufficient to admit the index finger of the operator. The thorough irrigation of the sinus is carried out, loose fragments are removed and entire sinus should be inspected under direct vision. Fractured fragments are reduced digitally.

Antral pack: A long strip of half inch ribbon gauze soaked in betadine or iodoform and lubricated with Vaseline is used to pack the antrum **(Fig. 30.23)**. The packing should be started at the back of the floor and laid in layers in an anteroposterior direction. Care is taken not to force the pack tightly at the floor of the orbit, but adjusted in such a way that the ocular level is brought to normalcy. The last end of the pack either may be brought out through the corner of the incision intraorally or through the nose, via a nasal antrostomy.

The pack is not retained for more than two weeks. In case of zygomatic complex fracture, it is reduced first and then the antral pack is inserted.

Balloon catheter: Shea and Anthony in 1952, devised a balloon for the purpose of supporting the comminuted orbital floor **(Figs 30.24A and B)**. Recently, the use of Foley's catheter no. 16 or 18 is recommended. The preliminary procedure is same as described for the insertion of an antral pack. Nasal antrostomy is performed and a curved hemostat

is passed from the antrum into the nasal antrostomy. The tips of the hemostat is opened to grasp the tip of the Foley's catheter and the hemostat is pulled into the antrum. The position of the catheter is adjusted in the antral cavity. Then 20 mL of sterile saline is inserted into the rubber stopper of the catheter and the balloon slowly inflated under direct vision, until a satisfactory reduction has been achieved. The balloon is kept for 1 to 2 weeks and then removed, after deflating by emptying the saline, through the nose.

Internal Fixation by Means of Bone Plate Osteosynthesis

The direct internal fixation of the fractured fragments can be carried out by bone plate osteosynthesis method. It either totally eliminates the need for IMF or minimizes the period of IMF. Relapse following management of fracture cases was of main concern to all of the treating surgeons in the past. Firm fixation of the fractured fragments is an ideal requirement in order to achieve an uneventful postoperative healing. Rigid internal fixation of these fragments provides three-dimensional stability and eliminates the risk of relapse and promotes better osteosynthesis.

Indications

- Cases where there are absolute contraindications to IMF, i.e. in epileptics, mentally retarded uncooperative patients, asthmatics, alcoholics, drug abusers, pregnant women, etc.
- When the patient wants to return back to work early.
- Edentulous patients with loss of bone segments, which need the maintenance of the gap or grafting, if indicated.
- In subcondylar and angle fractures of the mandible, early mobilization of the joint is required.
- Atrophic mandible requiring additional reinforcement.

Contraindications

- In heavily contaminated fractures, where there is active infection and discharge. However, some surgeons advocate the use of compression osteosynthesis in such cases
- In badly comminuted fracture, where open reduction may pose risk of compromising vascularity
- In children having mixed dentition, where there is a danger of injuring the developing teeth buds
- Presence of gross pathological abnormalities in the bone.

Advantages

- Simple technique
- Decreased intraoperative time
- Most of the time, intraoral approach is sufficient. However, in certain cases extraoral approach may be required
- Direct control of occlusion in intraoral technique
- Postoperative IMF is not needed or period of IMF is reduced
- Early return of function
- Reduced hospital stay
- Better esthetics and function, better three-dimensional stability
- Minimization of immediate postoperative complications, as mouth is not locked
- Better maintenance of oral hygiene
- Nutritional intake does not suffer
- Psychological advantage
- No weight loss
- No speech problem.

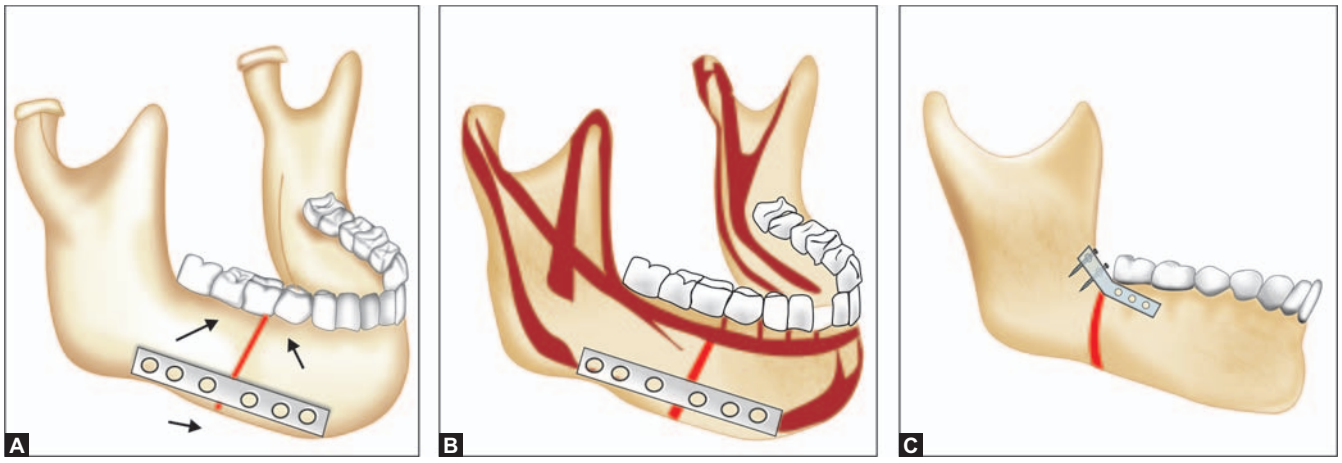
Precautions: Majority of complications in bone plate osteosynthesis are linked to infections, because of inadequate fixation of the fracture. The following points are important and if neglected lead to compromised results.

- Strict aseptic procedure is required and precision in the technique is very important
- Patient should be kept on preoperative antibiotics and the operation should be undertaken at the earliest
- Proper armamentarium should be used and if titanium plates are used, then they should be handled with titanium tipped instruments (Oxidation). Plates and screws also should be made up of the same metal
- Plates should be fixed along ideal osteosynthesis lines and minimum two screws on each side of the fracture line should be used
- The drill bit should be kept perpendicular to the outer cortex
- Patient should maintain good oral hygiene
- Tension on the flap or infection can lead to wound dehiscence. Careful soft tissue closure (with mobilization of tissue, if required) should be done.

Bone Plate Osteosynthesis

Bone plate osteosynthesis can be carried out using the following **(Figs 30.29A to C)**:

- Compression plate with bicortical screw system
- Noncompression plate with monocortical screw system.



Figs 30.29A to C: Bone plate osteosynthesis. (A and B) Rigid fixation. Eccentric dynamic compression plate system (EDCP); (C) Noncompression plating with monocortical screw fixation (Champy's technique)

Experimental and clinical experience has shown that the susceptibility to infection depends on the mobility of the fragments. The bony union can be promoted when the fragments are approximated firmly under pressure against each other. This principle is utilized in the development of compression bone plate system (AO system) by European surgeons. This system offers rigid fixation with intrafragmentary compression. There is no need for IMF postoperatively. Here, there is no intrafragmentary gap or it is less than 0.8 mm. During healing there is no callus formation. But there is primary healing of the bone, characterized by direct restoration of lamellar bone. Osteogenic elements and blood capillaries readily traverse the fracture site, resulting in direct longitudinal bone healing with less remodeling in 3–4 weeks. In this technique precision is needed. Occlusal relationship should be checked prior to screw fixation. Otherwise, this highly precise technique, will not allow any occlusal discrepancy correction later on, as it is possible in wire or monocortical bone plate osteosynthesis.

AO System (Figs 30.30 to 30.33)

- Dynamic compression plate (DCP)
- Eccentric dynamic compression plate (EDCP)

Plates and screws are made up of stainless steel and need removal later on. These plates are very bulky. Dynamic compression plate system makes compression osteosynthesis possible, because of the screw holes designed according to the spherical gliding principle for a 2.7 mm screw. In EDCP, the eccentric gliding hole principle is used. In eccentric dynamic compression plate, there are two lateral oblique holes in addition to conventional spherical gliding holes. When the screw with the spherical head is driven into the two inner holes, they provide interfragmentary compression. It is possible by means of two outer holes to produce additional compression at the alveolar margin of the fractured fragment. The two lateral oblique holes take over the function of the tension band in the alveolar margin.

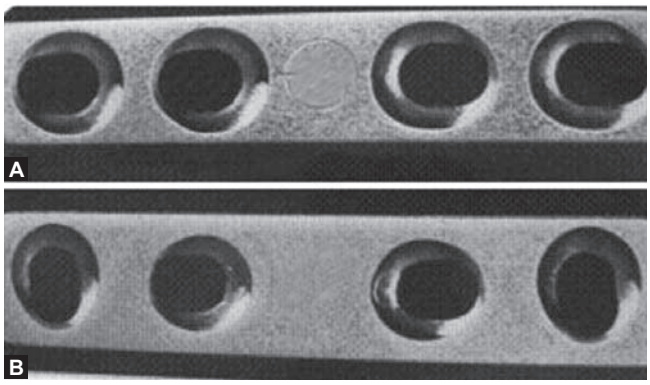
Miniplate Osteosynthesis (Noncompression Monocortical Screw System)

This is a complete different concept than compression bone plate system. This is developed in France by Michelet in 1973 and made clinically popular by Champy in 1975 (Strasbourg Miniplate Osteosynthesis).

Aim: To attain a functionally oriented fracture adaptation. Fixation with miniplate system, which is as small as possible. Application of the plate to the region of the traction side of the bone.

Therapeutic Principle: Fixation by Stability

Stability is achieved by a perfect anatomic reduction and intrafragmentary approximation without compression. Champy recognized that in function, it is possible to identify the lines of tension, which when controlled will stabilize the fracture. He also noted that the reciprocal compression force at the lower border, controlled by bone to bone contact across the fracture line. Because these are tensile forces, equivalent to a suspension bridge, small plates can take these loads. Thus, by identifying the lines of tension, miniplate osteosynthesis can be used to obtain immediate jaw function.



Figs 30.30A and B: AO system plates. (A) Dynamic compression plate; (B) Eccentric dynamic compression plate

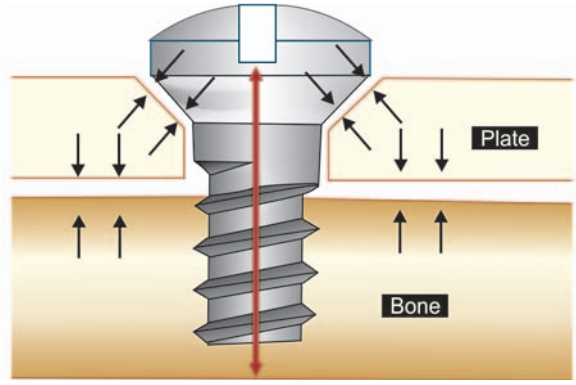
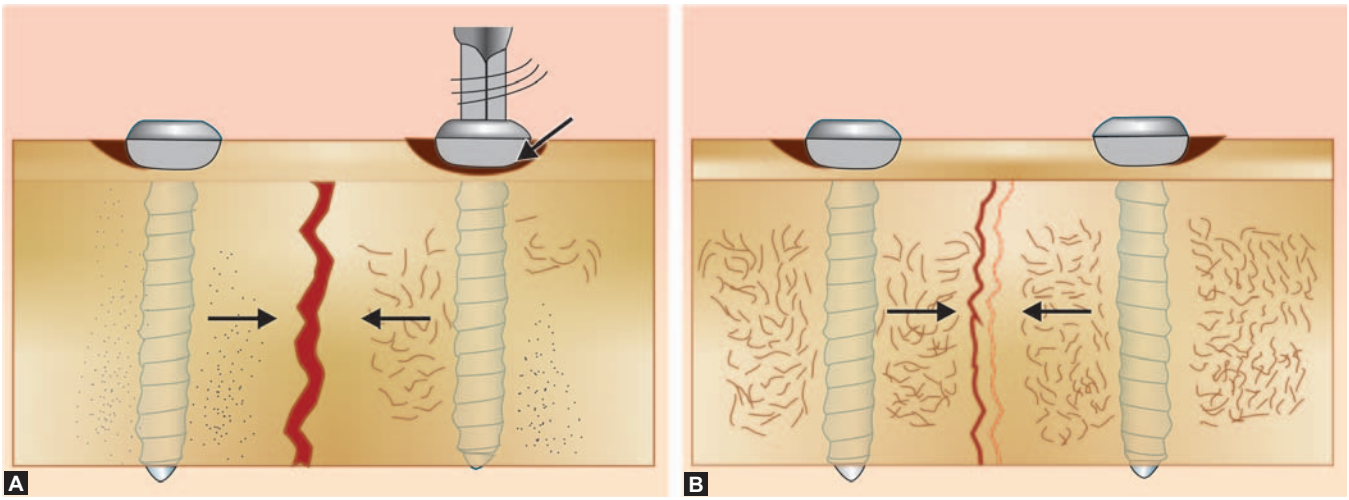


Fig. 30.31: Compressive forces between screw and plate countersink due to the tensile force induced into the screw. Force transmission takes place by the friction between the plate and bone



Figs 30.32A and B: Mode of action of dynamic compression plate (DCP). (A) Adaptation phase; (B) Compression phase

The important anatomical issues with monocortical miniplate osteosynthesis are:

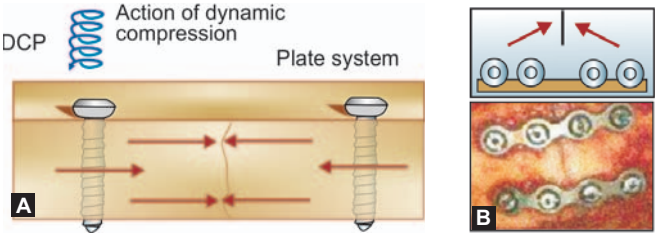
- The location of the dense cortical bone
- The location and course of the mandibular canal
- Displacing forces acting on the mandible.

Anatomy and Biomechanics of the Mandible

Champy's Ideal Osteosynthesis Lines

Mandible has parabola-shaped body **(Figs 30.34 to 34.37)**. It consists of the outer and inner cortical plates with central spongiosa. The external cortex is strong and thicker in chin region. It is reinforced laterally by the external oblique line— a strong projection. In the chin region, there is a stronger cortex inferiorly at the lower border. By the virtue of its compact bone, it provides good anchorage for osteosynthesis screws. In the tooth-bearing areas, alveolar process is of variable thickness. Screw fixation in this area is not possible, due to the anatomy of the roots of the teeth and structure of the bone. The mandibular canal runs from lingula to the mental foramen on a concave course directed upwards and forwards. Traced from behind forwards, the inferior alveolar nerve runs closer to the outer cortex and to the lower border (8–10 mm from lower border). Distance between the nerve and the outer cortex ranges between 4 mm and 6 mm. The mental foramen lies higher than the canine apices (no osteosynthesis).

In every mandibular fracture, the forces of mastication produce tension forces at the upper border and compression forces at the lower border. Therefore, distraction of the



Figs 30.33A and B: Side screw inserted and not tightened. Screw is inserted and tightened first. The screw head moves down the gliding plane of the hole in the plate

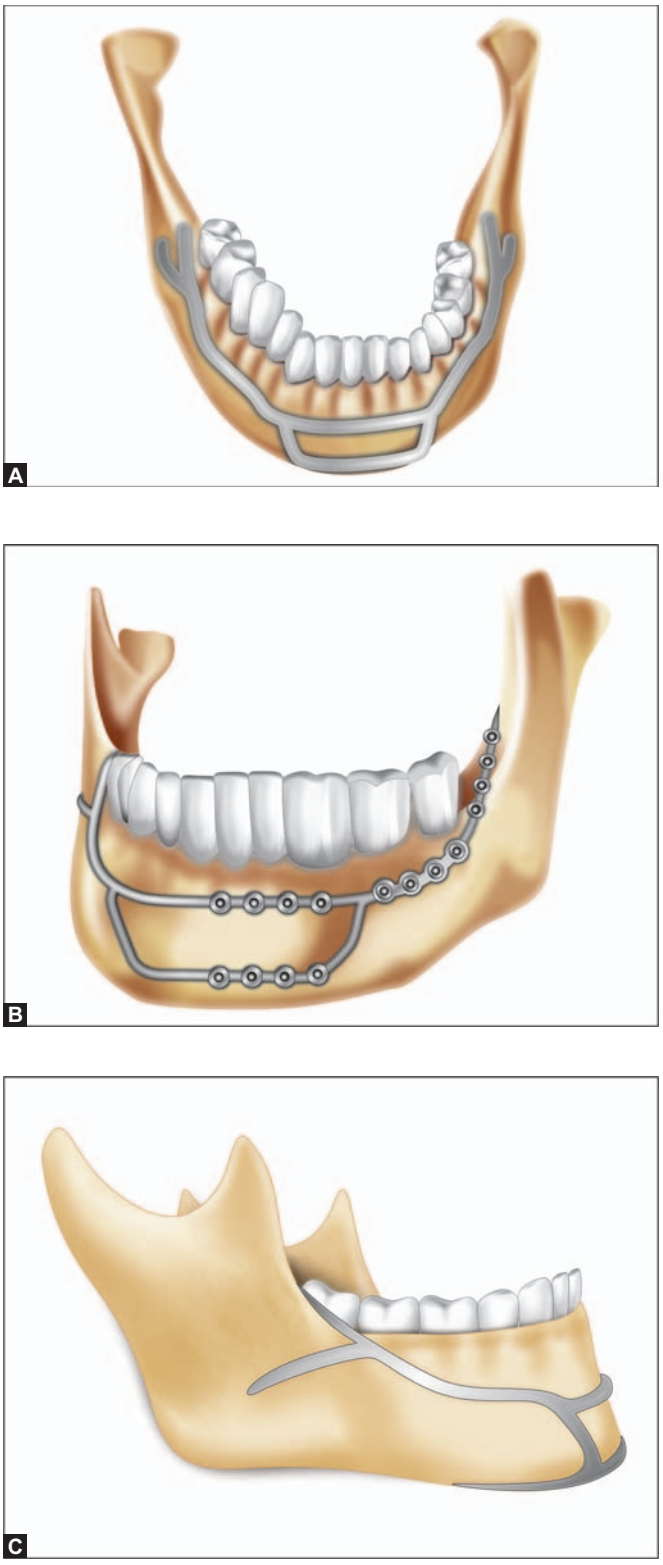
fractured fragments can be seen at the alveolar crest region. In the canine region, there are overlapping tensile and compressive loads in both the directions. Besides this torsional forces are also significant.

The experimental exercise on the model and on the fractured mandibles have confirmed the values calculated on the normal mandible is 60 DaN (maximum) in molar region and 100 DaN in the incisor region, allowing for the additional torsional forces. Taking into account these anatomical factors, the determination of these forces allows the establishment of "ideal osteosynthesis lines" for the mandibular body. It corresponds to the course of a line of tension at the base of the alveolar process. In this region a plate can be fixed with monocortical self-tapping screws. Behind the mental foramen, a plate can be applied immediately below the root apices and above the inferior alveolar nerve. At the angle of the jaw, the plate is most favorably placed on the broad surface of the external oblique line as high as possible. In the anterior region between the mental foramina, in addition to the subapical plate, another plate near the lower border of the mandible is necessary in order to neutralize torsional forces. Second plate is applied parallel to the first plate with a gap of 4.5 mm between them.

Biophysical properties of the osteosynthesis material: It should be bio-inert, biologically well tolerated. It can be miniaturized. It should be strong enough to withstand the bending and tension forces up to 60–100 DaN.

Alloy of chrome, nickel and molybdenum with a trace of 0.03% carbon ensures good malleability. Screws and plates can be also made up of stainless steel, titanium, etc.

Miniplates: These are available as 2 cm long, 0.9 mm thick and 6 mm wide plates. Screws, plates and instruments should be made up of same material, since variation in material will lead to oxidation reduction phenomena, with detrimental tissue effects. The screws



Figs 30.34A to C: Champy's ideal osteosynthesis lines for minibone plate fixation

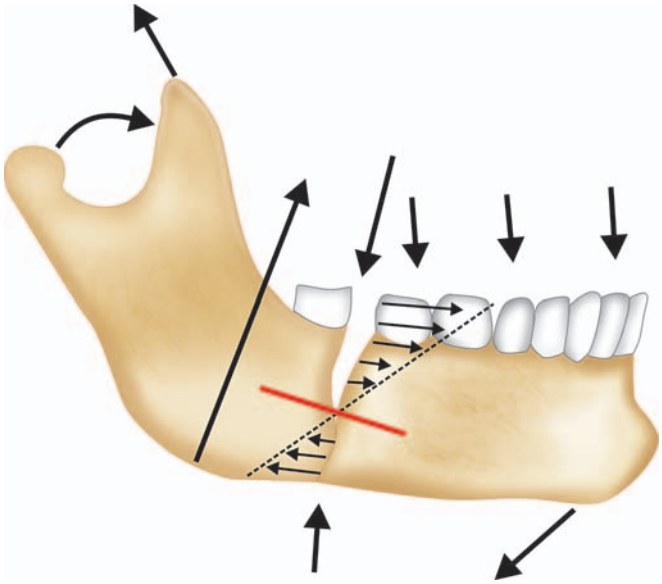


Fig. 30.35: Red line indicates "the line of zero force" at the mandibular canal level. A fracture is subjected to tensile forces above the line and to compressive forces below the line

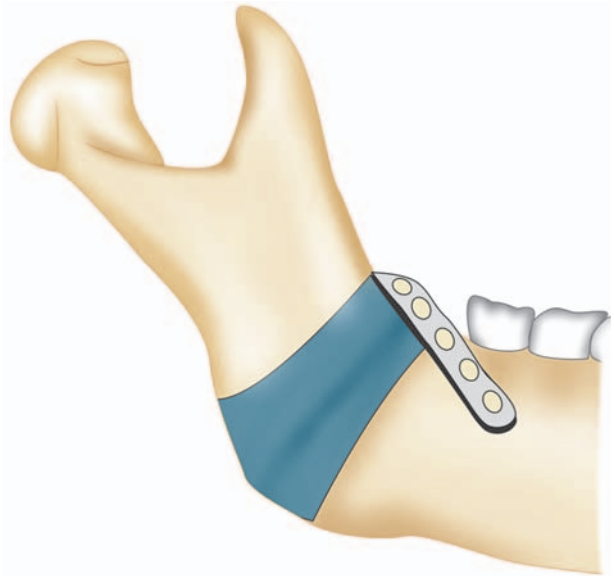


Fig. 30.36: Mini bone plate osteosynthesis at the angle region



Figs 30.37A to C: Miniplate osteosynthesis at symphysis, parasymphysis and angle region to neutralize the masticatory forces

have a thread of 10/10 and in a cortical bone with an average thickness of 3.3 mm, the screws are secured with three turns. This is sufficient for monocortical anchorage.

Points to be Observed

- The drilling must be precise and must be monoaxial. Otherwise, an unfavorable conical bur hole results
- The screws should be self-tapping
- The drill must be of the same width as of the screw core
- The screw thread must be relatively narrow, so that considerable contact is made in between the turns of the thread, which is 1 mm
- Plates must be fixed along the ideal osteosynthesis lines.

Complications: There are few complications directly related to the use of miniplates. The complication rates with respect to infection, delayed union, malunion and malocclusion vary from 5% to 15%.

Complications can arise due to:

- Incorrect diagnosis
- Incorrect occlusion
- Incorrect osteosynthesis and include:
  - Infection
  - Dehiscence of wound, exposure of plate
  - Malocclusion
  - Fracture mobility
  - Pain at the site of plate
  - Metallic feeling for male patient during shaving.

Points to Remember

- Etiology of maxillofacial injuries
- Local clinical examination of maxillofacial injuries
- Basic principles of treatment of a fracture
- Different types of wiring and splints
- Internal fixation methods
- External fixation methods.

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CHAPTER 31 Fractures of the Middle-third of the Facial Skeleton

INTRODUCTION

Fractures of the middle-third of the face are seen less frequently than the fractures of the mandible. However, the incidence is increasing due to high-speed transportation accidents.

MIDDLE-THIRD OF THE FACIAL SKELETON

Middle-third of the facial skeleton is defined as an area bounded superiorly by a line drawn across the skull from the zygomaticofrontal suture of one side, across the frontonasal and frontomaxillary sutures to the zygomaticofrontal suture on the opposite side, and inferiorly by the occlusal plane of the upper teeth, or if the patient is edentulous, by the upper alveolar ridge. Posteriorly, the region is demarcated by the sphenoethmoidal junction, but includes the free margin of the pterygoid laminae of the sphenoid bone inferiorly.

Bones Constituting the Middle Third of the Face

These are following eight paired bones and two unpaired bones constituting the middle-third of the face **(Fig. 31.1)**.

- Two maxillae
- Two palatine bones
- Two zygomatic bones and their temporal processes
- Two zygomatic processes of temporal bones
- Two nasal bones
- Two lacrimal bones
- The ethmoid bone and its attached conchae—unpaired
- Two inferior conchae
- Two pterygoid plates of the sphenoid
- The vomer—unpaired.



Fig. 31.1: Bones constituting the middle third of the face

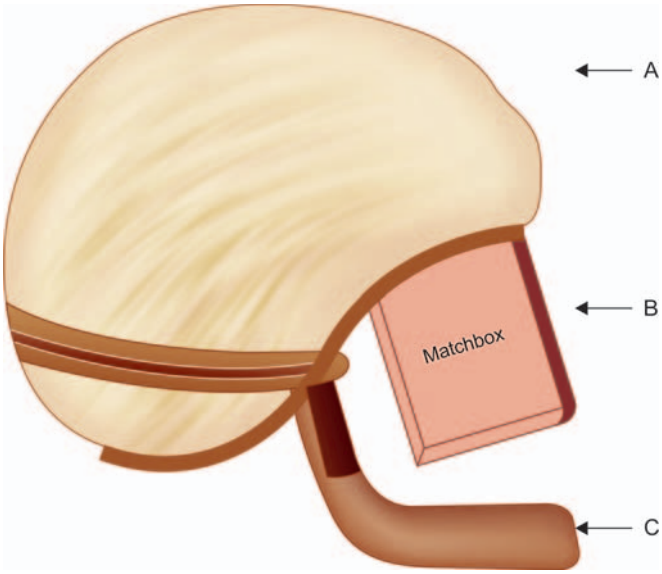


Fig. 31.2: Comparison of the midface to a 'Matchbox': (A) Skull; (B) Midface; and (C) Mandible

Physical Characteristics of the Midfacial Skeleton

- The middle-third of the facial skeleton is made up of considerable number of bones, which are rarely fractured in isolation.
- All the bones are comparatively fragile and they articulate in a most complex fashion.
- The greatest portion of the middle-third of the face is made up of the maxilla, which is attached to the cranium and supported by a strong system of buttresses.
- The maxilla is capable of absorbing considerable force by transmission of the force to the adjacent articulating bones. Midface acts as a cushion for the trauma directed toward the cranium from the anterior or anterolateral direction analogous to a "matchbox" sitting below and in front of a hard shell containing the brain. Violent forces to this region are dissipated or absorbed by fractures of the maxilla and other facial bones, and thus offer protection to the brain and spinal cord **(Fig. 31.2)**.
- The area of the middle-third of the facial skeleton is anatomically complex and complicated, so that fractures of this area are generally comminuted, especially the bones of the nasoethmoidal complex and anterior maxillae. It is this inward crushing causes "typical dish face deformity".
- The composite structure of these complex bones is so designed that it withstand the forces of mastication from below and provides protection to the vital structures (e.g. eyes, brain, etc.). The forces of mastication are distributed around the fragile areas of the nose and paranasal sinuses to the base of the skull.
- This type of structure is able to withstand considerable amount of force applied in a vertical manner from below, but the bones can be easily fractured by relatively small impact if applied from other directions, i.e. anterior, superior or lateral aspects.
- The facial bones, as a whole, have a very low tolerance to impact forces from the front and sideways. The nasal bones are least resistant followed by the zygomatic arch, while the maxilla itself is very sensitive to horizontal impacts.
- If the bones comprising the middle-third are removed from the skull, it has been seen that the frontal bone and body of the sphenoid form an inclined plane, which slopes downward and backward from the frontal bone at an angle of about 45° to the occlusal plane of the upper teeth. The bones of the middle-third of the facial skeleton articulate with these strong foundation bones, and when fracture occurs, they are crushed or sheared off the cranial base. There is slight amount of backward but marked downward displacement is seen because of the steep slope of the base of the skull. This results in the premature gagging of the posterior teeth of the maxilla with the mandibular teeth, causing resultant anterior open bite and lengthening of the face, and in extreme cases, the soft palate may be pushed down upon the dorsum of the tongue causing airway obstruction **(Fig. 31.3)**.
- Any gross disruption of the maxillae will fracture and displace the elements of the nasal septum and nasal bones and expose the paranasal air sinuses to the possibility of infection. In addition, nasal respiration may be impeded by the nasal airway becoming occluded by blood clot **(Fig. 31.4)**.
- Comminution of the paper-thin bone of the orbital floor and medial wall of the orbit readily occurs. Along with backward and downward displacement of the middle-third, there is impairment for the support of the eye. Diplopia of a varying degree can occur and is most severe, when there is rupture of the medial or lateral attachments of the suspensory ligament of Lockwood.
- A shearing stress applied to the ethmoidal region results in comminution of the cribriform plate of the ethmoid bone and provides direct access to the anterior cranial fossa. Leakage of cerebrospinal fluid can take place

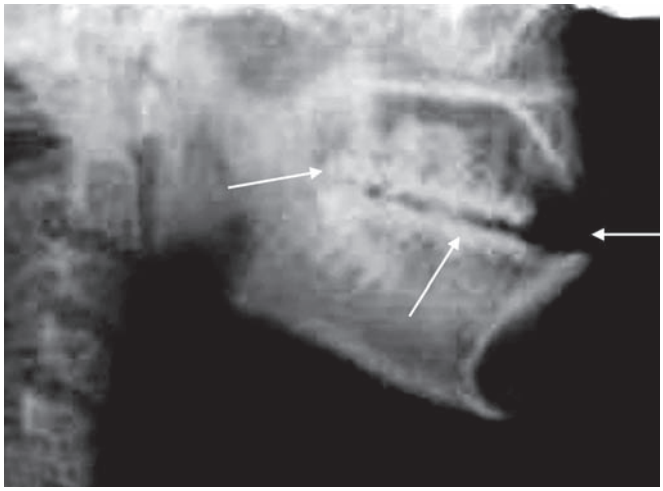


Fig. 31.3: Lateral cephalogram showing the posterior and downward displacement of the middle third of maxilla due to trauma. Note the reverse overjet, anterior open bite, premature gagging of the posterior teeth (arrows)

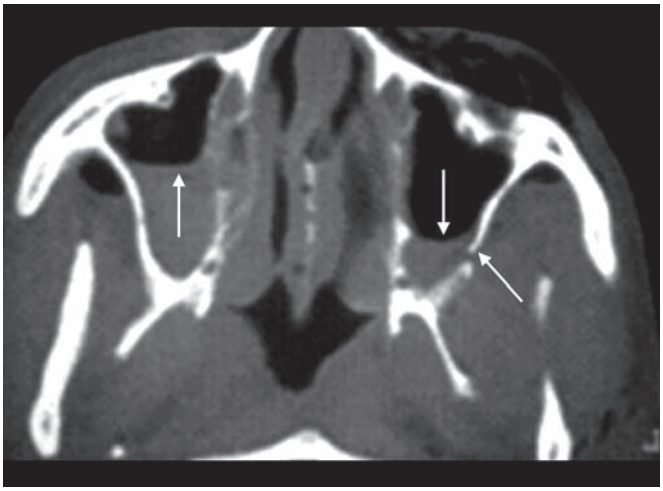


Fig. 31.4: Gross displacement of nasal bones and zygoma bring about involvement of maxillary sinuses. Bleeding in the maxillary sinuses shows the *fluid collection level* in the CT scan (arrows)

following this injury. It may appear running down the nose, mixed with the blood. It is easier to detect when the blood begins to coagulate. If the patient is lying down then the CSF may pass downward in the nasopharynx, and there may be presence of salty taste during swallowing. The flow of CSF increases if patient sits up with head inclined forward, coughing, straining or on compression of the jugular veins.

- The maxillary, palatine, ethmoid, vomer, lacrimal and body of the sphenoid bones are enclosed in mucosa covering large areas of their surfaces, hence the blood supply to any part of the midfacial skeleton is never compromised.

Applied and Surgical Anatomy

The majority of the skeleton of the middle-third of the face is composed of wafer thin sheets of the cortical bone with stronger bony reinforcement comprising of the following:

- The palate and alveolar process
- The lateral rim of the pyriform aperture extending upward via the canine fossa to the medial orbital rim and then to the glabella
- Zygomatic buttress and the connections to the inferior and lateral orbital margins, and the zygomatic arch
- The orbital rims
- The pterygoid plates.

The bulk of the strength lies in the facial surfaces of the skeleton. Although thin at sites, other than those mentioned above, the whole skeleton is strong because the interconnected laminae provide an excellent cross-braced type of structure.

The maxilla, the composite of the maxillary and palatine bones, forms the largest part of the middle-third of the face and contributes to the formation of the orbit, the nasal cavities and the hard palate (roof of the mouth). The body of each maxillary bone is hollowed out by the maxillary sinus.

The body of each maxilla has four processes: frontal, zygomatic, palatine and alveolar. The stability of the maxilla is obtained by bracing against the anterior part of the cranial base. The maxillae are ingeniously designed to resist the forces of mastication, to absorb the shock of the occluding teeth and to distribute the load as evenly as possible over the cranial base.

This load distribution is achieved by the arched shape of the palate, and the abutments of the maxillae against the frontomaxillary, zygomaticomaxillary and maxillary ethmoidal sutures. Posteriorly a strong buttress is provided by the junction of the pyramidal process of the palatine bone and the pterygoid laminae of the sphenoid bone.

Further support is provided by the vomer and vertical plate of the ethmoid in the nasal cavity. The zygomatic bone redistributes the load to the frontal bone via the zygomaticofrontal suture, and, to a lesser extent, to the temporal bone via the junction of the temporal process of the zygomatic bone and the zygomatic process of the temporal bone. Furthermore, the presence of the

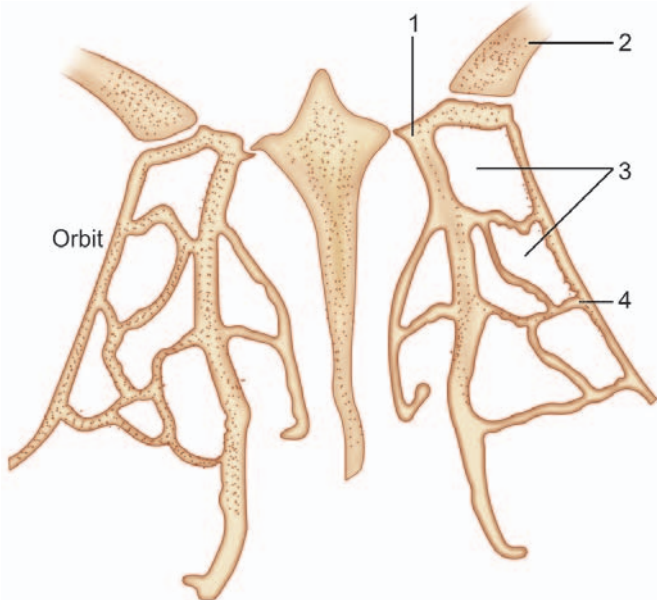


Fig. 31.5: Coronal section of the skull showing delicate laminae framework distributed in a vertical direction. Alignment is along the lines of principle stress: 1—Cribriform plate; 2—Frontal bone; 3—Ethmoid air cells; and 4—Lamina papyracea

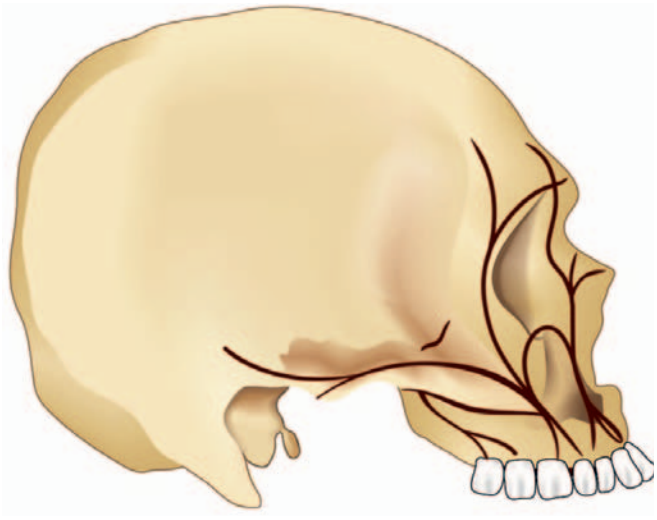


Fig. 31.6: Supporting anterior, middle and posterior vertical pillars of the maxillary skeleton

maxillary and ethmoidal air sinuses is responsible for the honeycomb type of formation typical of the middle-third of the facial skeleton, which is best seen in the coronal section of the skull. The delicate laminae, which constitute this lattice framework, are principally distributed in a vertical direction, thereby being aligned along the lines of principal stress **(Fig. 31.5)**.

Supporting Vertical and Horizontal Pillars of the Maxillary Skeleton

Vertical pillars: On either side of the facial skeleton, one finds three pillars or buttresses: anterior, middle and posterior **(Fig. 31.6)**.

- **Anterior or the canine pillar:** It starts in the region of the alveolar process of the canine, forms the lateral boundary of the anterior nasal aperture and continues as the frontal process of the maxilla to the frontal bone.
- **Middle or zygomatic pillar:** It starts in the region of the first molar, bends upward and outward as the zygomaticoalveolar crest and the zygomatic process of the maxilla to continue toward the frontal process of the zygoma to end at the zygomatic process of the frontal bone.
- **Posterior or pterygoid pillar:** It is the pterygoid process of the sphenoid bone to which the pyramidal process of the palatine bone is anchored. These vertical pillars are braced against each other by the superior and inferior orbital rims and the zygomatic arch.

Horizontal pillars (Fig. 31.7):

- Supraorbital rims with frontal bone
- Infraorbital rims
- Alveolar process.

Nerve Supply

The middle-third of the face receives its nerve supply from the second division of the fifth nerve. Branches to the teeth pass through the outer cortex of the bone. The infraorbital nerve passes through the infraorbital canal below the floor of the orbit to innervate the soft tissues of the lower lid, the cheek and the lateral aspect of the nose and the upper lip. The palatine branches innervate the mucosa of the palate. The nasopalatine nerve passes anteriorly in the mucosa of the nasal septum bilaterally and through the incisive foramen to innervate the mucosa of the anterior palatine area.

Important Blood Vessels

The third part of the maxillary artery and its terminal branches are closely associated with the fractures of the middle-third of the face. Occasionally the artery or its greater palatine branch is torn in the region of the pterygomaxillary fissure or pterygopalatine canal resulting in severe life-threatening hemorrhage into the nasopharynx. Insertion of postnasal pack is needed for 24 hours. Adequate reduction of the fracture will prevent further bleeding.

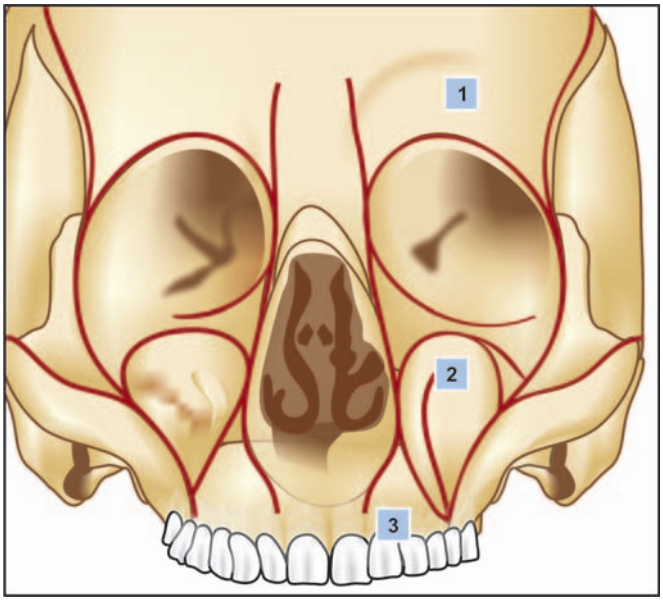


Fig. 31.7: Horizontal pillars of the maxillary skeleton: 1—Supraorbital rim; 2—Infraorbital rim; and 3—Alveolar process

Surgical Anatomy

Fractures of the maxilla, usually the result of direct force, are range from simple alveolar fractures to extensive injuries to the bones of the nose, orbit, palate, skull, etc.

Displacement is usually entirely the result of the traumatic force. Muscle contraction plays an unimportant role in the displacement of maxillary fractures, except in those extending into the region of the pterygoid plates, in which displacement of maxilla may be in a downward and posterior direction due to the action of the pterygoid muscles. In complete craniofacial disjunction associated with fractures of the zygoma, action of the masseter muscle may be a factor in displacement.

- The lacrimal fossa is formed partially by the maxilla, and injuries to the nasolacrimal duct may be associated with the fractures of the maxilla, which results in epiphora.
- Damage to the infraorbital and zygomatic nerves can occur unilaterally or bilaterally with zygomatic or maxillary fractures. Here, the anesthesia or paresthesia of the skin of the cheek and upper lip is present. Full recovery may take up to 2 years. The anterior, middle, posterior superior alveolar nerves may be damaged, but patient seldom notices the anesthesia of the gum, but if tested with the instrument, areas of anesthesia will be found.
- Cranial nerves within the orbit may sustain damage. The sixth nerve is most frequently involved; sometimes the contents of the superior orbital fissure are all damaged, in which case ophthalmoplegia, dilation of the pupil and anesthesia within the distribution of the ophthalmic branch of the fifth cranial nerve are noted. Rarely the orbital apex is fractured with resultant damage to the optic nerve and blindness.
- Optic foramen is a ring of dense compact bone; therefore, invariably the fracture line gets deflected away from the foramen protecting the optic nerve. The prominence of the zygomatic bone also protects the orbit from all impinging objects.
- Fractures involving the orbital walls may give rise to alteration in the position of the globe of the eye (ocular level). The ocular level is normally maintained by the suspensory ligament of Lockwood, which is attached on the medial side on the lacrimal bone and laterally inserted into Whitnall's tubercle, situated on the inner aspect of the zygomatic bone just below the frontozygomatic suture. Separation at or above this junction will bring about change in ocular level. As the globe of the eye drops, the upper eyelid follows it downward known as "hooding of the eye".
- If the orbital floor is fractured, there will be herniation of orbital contents into the maxillary sinus. There can be entrapment of tissues resulting in the restriction of the movements of inferior rectus and oblique muscles. There can be temporary or permanent diplopia due to prevention of the upward and outward rotation of the eye.
- Herniation of the orbital contents into the maxillary sinus or through the thin lamina papyracea of the ethmoid bone on the medial wall of the orbit will lead to enophthalmos.
- Detachment of the medial canthal attachment of the eye may occur in severe nasoethmoidal complex fractures resulting in traumatic telecanthus.
- Retrobulbar hemorrhage can cause temporary blindness and exophthalmos.
- Gross comminution of the antral walls and other fractures involving sinuses can cause bleeding. The sinus may be full of blood and appear hazy in the radiograph. There may be unilateral or bilateral epistaxis depending on the involvement.
- A depressed fracture of the zygomatic arch or displaced zygoma can cause impingement on the coronoid process of the mandible, and it may cause mechanical blockage for the normal movements of mandible. Restricted oral opening may be seen.
- Mid-palatine split of the maxilla is only possible when the injury results from a blow transmitted upward via the mandibular teeth with the jaw open **(Fig. 31.8)**.

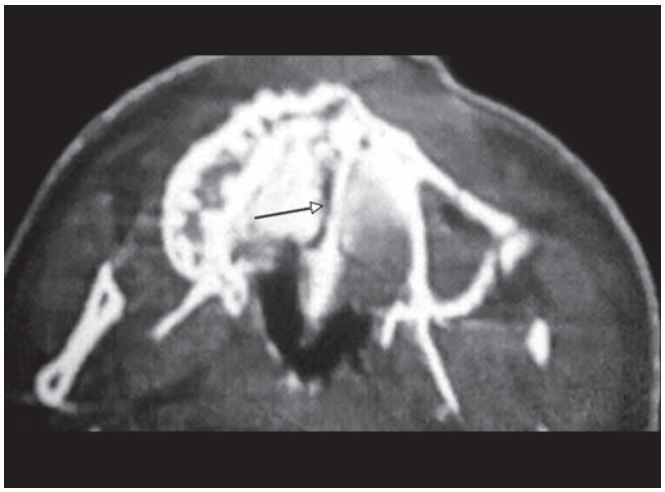


Fig. 31.8: CT scan showing midpalatal split of the maxilla along with LeFort II fracture

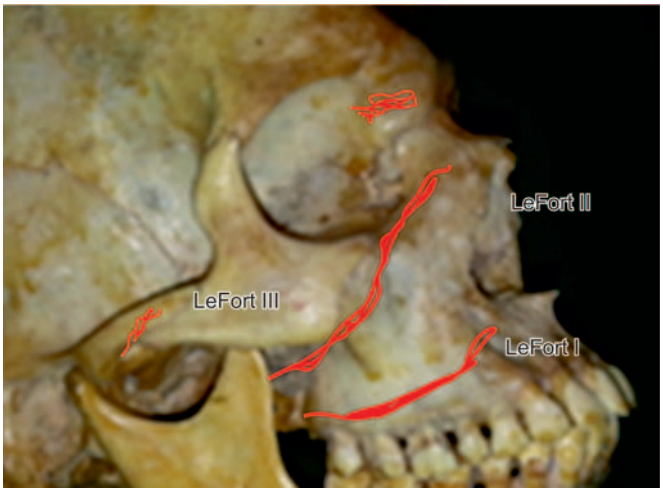


Fig. 31.9: LeFort's classification for middle third of the facial skeleton

CLASSIFICATION OF FRACTURES OF MIDDLE-THIRD OF FACIAL SKELETON

Classification is mainly helpful for communication purpose. The present precise knowledge of the lines of fracture in the middle-third of the facial skeleton, which are produced following injury, is largely due to the experimental studies carried out by a French surgeon, Rene LeFort in 1901 in Paris. Following experimental trauma to the cadaver head and removal of the soft tissues, LeFort discovered that the complex fracture patterns could be broadly subdivided into three groups: LeFort I, LeFort II and LeFort III **(Fig. 31.9)**.

Erich's (1942) classified these fractures as per the direction of the fracture line **(Figs 31.10 and 31.11)**.

- Horizontal fracture
- Pyramidal fracture
- Transverse fracture.

Depending on the relationship of the fracture line to the zygomatic bone, these fractures classified as:

- Below the zygomatic bone—subzygomatic fractures
- Above or including the zygomatic bone—suprazygomatic fracture.

Depending on the level of a fracture line, these fractures are classified as:

- Low-level fracture
- Mid-level fracture
- High-level fracture

General classification can be applied to the maxillary fractures (discussed in the chapter Mandibular Fracture).

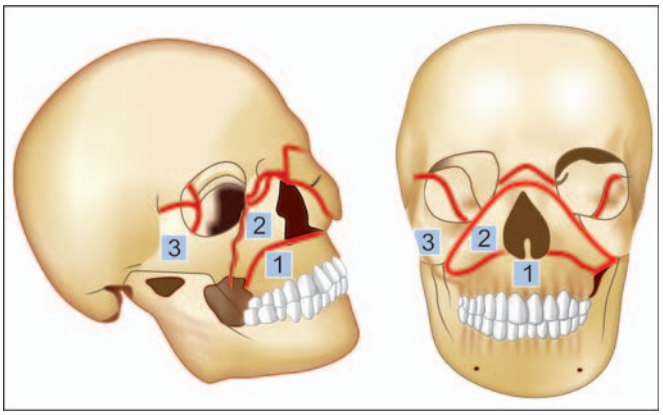


Fig. 31.10: Erich's classification of fractures of the middle third of the facial skeleton: 1, Horizontal fracture; 2, Pyramidal fracture; 3, Transverse fracture

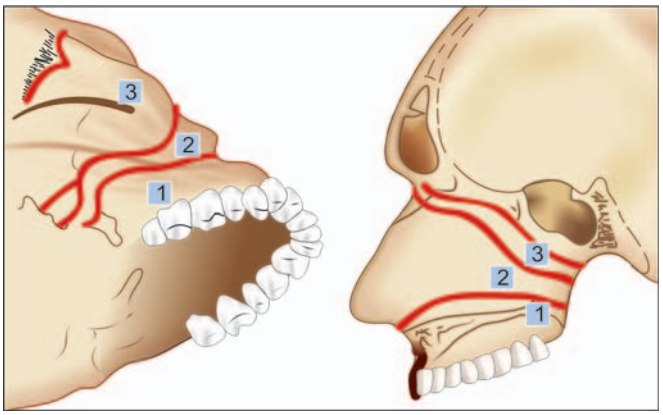


Fig. 31.11: Fractures of the middle third of the face: 1, Horizontal or Guerin or LeFort I fracture; 2, Pyramidal or LeFort II fracture; 3, Craniofacial disjunction: transverse or LeFort III fracture

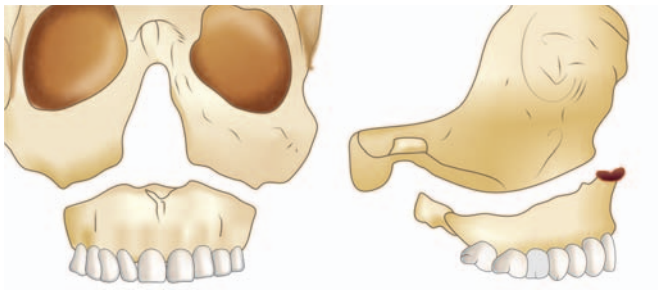


Fig. 31.12: LeFort I fracture lines

Rowe and William's classification (1985):

- Fractures not involving the teeth and alveolus
  - Central region
  - Lateral region
- Fractures involving the teeth and alveolus
  - Central region
  - Combined central and lateral region.

The most universally used classification is LeFort's classification. Clinically, the identical solitary lines may not be seen, but the direction and description of the lines may help in planning the reduction and fixation. Otherwise, at many places, such as anterior wall of the maxillary sinus, multiple fragmentations may be seen.

LeFort I Fracture (Low-level, Subzygomatic Fracture)

It is also called as *horizontal fracture* of the maxilla or *Guerin's* fracture. It is also known as *floating fracture,* as there is a separation of complete dentoalveolar part of the maxilla (pterygomaxillary disjunction), and the fractured fragment is held only by means of soft tissues. The fractured fragment is freely mobile and the resultant displacement depends on the direction of the force. Depending on the displacement of a fragment, variety of occlusal disharmony can be seen in this type of fracture (anterior open bite, cross bite, reverse overjet, etc.).

A violent force applied over a more extensive area, above the level of the teeth result in a LeFort I fracture, which is not confined to smaller section of the alveolar bone. Here, the horizontal fracture line is seen above the apices of the teeth, which detaches the tooth-bearing portion of the maxilla from the rest of the facial skeleton **(Fig. 31.12)**. The fracture line commences at the point on the lateral margin of the anterior nasal aperture, passes above the nasal floor and passes laterally above the canine fossa and traverses the lateral antral wall, dipping down below the zygomatic buttress and then inclines upward and posteriorly across the pterygomaxillary fissure to fracture the pterygoid laminae at the junction of their lower third and upper two-thirds. At the same time, from the same starting point, the fracture also passes along the lateral wall of the nose and subsequently joins the lateral line of fracture behind the tuberosity. The typical LeFort I fracture is always bilateral, with the fracture of the lower third of the nasal septum. But, it can be unilateral also. The displacement depends on the direction and severity of the force. Posterior, lateral displacement or rotation around its axis can be seen. The LeFort I fracture may occur as a single entity or in association with LeFort II and III fractures.

Clinical Signs and Symptoms of LeFort I Fracture

- Slight swelling and edema of the lower part of the face along with the upper lip swelling. (Gross edema or facial disfigurement is not present).
- Ecchymosis in the labial and buccal vestibule as well as contusion of the skin of the upper lip may be seen. Laceration of upper lip and intraoral mucosa may be seen.
- Bilateral epistaxis or nasal bleeding may be observed.
- The most common significant feature is the mobility of the upper dentoalveolar portion of the jaw, which is frequently mobile to digital pressure.
- Occlusion may be disturbed. Patient may not be able to masticate the food.
- Pain while speaking and moving the jaw.
- Sometimes there may be upward displacement of the entire fragment, locking it against the superior intact structures, such a fracture is called as impacted or telescopic fracture. A classical anterior open bite may be seen in this case.
- Percussion of the maxillary teeth produces dull "cracked cup" sound.

LeFort II (Pyramidal or Subzygomatic) Fracture

Violent force, usually from an anterior direction, sustained by the central region of the middle-third of the facial skeleton over an area extending from the glabella to the alveolar margin results in a fracture of a pyramidal shape. The force may be delivered at the level of the nasal bones **(Fig. 31.13)**.

The fracture line runs below the frontonasal suture from the thin middle area of the nasal bones down on either side, crossing the frontal process of the maxillae and passes anteriorly across the lacrimal bones,

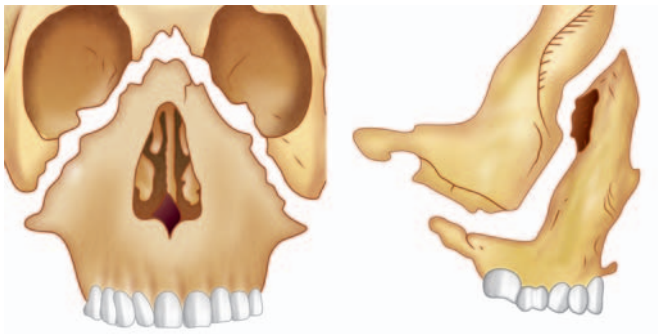


Fig. 31.13: LeFort II fracture lines

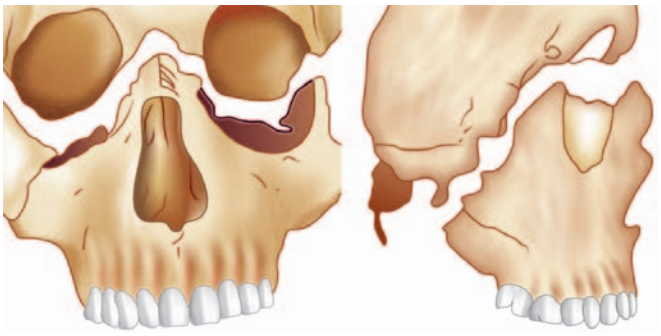


Fig. 31.14: LeFort III fracture lines

immediately anterior to nasolacrimal canal. From this point, the fracture line passes downward, forward and laterally crossing the inferior orbital margin in the region of zygomaticomaxillary suture. It may or may not involve the infraorbital foramen. The fracture line now extends downward and forward and laterally to traverse the lateral wall of the antrum, just medial to the zygomaticomaxillary suture line. As in LeFort I fracture, this fracture line passes beneath the zygomatic buttress, but after that, it inclines rather more abruptly than in the former instance, traversing the pterygomaxillary fissure at a higher level and fracturing the pterygoid laminae approximately midway from its base. Separation of the entire pyramidal block from the base of the skull is completed via the nasal septum.

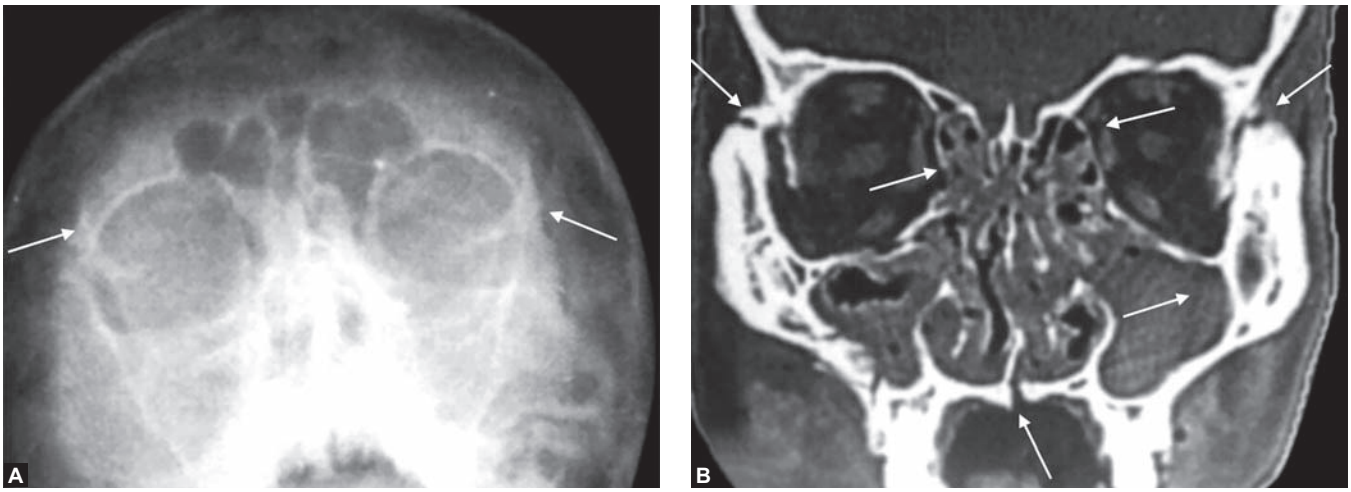
Clinical Signs and Symptoms of LeFort II Fracture

- There is a gross edema of the middle-third of the face known as ballooning or moon face. Edema sets in within a short time of injury.
- Presence of bilateral circumorbital edema and ecchymosis (black eye). Rapid swelling of the eyelids makes examination of the eyes difficult.
- Bilateral subconjunctival hemorrhage confined to medial half of the eye.
- The bridge of the nose is depressed (flat face). Nasal disfigurement.
- If there is impaction of the fragment against the cranial base then shortening of the face with anterior open bite is seen.
- If there is gross downward and backward displacement of the fragment then elongation or lengthening of the face is seen with posterior gagging of the occlusion with anterior open bite (dish-shaped face).
- Bilateral epistaxis may be present.
- Difficulty in mastication and speech.
- Loss of occlusion may be seen.
- Airway obstruction may be seen due to posterior and downward displacement of the fragment impinging on the dorsum of the tongue.
- Surgical emphysema—crackling sensation transmitted to the fingers due to escape of air from the paranasal sinuses is seen.
- CSF leak may be present.
- Step deformity at the infraorbital margins may be seen.
- Anesthesia and/or paresthesia of the cheek are noted.

LeFort III Fracture (Transverse or Suprazygomatic) Fracture

It is also known as *high-level* fracture **(Fig. 31.14)**. The line of fracture extends above the zygomatic bones on both sides as a result of trauma being inflicted over a wider area at the orbital level. The force is usually applied from the lateral direction with a severe impact. Here the initial impact is taken by the zygomatic bone resulting in depressed fracture and then because of the severe degree of the impact, the entire middle-third hinge about the fragile ethmoid bone, and the impact then transmitted on the contralateral side resulting in laterally displaced zygomatic fracture of the opposite side (craniofacial disjunction).

In a typically high-level LeFort III fracture, the line commences near the frontonasal suture causes dislocation of the nasal bones and disruption of cribriform plate of the ethmoid bone with tearing of dura mater and consequent CSF rhinorrhea. In such cases, the line of fracture crosses both the nasal bones and the frontal process of the maxilla, near the frontonasal and frontomaxillary sutures and then traverses the upper limit of the lacrimal bones. Continuing posteriorly, the line crosses the thin orbital plate of the ethmoid bone constituting part of the medial wall of the orbits. As the medial orbital wall is very thin, comminution of the fracture line is seen in this region.



Figs 31.15A and B: High-level fracture of middle third of the face with midpalatal split. (A) PA view Water's position; (B) Coronal CT scan showing *the break in the continuity at various levels.* Note the deviation of nasal septum, haziness of both the maxillary sinuses, bilateral fractures at frontozygomatic sutures, midpalatal split, fractures of nasal bones and maxilla

As the optic foramen is surrounded by a dense ring of bone, the fracture line gets deflected downward and laterally to reach the medial aspect of the posterior limit of the inferior orbital fissure. From this point, the fracture descends across the upper posterior aspect of the maxillae in the region of the sphenopalatine fossa and upper limit of the pterygomaxillary fissures, and fractures the roots of the pterygoid laminae at its base.

The inferior orbital fissure constitutes a natural line of weakness, and from its anterior and lateral end on each side, a further line of fracture passes across the lateral wall of the orbit, adjacent to the junction of the zygomatic bone with the greater wing of sphenoid. The fracture line separates the zygomatic bone from the frontal bone near the suture and then inclines laterally, running abruptly downward across the infratemporal surface, thus in effect joining the previous line of fracture seen on the medial wall of the orbit. The entire middle-third is thus detached from the dense cranial base; the occlusal plane of the maxillary teeth in most instances being tilted downward and backward, so that there is gagging of teeth with anterior open bite.

Clinical Signs and Symptoms of LeFort III Fracture

Clinically this fracture appears similar to the LeFort II fracture, but close examination demonstrates a more serious condition. After stabilizing the head and then gripping of the maxillary teeth with one hand, and simple manipulation confirm complete movement of the middle-third of the face. Mobility of whole skeleton as a single block can be felt.

- Gross edema of the face, ballooning. "Panda facies", within 24–48 hours.
- Bilateral circumorbital/periorbital ecchymosis and gross edema—"raccoon eyes". Gross circumorbital edema prevents eyes from opening.
- Bilateral subconjunctival hemorrhage, where posterior limit is not be seen, when patient is asked to look medially.
- There may be tenderness and separation at the frontozygomatic sutures. This produces lengthening of the face and lowering of the ocular level. Unilateral or bilateral hooding of the eyes is seen.
- Characteristic "dish face" deformity.
- May be enophthalmos, diplopia or impairment of vision, temporary blindness, etc.
- Flattening and widening, deviation of the nasal bridge.
- Epistaxis, CSF rhinorrhea.

Midline Separation of the Maxilla

A natural line of weakness exists at the sutural interface between the two palatine bones of the maxilla. This is usually associated with high-level impact. Any degree of separation of maxillae will result in associated fracture of zygomatic bones as pressure is exerted upon the zygomaticomaxillary suture **(Figs 31.8 and 31.15)**.

Modification of LeFort's Fracture Classification

At the turn of the century, midface fracture patterns are seem to be far more complex than those produced in LeFort's laboratory in 1901. Fractures involving the cranial base and other midface fracture configurations, including severely comminuted segments of the facial skeleton, are not accurately classifiable using the traditional LeFort scheme. A modified classification system is therefore proposed by *Marciani in 1993* to more precisely define LeFort, nasoorbital ethmoid (NOE) and zygomaticomaxillary fracture patterns.

- *LeFort I:* Low maxillary fracture
  - *Ia:* Low maxillary fracture/multiple segments
- *LeFort II:* Pyramidal fracture
  - *IIa:* Pyramidal and nasal fracture
  - *IIb:* Pyramidal and NOE fracture
- *LeFort III:* Craniofacial disjunction
  - *IIIa:* Craniofacial disjunction and nasal fracture
  - *IIIb:* Craniofacial disjunction and NOE fracture
- *LeFort IV:* LeFort II or III fracture and cranial base fracture
  - *IVa:* + Supraorbital rim fracture
  - *IVb:* + Anterior cranial fossa and supraorbital rim fracture
  - *IVc:* + Anterior cranial fossa and orbital wall fracture.

Rowe and William's (1985) Classification

A. Fractures not involving the dentoalveolar component

- **Central region**
  - Fractures of the nasal bones and/or nasal septum
    - Lateral nasal injuries
    - Anterior nasal injuries
  - Fractures of the frontal process of the maxilla
  - Fractures of type *a* and *b* which extend into the ethmoid bone (nasoethmoid)
  - Fractures of type *a*, *b*, and *c* which extend into the frontal bone (fronto-orbito-nasal dislocation)
- **Lateral region**: Fractures involving the zygomatic bone, arch and maxilla (zygomaticomaxillary complex) excluding the dentoalveolar component.

B. Fractures involving the dentoalveolar component

- **Central region**
  - *Dentoalveolar fractures:* Iatrogenic fractures of maxillary tuberosity and floor of the maxillary antrum occur during extraction of maxillary third and second molars. Whenever the trauma is distributed over a wider area involving the alveolus in addition to the teeth then a fracture of a block of alveolar bone together with two or more teeth will occur. The complete section is usually palatally driven, but labial or buccal displacement also can be seen. Because of this type of fracture, the occlusion gets disturbed. There may be associated tear of the soft tissues seen. Dentoalveolar fractures should be reduced as early as possible and can be stabilized using horizontal Erich's arch bar fixation or any kind of horizontal dental arch wiring. The support of the adjoining firm teeth is taken for stabilization. Before final tightening of the wires, occlusion of the teeth should be checked.
  - *Subzygomatic fracture*
    - LeFort I (low-level or Guerin)
    - LeFort II (pyramidal)

  The above fractures may be unilateral or associated with fracture of zygomatic bone.
- **Combined central and lateral region fractures**
  - High-level, suprazygomatic fractures—LeFort III
  - LeFort III with midline split
  - LeFort III with midline split + fracture of the roof of the orbit or frontal bone.

FRACTURES OF THE ZYGOMATIC COMPLEX

The zygomaticomaxillary complex plays a key role in the structure, function and esthetics of the facial region. It provides normal cheek contour and separates the orbital contents from the temporal fossa and the maxillary sinus. As the zygomatic bone is closely associated with the maxilla, frontal and temporal bones, and they are usually involved when a zygomatic bone fracture occurs; therefore these types of fractures are referred to as *"zygomatic complex fractures" or "zygomaticomaxillary complex fractures" or "tripod fractures". (Some authors describe the zygomaticomaxillary and zygomaticosphenoid suture lines as a single unit.) However, the term "tetrapod fracture" is now considered more accurate description, because four suture lines are disrupted, namely (1) zygomaticotemporal suture, (2) zygomaticomaxillary suture, (3) frontozygomatic suture and (4) zygomaticosphenoid suture.*

The zygomatic bone usually fractures in the region of the zygomaticofrontal suture, the zygomaticotemporal suture and the zygomaticomaxillary suture. It is unusual for the zygomatic bone itself to be fractured, but in extreme violence, the bone may be comminuted or split across. The isolated zygomatic arch fracture may occur without displacement of the zygomatic bone.

Applied Anatomy

The disarticulated zygomatic bone is a dense, strong structure rather like a four pointed star (quadrupled structure), slightly curved on flat surface, with the upper point forming the frontal process, the distal point forming the temporal process or anterior section of the arch, the medial point forming the outer half of the inferior orbital rim and the lower point constituting the buttress, which can be palpated in the upper buccal sulcus. The convexity on the outer surface of the zygomatic body forms the point of greatest prominence of the cheek. Therefore, the zygoma plays a major role in facial contour. The zygoma articulates with four bones: the frontal, sphenoid, maxillary and temporal.

- The most striking feature is the thickness and strength evident at the zygomaticomaxillary suture area.
- Medial to this broad sutural interface is an area of extremely thin bone comprising the lateral wall of the antrum.
- The buttress distributes the masticatory stress to the cranial base and is adapted to withstand a considerable force from below via the broad zygomaticomaxillary suture.
- A slender temporal process extends posteriorly to form along with the zygomatic process of the temporal bone, the zygomatic arch. The coronoid process of the mandible moves between the arch and the infratemporal fossa.
- The temporalis fascia is attached to the zygomatic bone and arch, whereas, the temporalis muscle is inserted via its tendon into the tip and anteromedial surface of the coronoid process of the mandible. The space between the fascia and the muscle provides a route to approach the posterior surface of the zygomatic bone and the medial aspect of the arch, which is utilized for elevation of the bone during reduction procedure.
- Rowe has suggested that the displacement of the zygomatic bone can be best understood by reference to rotation about different axes. Here, the *vertical axis* is an imaginary line drawn from the frontozygomatic suture, which passes downward through the center of the body to the buttress. A blow received *in front of* the vertical axis will result in rotation of the horizontal plane, represented by the outer half of the inferior orbital margin and orbital floor. There is outward movement of the center of the arch. If the blow is received *behind* the vertical axis then the rotation of the horizontal plane in the opposite direction is noticed with considerable movement of the arch and outward movement of the rim and floor.

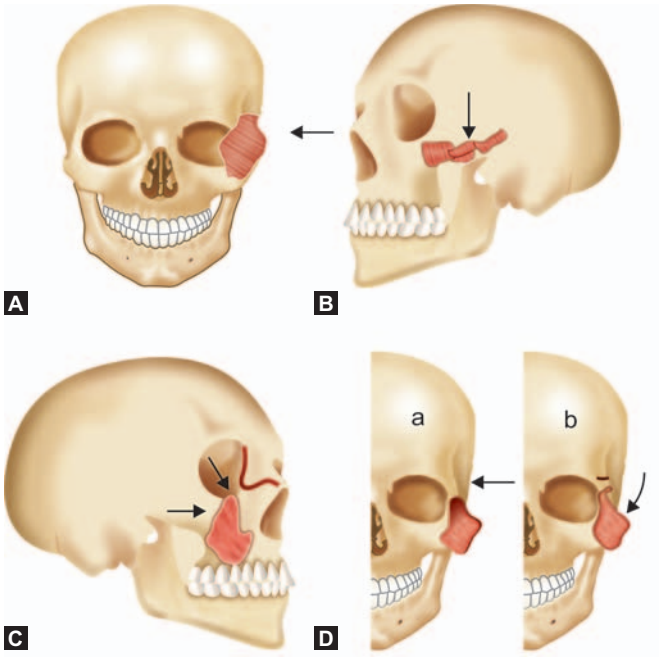
The *longitudinal* or *horizontal axis* is represented by a line at the level of the infraorbital foramen which passes from in front horizontally backward through the center of the body of the bone and the zygomatic arch. An *impact above this level* results in rotation of the vertical plane with medial movement of the frontal process and a slight outward movement at the buttress. If the impact is received directly on the line then there is *en bloc* displacement. But, with an *impact received from below* the longitudinal axis then there is lateral movement of the frontal process and medial displacement of the buttress into the antral cavity.

Classification of the Zygomatic Complex Fracture

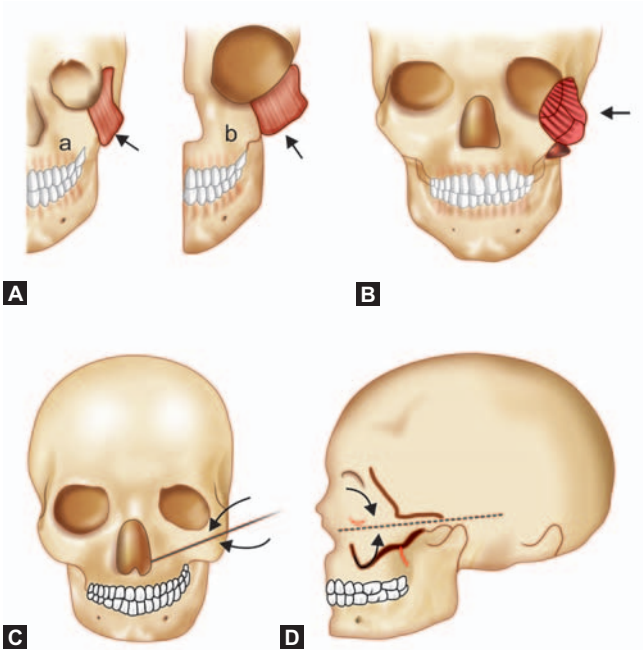
Rowe and Killey (1968) (Figs 31.16 and 31.17)

- *Type I:* No significant displacement
- *Type II:* Fractures of the zygomatic arch
- *Type III:* Rotation around the vertical axis
  - Inward displacement of orbital rim
  - Outward displacement of orbital rim
- *Type IV:* Rotation around the longitudinal axis
  - Medial displacement of the frontal process
  - Lateral displacement of frontal process
- *Type V:* Displacement of the complex *en bloc*
  - Medial
  - Inferior
  - Lateral (rare)
- *Type VI:* Displacement of the orbitoantral partition
  - Inferiorly
  - Superiorly (rare)
- *Type VII:* Displacement of orbital rim segments
- *Type VIII:* Complex comminuted fractures.

In 1985, Rowe changed his 1968 classification and gave more clinical significance by dividing fractures into stable and unstable varieties. This is similar to the classification created by *Larsen and Thomsen in 1968, which is a very simple, yet practical classification for zygomatic fractures.*



Figs 31.16A to D: Fractures of the zygomatic complex. (A) Type I: No significant displacement. (B) Type II: Zygomatic arch fracture. (C) Type III: Unrotated body fracture. (D) Type IV: Medially rotated body fractures: a, outward at zygomatic prominence; b, inward at zygomaticofrontal suture



Figs 31.17A to D: Fractures of the zygomatic complex. (A) Type V: Laterally rotated body fractures: a, upward at infraorbital margin; b, outward at zygomaticofrontal suture. (B) Complex fractures (C and D) Directions of force

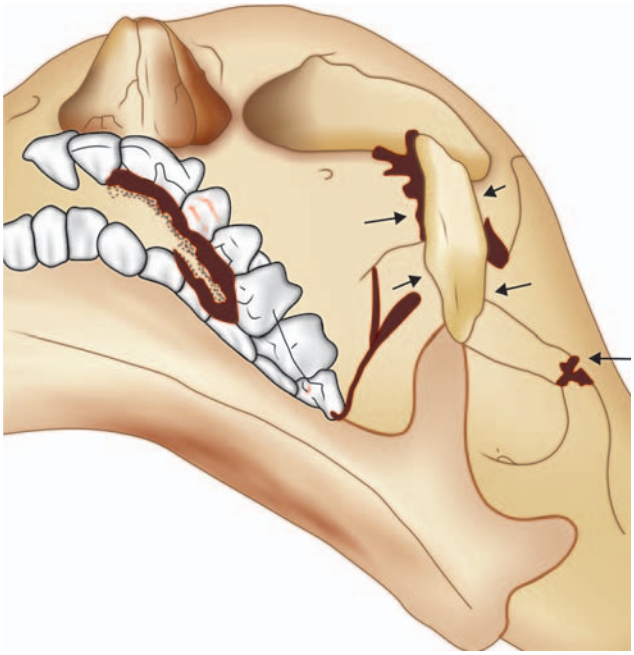


Fig. 31.18A: Fracture of the zygomatic arch impinging on the coronoid process of the mandible (arrows)

Rowe's Modified Classification (1985)

- *Group A:* Stable fracture—showing minimal or no displacement and requires no intervention.
- *Group B:* Unstable fracture—with great displacement and disruption at the frontozygomatic suture and comminuted fractures. Requires reduction as well as fixation.
- *Group C:* Stable fracture—other types of zygomatic fractures which require reduction but no fixation.

Fractures of the zygomatic arch alone, not involving the orbit, can be classified as follows **(Figs 31.18A and B)**:

- Minimum or no displacement
- V-type in fracture
- Comminuted fracture.

Manson et al. Classification (1990)

Manson et al. proposed more modern classification based on pattern of segmentation and displacement of zygomaticomalar complex and also based on 3D CT-based classification correlated with mechanism of energy-directed and related to surgical exposure and fixation.

- **Low-energy fracture:** 18%, incomplete fractures of one or more articulations may be present with or without displacement. Zygomaticofrontal suture unaffected. No reduction is required as there is inherent stability to the fracture.



Courtesy: Dr Kumar Nilesh

Fig. 31.18B: 3D CT Scans showing various patterns of zygomaticomaxillary complex fractures

- **Medium-energy fracture:** 77%, complete fractures of all articulations with mild-to-moderate displacement. Comminution may be present. An open reduction internal fixation of anterior buttresses via two incisions: eyelid and intraoral incisions. Adequate reduction is based on alignment of greater wing of sphenoid in the lateral orbit.
- **High-energy fracture:** 5%, comminution in lateral orbit and extensive posterior and lateral displacement with segmentations of zygomatic arch. Associated with panfacial or LeFort fractures. Coronal surgical exposure to correct width of the face along with alignment of sphenoid wing.

Zing et al. Classification (1992)

- **Type A:** Injuries are isolated to one component of the tetrapod structure, (incomplete low-energy fracture with fracture of only one zygomatic pillar).
  - I. Isolated zygomatic arch fracture
  - II. Isolated lateral orbital wall fracture
  - III. Isolated infraorbital rim fracture.
- **Type B:** Complete monofragment fracture with displacement along all four articulations/buttresses (classical tetrapod fracture).
- **Type C:** Multifragment complex fractures including fragmentation/comminution of the zygomatic body.

Ogata H et al. Classification (2013)

This is a new method of classification of zygoma fracture based on 3D CT scan, and the type of trauma inflicted, which can be used to plan surgical strategy. The most stable region of the zygoma is the zygomaticofrontal area or ZF, which comprises thickened cortical bone and is triangular in shape. Collapse of zygomaticofrontal requires a strong external force. Therefore, the classification of external forces based on the deviation of the zygoma, featuring zygomaticofrontal was considered. This was done by observing preoperative 3D CT scan.

Zygomaticofrontal Analysis

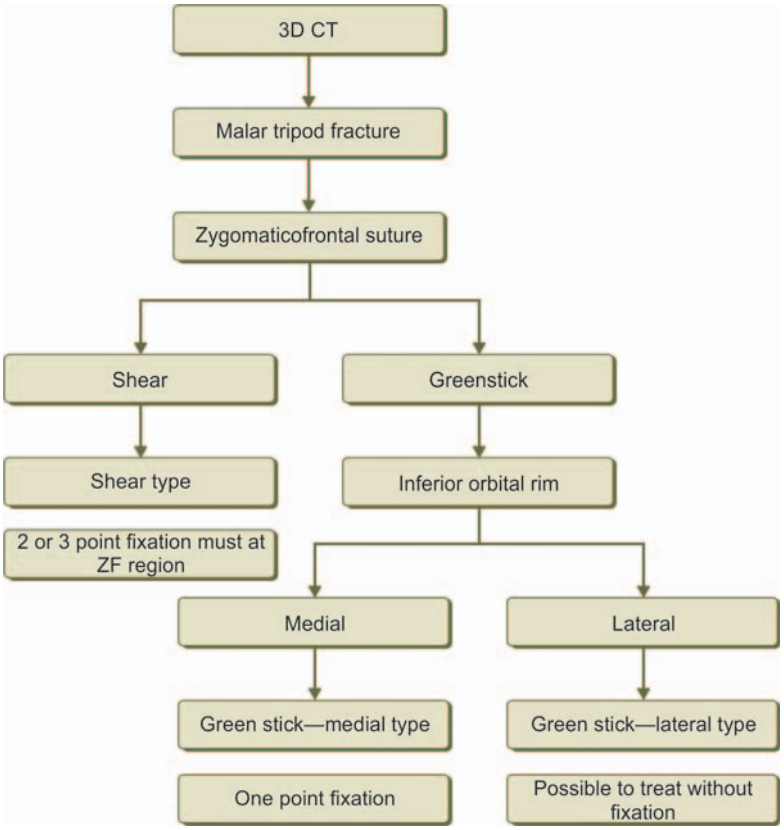
- **Shear type fracture:** Presence of a gap or deviation of the zygomaticofrontal.
- **Greenstick type fracture:** Absence of a gap or deviation of the zygomaticofrontal.

Inferior orbital rim analysis: It is done depending on rotation of zygoma related to infraorbital rim.

- Lateral type
- Medial type.

Treatment strategies are planned depending on zygomaticofrontal status. Shear type is a high-energy injury regardless of medial or lateral rotation at infraorbital. For shear type of fracture of zygoma, two point fixation with bone plates is suggested, including zygomaticofrontal. Greenstick fracture with medial rotation of infraorbital has a risk of postoperative setback, so at least one point plate fixation at zygomaticofrontal or infraorbital is required, while greenstick lateral rotation needs only reduction without plating **(Flowchart 31.1)**.

Flowchart 31.1: The protocol for treatment of zygoma fracture as per Ogata classification



Signs and Symptoms

- *Flattening of the injured cheek* (possibly masked by swelling)—most common displacement of the complex is inward. Immediately following the injury or after the acute phase of the edema is subsided, then an alteration of contour on the affected side is apparent. This is best seen by viewing the patient either from above by standing behind and above the patient and comparing both the sides of the face or by viewing it from below
- Unilateral epistaxis may be present
- Circumorbital ecchymosis will develop after few hours from effusion of blood into the surrounding tissues. Circumorbital edema can be quite gross. The examination of the eye may not be possible till edema subsides
- Subconjunctival hemorrhage is observed at the outer canthus; if the patient is asked to look medially, the posterior limit of the effusion cannot be defined. Such an appearance is indicative of fracture of the lateral orbital wall or floor
- Depression of the ocular level/limitation of ocular movement may be seen
- Proptosis of the eye may be seen due to retrobulbar hemorrhage
- Patient may complain of diplopia and/or blurring of vision
- Anesthesia of the cheek, nose and lip may be present
- Edema of the cheek and eyelids; traumatic emphysema can often be detected in the infraorbital region if air escapes into the tissues from the maxillary sinus
- Step deformity of the infraorbital margin
- Limitation of mandibular movement
- Ecchymosis and tenderness in the upper buccal sulcus, change in sensation of the teeth and gums
- Enophthalmos may be seen.

Radiographic examination: Occipitomental projection is the best projection for the complex.

DIPLOPIA

Diplopia is a relatively common complication following fractures of the zygomatic complex. It is a blurred, double vision experienced by the patient. Diplopia can be of *temporary* or *permanent* nature following injury. It is also important to distinguish between two varieties of diplopia: *monocular diplopia* and *binocular diplopia.*

Monocular Diplopia

Double vision through one eye, with the other closed, requires the immediate attention of an ophthalmologist, as it indicates a detached lens or other traumatic injury of the globe.

Binocular Diplopia

When looking through both eyes simultaneously, double vision is experienced by the patient is a common complaint and occurs in approximately in 10–40% of zygomatic injuries. Diplopia can be caused due to the following.

Physical Interference

- Intramuscular hematoma or edema of one or more of the extraocular muscles
- Disturbance to the attachment of inferior rectus or inferior oblique muscle (change in orbital shape with displacement of the globe causing muscle imbalance)
- Herniation of periorbital fat into the maxillary sinus (orbital floor fracture)
- Muscle or periorbital tissue entrapment in the fractured fragments (immediate and temporary diplopia)
- Development of fibrous adhesions and fat atrophy (late and permanent diplopia) during post-traumatic healing.

Functional Interference

- Orbital floor fracture leads toward displacement of globe due to disturbance to the inferior rectus and inferior oblique muscle.
- Enophthalmos and globe ptosis associated with marked displacement of the globe can cause diplopia.

Neurological Causes

- Paralysis due to neuromuscular injury or edema
- Supranuclear impairments of 3rd, 4th and 6th cranial nerves
- Superior orbital fissure or intraorbital damage
- Intracranial infranuclear injuries may lead to paresis of the nerve or paralysis of a muscle (late serious complication).

Diplopia is a common symptom in the early stages of the injury, which is caused mainly due to edema and effusion (hemorrhage) in and around the region of the extraocular muscles. This type of diplopia is usually temporary, but when there is actual damage to the extraocular muscles or to their nerve supply, recovery is less certain. It can be also caused by enophthalmos, which results when orbital fat herniates through the fractured orbital floor into the maxillary sinus (a fracture of the orbital floor in isolation is termed as a blowout fracture). Diplopia due to this reason

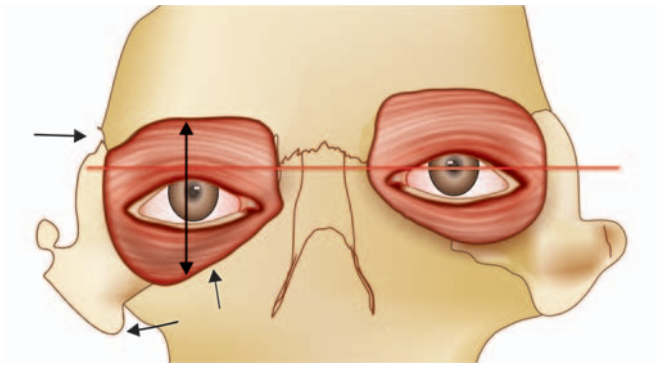


Fig. 31.19: Alteration of ocular level is seen due to the fracture dislocation of the lateral orbital rim. The palpebral ligament is attached to the frontal process of the zygoma. Arrows show the downward displacement of the eye and the palpebral ligament with displaced bone fragments



Fig. 31.20: Testing the motions of the eyes in all nine positions of gazes (arrows). The ninth gaze is the frontal gaze. At the same time, diplopia and ocular level is also checked

at the time of injury may not necessarily be a cause for concern but must be followed closely after reduction of a fracture. Whenever the level of the eyes is altered because of injury, there is invariably alteration in the visual axis as well as in the lines of action of the extraocular muscles and results in diplopia.

Alteration of the ocular level depends on the level at which the fracture occurs in the lateral wall of the orbit **(Fig. 31.19)**. (The globe of the eye is supported by Lockwood's suspensory ligament, which is a fascial sling passing from the medial attachment in the region of the lacrimal bone, to be inserted laterally into Whitnall's tubercle, on the lateral wall of the orbit, just below the frontozygomatic suture). If the fracture passes below Whitnall's tubercle, the zygomatic bone can be grossly displaced downward without alteration in the level of the globe of the eye. But, if the fracture occurs above Whitnall's tubercle then alteration of the optical axis results in diplopia.

This is because of the globe getting lowered on one side and thereby the inferior rectus muscle is slightly shortened, and the superior rectus is slightly lengthened. Here because of the displacement of the bone and change in ocular level, the upper lid exhibits a typical physical sign known as "hooding" of the globe.

Diplopia resulting from damage to the extraocular muscles or their nerves is more serious. The extraocular muscles can become trapped within the bony fragments of the floor of the orbit and the inferior oblique muscle is the most commonly affected. Examination of the eye should include testing the fundus for evidence of edema and hemorrhage, and testing extraocular muscle function. The result of the examination should be clearly noted so that the progress can be objectively assessed.

Testing the Motions of the Eye and Diplopia

Movement of the eye can be tested by holding a finger or an object at least an arm's length in front of the eyes. The movement of the eye should be examined in all nine positions of the gaze **(Fig. 31.20)**. Simultaneously patient should be asked to report double vision as the finger is moved. The degree of diplopia can most accurately be recorded by means of a Hess chart. The chart shows which of the extraocular muscles is functioning abnormally and by repeating the examination every alternate day, the progress of the diplopia can be monitored. Rapid improvement as shown on the Hess chart indicates that double vision was caused by temporary muscle edema. If, however, the Hess chart remains unchanged in the first week then the more permanent damage is suspected and future decisions for treatment can be taken.

Differentiating Points for Etiology of Diplopia

Diplopia in the extreme upward and downward gaze is generally due to general edema of the orbit. Diplopia of edema or hemorrhage origin resolves in 5–7 days.

Complete lack of eye movement in one direction is due to mechanical interference or neuromuscular injury (muscle entrapment). If not corrected, it can lead toward permanent persistent diplopia, which is seen in 3–15% of the patients, due to scar contracture and adhesions either within ocular muscles or between them and other structures.

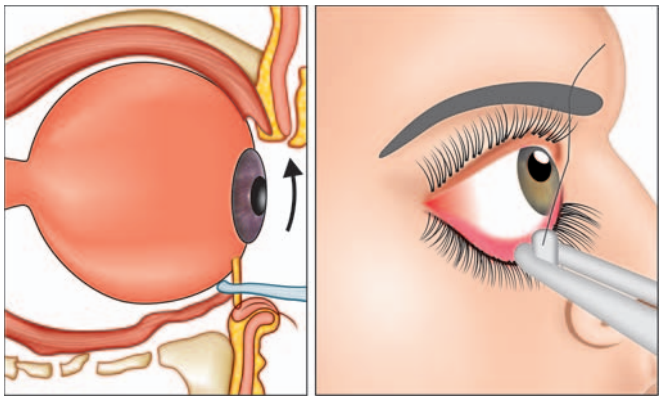


Fig. 31.21: Forced duction test to check the entire range of ocular motion





Figs 31.22A and B: (A) Proptosis of the right eye caused by a retrobulbar hemorrhage due to fracture of the zygomatic bone; (B) Swelling and ptosis of the right eyelids due to lymphatic obstruction and injury to the levator muscles

Neural injuries may cause diplopia only in upward and lateral gaze.

Differentiation between paralysis due to the edema or neuromuscular entrapment can be done by carrying out following test.

Forced duction test: Here a small tissue holding forceps is used to grasp the tendon of the inferior rectus muscle through the conjunctiva of the inferior fornix, and the patient is asked for the entire range of motion. An inability to rotate the globe superiorly signifies entrapment of the muscles in the orbital floor **(Fig. 31.21)**.

Hess test: Diplopia can be recorded conveniently by charting the Hess test. The test is based upon the projection of dissimilar images from each eye. The patient sits in front at a distance of 1 meter from a screen wearing a red/green goggle. The examiner holds a red test object against the screen and the patient tries to indicate the position of the object by touching it with a green tipped wand. The result of his efforts is charted when his head is held still and he moves his eyes from the primary position to the horizontal right and left extremes of movements. This is repeated when looking above, to the right above and to left above. The equivalent lower positions are also charted.

ENOPHTHALMOS

In simple words, enophthalmos is the inward sinking of the eye. It is a troublesome sequel to the fractures of the zygomatic complex. It occurs following injury due to following:

- Loss/decrease of volume of orbital contents—herniation of orbital soft tissues in the maxillary sinus or medial wall.
- Increase in the volume of the bony orbit due to fractures of its walls. Lateral and inferior displacement of the zygoma or disruption of the inferior and lateral orbital walls or both (can be appreciated by quantitative CT scan).
- A loss of ligament support.
- Post-traumatic fibrosis, scar contraction and fat atrophy.
- Combination of all these.

Initially enophthalmos is difficult to diagnose in acute cases, as adjacent soft tissue edema always produces relative enophthalmos.



Fig. 31.23: Typical circumorbital ecchymosis and circumorbital edema due to LeFort II fracture

Clinical Features of Enophthalmos

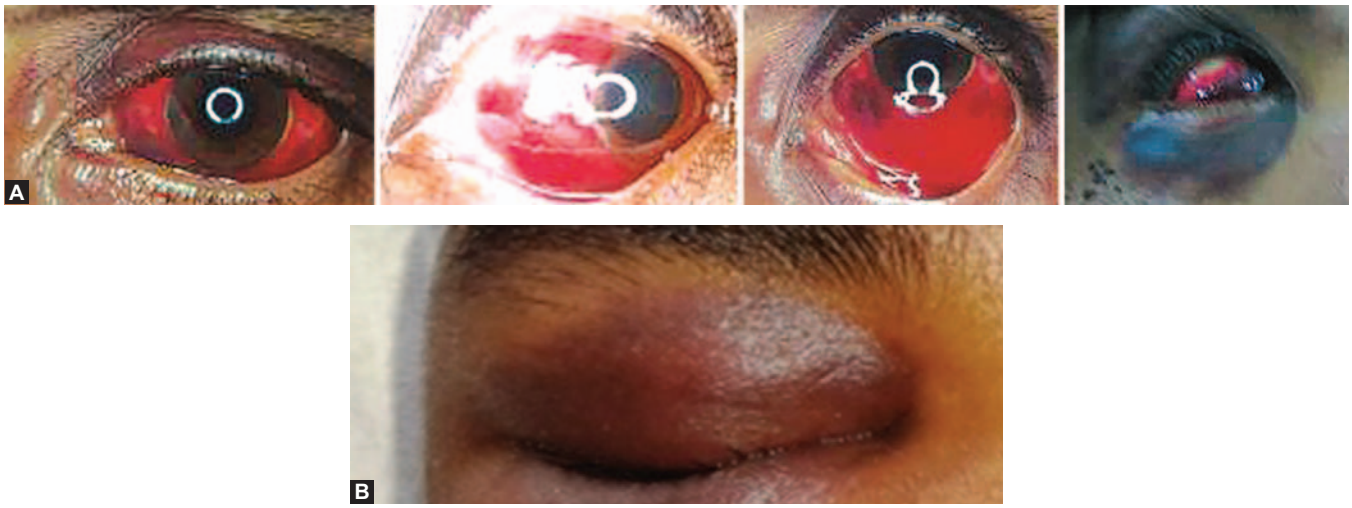
Clinical features of enophthalmos are accentuation of the upper eyelid hooding, anterior projection of the globe as viewed from above is reduced on the side of the injury.

Enophthalmos can be corrected by surgical intervention as soon as possible. There is always a difficulty to correct it secondarily because of the fibrosis. Postoperatively, even after restoration of the orbital rims and floor at the time of surgery, defects occurring posteriorly along the medial or lateral wall or both areas are common and frequently overlooked.

Surgery to reduce the orbital volume is done by placing a space occupying material behind the globe. Glass beads, silicone sheets and sponges, hydroxyapatite, Teflon beads are the nonresorbable materials, which can be used to



Figs 31.24A to C: (A) Typical subconjunctival ecchymosis in a case of zygomatic bone fracture. Note the edema of the eyelids. (B) Forcible separation of the eyelids and patient is asked to look medially. Subconjunctival hemorrhage is seen at the outer canthus. Note that the posterior limit of the effusion cannot be defined. (C) Coronal CT scan showing the *fracture of the lateral orbital wall and the floor and left zygomatic bone* (arrows). Note the displacement of the bones and haziness of the left maxillary sinus



Figs 31.25A and B: Extensive subconjunctival ecchymosis with pronounced bulging of the conjunctiva in case of fracture of the left zygomatic bone and nasomaxillary process and fracture of the orbital plate of the ethmoid bone. Ocular movements are not affected

maintain their bulk within the orbit. But, there can be problem of extrusion, migration or infection. Cartilage grafts are more popular for rebuilding the orbital volume.

Blindness

Diminished vision or blindness is brought about by retrobulbar hemorrhage or laceration of the optic nerve or hemorrhage into the optic nerve itself. Damage to the retinal artery or injury to optic nerve lead to permanent blindness.

Retrobulbar hemorrhage brings about temporary blindness or diminished vision. There may be proptosis, periorbital swelling, which increase in size, retrobulbar pain and dilation of the pupil and ophthalmoplegia **(Figs 31.22A and B)**. Initial conservative treatment leads to gradual absorption of hemorrhage and full range of motion with gaining the vision is seen within several weeks. The conservative treatment consist of ice application, sedative, bed rest, diuretics as IV mannitol and high doses of systemic steroids—3 mg/kg of dexamethasone every 6 hour **(Figs 31.22 to 31.25)**.

Points to Remember

- Applied and surgical anatomy of middle-third of the facial skeleton
- Classification and clinical signs and symptoms of fractures of middle-third of facial skeleton
- Fractures of the zygomatic complex-classifications,signs and symptoms
- Diplopia
- Enophthalmos.

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CHAPTER 32 Principles of Treatment of Midfacial Fractures

INTRODUCTION

The principles of treatment of midfacial fracture consist of the reduction and fixation of the fractured bones to one another and to the skull. Restoration of the occlusion is a must for the correct reduction of the dentulous jaw segments. The bony framework and buttresses of the midface must also be repositioned or restored and fixed. Restoration of the form will also restore the function. Reduction and fixation can be achieved by either conservative or operative methods. It should be undertaken as early as possible following injury. The sooner the treatment is carried out, the greater the prospects for restoration of normalcy.

After the availability of minibone plate system, the conservative methods have largely been replaced by surgical methods. Common to both methods is splinting of both jaws in all cases, in which the alveolar process of the maxilla is involved in the fracture. Fixation of the midface must be maintained by external or internal skeletal fixation until consolidation is achieved. The immobilization to stable skeletal segments of the skull should be maintained for approximately 6–8 weeks. Intermaxillary fixation (IMF), is maintained until occlusal disturbances can no longer result, that is, 3–4 weeks. In case miniplate osteosynthesis has been performed, then there is no need for IMF.

METHODS OF REDUCTION FOR MIDFACE FRACTURES

Manual Reduction

Manual reduction can be carried out in all fresh fractures and where the fragments are not impacted. As a rule, arch bars are first applied to the teeth. The lower jaw serves as a template, so that the occlusion can be checked.

1. **Simple manipulation by hand** is possible in fresh fractures, maxilla is held between the index finger and thumb and brought into normal occlusion. Another method is to fix two double wires encircling the first and second maxillary molars and twisting them individually on either side. Both the twisted wire ends are held by means of wire holders or hemostats and simultaneously downward movement of the maxilla will help to achieve the normal occlusion.
2. **Dingman and Harding in 1951**, suggested the use of dental compound loaded into impression tray for mobilizing the fractured fragment of maxilla. This can be used, where some amount of fibrosis has set in because of delayed treatment. When the impression compound sets, then the firm grip can be taken on the maxillary arch and the handle of the tray is used for rocking the maxilla.
3. **Propescu and Burlibasa in 1966**, have described reduction by rubber dam sheets or by means of long ribbon/strip gauze or rubber catheters. Whenever the maxilla is impacted and simple manual mobilization is not possible, then this method can be tried, if sophisticated instruments are not available. The rubber catheter's end is passed from the nostril into the oropharynx and it is grasped with the help of hemostat and brought out of the oral cavity. So, you have one end coming out from nostril and other end through the oral cavity, same procedure is repeated on the other side through the nostril. After grasping all four ends of the catheter and stabilizing the head, maxilla can be rocked into the normal occlusion.
4. **Reduction by using special instruments**—specially constructed disimpaction forceps can be used to take firm grasp of the maxilla and reduce it into the position.

Rowe's maxillary disimpaction forceps—are available as right and left forceps and always used in pairs. These are two pronged forceps, where one prong fits into the nasal floor and another one on the hard palate. Anterior traction in the case of a split palate, may be facilitated by

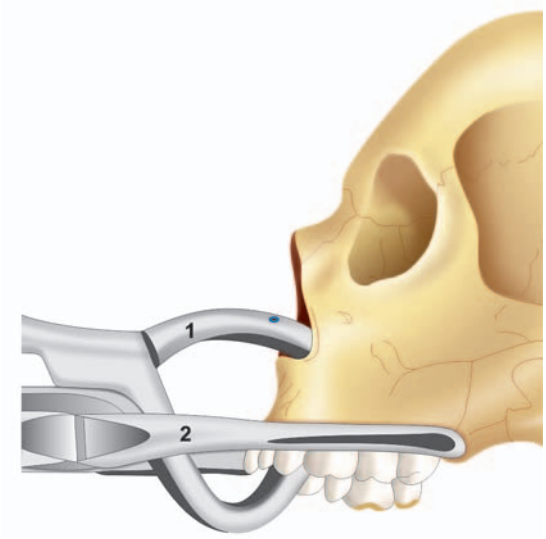


Fig. 32.1: Reduction of maxillary fractures [(1) Rowe's maxillary disimpaction forceps, (2) Hayton William's disimpaction forceps]

the use of the special forceps devised *by Hayton Williams.* These are applied to the buccal aspect of the alveolar process and medial compression exerted until the two halves of the upper jaw are approximated. A screw top is adjusted to prevent crushing of the bone. It is possible to combine the use of these forceps with Rowe's maxillary disimpaction forceps. The stabilized maxillary block may then be disimpacted and drawn forward **(Fig. 32.1)**.

Reduction by Traction

Repositioning the fractures that are already in a state of partial consolidation or when attempted manual reduction is met with failure, then reduction by elastic traction is tried to interdigitate the fractured fragments. This is mainly used in delayed cases, where the fracture is 10–14 days old and no longer sufficiently mobile.

- Intraoral elastic traction
- Extraoral elastic traction with appropriate extension bars and side bars.

Intraoral intermaxillary elastic traction may be used in an appropriate direction to restore normal occlusion. Once the satisfactory occlusion is achieved, it is replaced by IMF.

Conservative Treatment

Reduction and fixation of the fractured midface is indicated in cases, where surgery is not possible on account of poor general condition of the patient or where there is extensive comminution with tissue loss, making internal skeletal fixation impossible. It may be used also as a supplementary measure with the surgical treatment of midfacial fracture.

Supervised Spontaneous Healing

Fixation may be dispensed with, where mobility at the fractured maxilla is only slight, providing that the occlusion is not disturbed. In such cases the progress of healing is merely supervised. The patient is advised to avoid chewing during the first 2–3 weeks and should remain on a liquid or semisolid diet.

Mono-maxillary fixation*:* This method is used when tooth bearing section of the maxilla is not fractured and therefore can serve as fixation point. The arch bar or palatal acrylic plates can be used. This can be used for unilateral fractures of maxilla or higher fractures without occlusal discrepancies. As a rule monomaxillary fixation must be maintained for 6 weeks.

IMF: It is maintained for 3–4 weeks and at the end of this period IMF wires and the lower arch bars are removed.

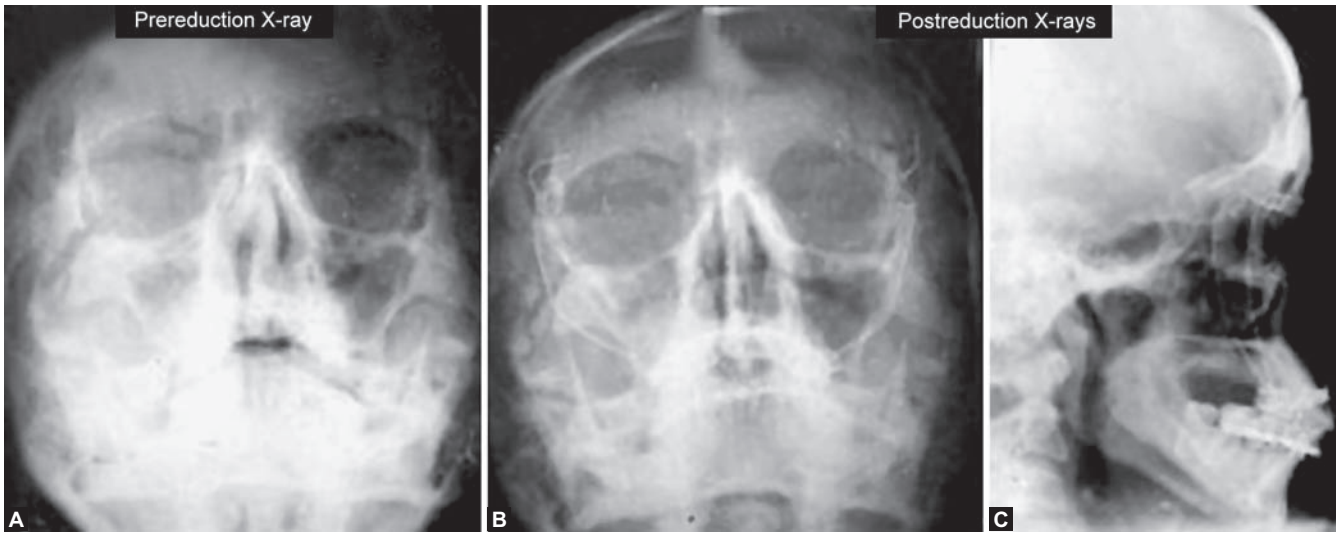
Internal skeletal wire suspension: Many times, in addition to IMF, additional support is required for immobilization of the jaws. Craniomaxillary or craniomandibular suspension can be carried out using the stable point above the fracture line. The selection of the site for suspension wire will be dependent on the level of fracture line. The procedure for internal skeletal wire suspension is done through a minor surgery.

- Application of arch bars
- Reduction of fracture by closed method—occlusion is checked
- Fixation of the midface to the base of the skull by means of suspension wires.
- Fixation of the midface by tightening the suspensory wires and IMF
- For edentulous patients, available prosthesis or Gunning splint is used.

LeFort I fracture: IMF fixation by zygomatic arch suspension, if necessary additional suspension at the piriform aperture.

LeFort II fracture: Zygomatic arch suspension or frontal bone suspension. Intraosseous wiring may be done at infraorbital margins.

LeFort III fracture: Intraosseous wiring at zygomatico-frontal sutures and bilateral frontomalar suspension is used after the application of arch bars. Intraosseous wiring may



Figs 32.2A to C: Closed reduction with immobilization of fragments using suspensory wirings above the frontozygomatic sutures and intermaxillary fixation (IMF)

be done at the infraorbital margin, if step deformity exists **(Figs 32.2A to C)**.

Open Reduction

Open reduction is carried out under endotracheal anesthesia with nasal intubation. Intraoral vestibular incision is taken from first molar to first molar region on either side. Mucoperiosteal flap is reflected to expose the fracture line. After identifying the fracture line, in old fractures, an osteotome is inserted to mobilize the fragment. Disimpaction forceps can be used and the fragment is brought into normal occlusion by manipulation. Temporary IMF is carried out and fracture fragments are fixed under direct vision by intraosseous wiring or minibone plates with screws **(Figs 32.3 to 32.6)**.

For extensive high level fractures of the midface bicoronal incision can be taken. Various incisions for exposure of midface skeleton are follows **(Fig. 32.7)**:

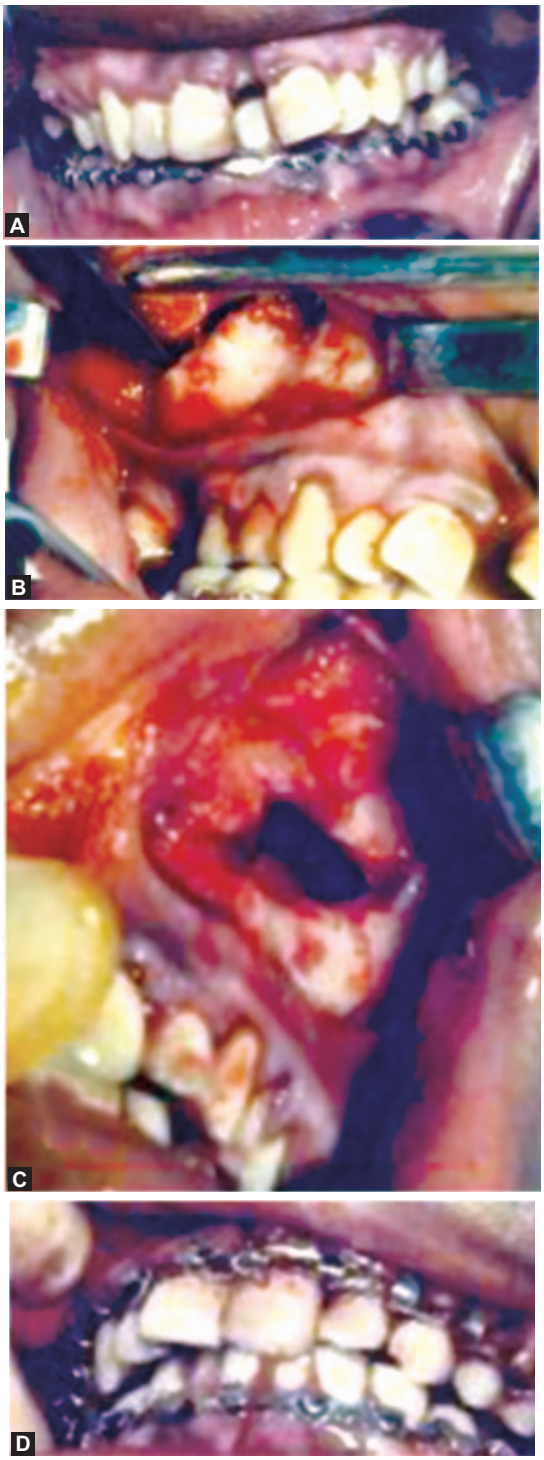
1. Supraorbital eyebrow incision
2. Subciliary incision
3. Median lower eyelid incision
4. Infraorbital incision
5. Transconjunctival incision
6. Zygomatic arch incision
7. Transverse nasal incision
8. Vertical nasal incision
9. Medial orbital incision.

Manson et al. described the maxillary fractures in relation to impact energy and suggested the treatment modalities for these different categories **(Table 32.1)**.

Table 32.1: Maxillary fractures categories by Manson et al. (1990)

Low Energy	*Medium Energy*	*High Energy*
9%	85%	6%
Simple "buckle" in posterior or	Ant. and Post wall	Communition and extreme displacement
medial aspect of maxillary sinus	pterygoid plate fracture	Associated components severely fractured
Pterygoid plates and anterior walls	often Lefort I and II fracture	Most unstable and challenge to repair
Uninvolved, malocclusion	Patterns, direct impact	
No maxillary movement	Influences associated fracture	
IMF and elastics	ORIF	

Abbreviations: IMF, intermaxillary fixation; ORIF, open reduction and internal fixation



Figs 32.3A to D: (A) LeFort I fracture with midpalatal split-occlusal disharmony; (B) Intraoral buccal vestibular incision to expose the fracture line on right side; (C) Left side surgical exposure to expose the fracture line and bony defect in the anterolateral wall of the maxillary sinus; (D) Fracture reduction done to achieve satisfactory occlusion

Fracture of the Floor of the Orbit (Blow-out Fracture)

True blow-out fracture occurs as a result of direct trauma to the orbit with an object larger than the globe size (cricket ball injury) **(Fig. 32.8)**. Here primarily, there is an increase in hydraulic pressure within the orbit resulting from compression of the orbital contents. In addition, forces acting on the bone play a part. The fractured orbital floor gives way into the maxillary sinus. At the same time, orbital fatty tissue and sometimes muscles, (inferior rectus and inferior oblique) prolapse into the sinus like a hernia.

The infraorbital rim remains intact. The fracture may go unnoticed due to the presence of orbital, periorbital edema, hematoma and the clinically intact infraorbital ridge. Enophthalmos with restriction of the extraocular movements and at times diplopia may be present. Diagnosis can be confirmed by forced duction test and by hanging drop appearance in PA view Water's position radiograph or by computed tomography (CT) scan **(Figs 32.9 and 32.10)**.

Treatment consists of surgical exploration of orbital floor and reconstruction of the orbital floor by silastic sheet or bone graft, whenever necessary. Otherwise balloon support or ribbon gauze packing can be used in the maxillary sinus.

TREATMENT OF FRACTURES OF THE ZYGOMATIC BONE

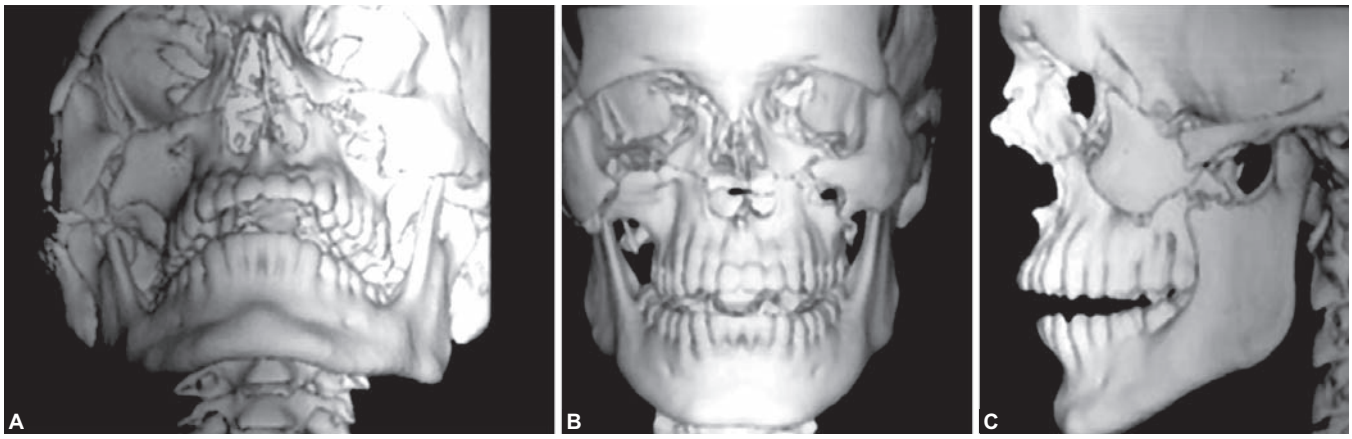
In majority of cases, early operation is advisable, provided that there are no ophthalmic or cranial complications. Whenever there is a gross periorbital edema and ecchymosis, postponement of the operation for 3–5 days can be done, but it should not be prolonged more than 2 weeks.

Stable fractures: Simple elevation will be sufficient, because of high degree of stability due to integrity of temporal fascia and the interdigitation of the fracture lines. No additional fixation is required after reduction.

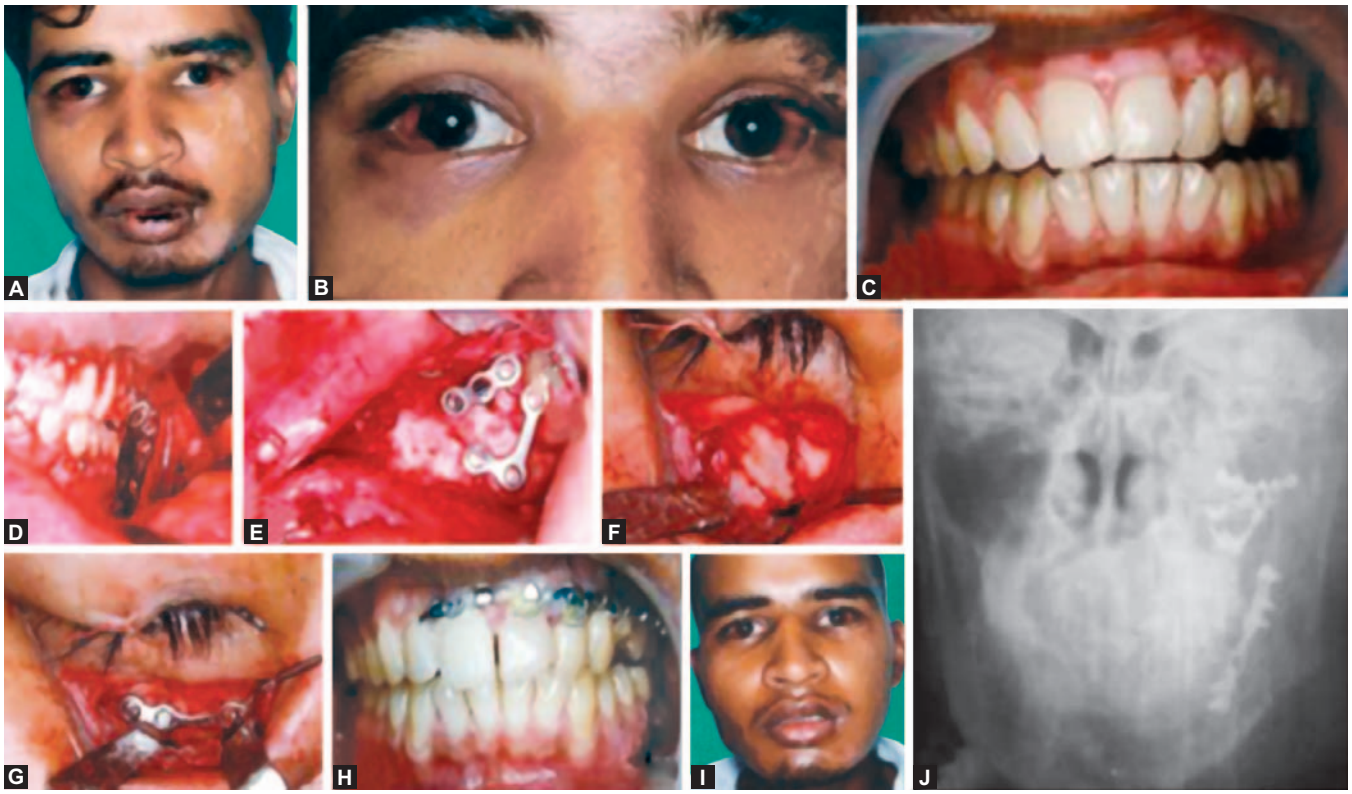
- Type 1: No treatment
- Type 2: Unless vertically displaced
- Type 3: and
- Type 4 (a): Open reduction may be required and transosseous wiring is advisable.

Unstable fractures: Require open reduction and transosseous wiring or bone plating.

- Type 4 (b)
- Types 5, 6, and 7, 8



Figs 32.4A to C: Three-dimensional computed tomography (3D CT) scan LeFort II fracture with R zygoma and arch fracture. Note the anterior open bite due to downward and backward displacement of maxilla



Figs 32.5A to J: (A) Front face after trauma; (B) Subconjunctival hemorrhage with circumorbital ecchymosis; (C) Deranged occlusion; (D) Bone plate fixation after open reduction at L angle; (E) Bone plate fixation at L zygomatic buttress; (F) Infraorbital rim fracture exposed via extraoral infraorbital incision; (G) Bone plate fixation at L-infraorbital rim; (H) Satisfactory occlusion after reduction; (I) Postoperative front face; (J) Postoperative PA view mandible

Operative Technique

Reduction of zygomatic fracture can be done by following approaches—

1. Temporal fossa approach (Gilles et al., 1927).
2. Buccal sulcus approach (Keen, 1909).
3. Lateral coronoid approach (Quinn, 1977).



Figs 32.6A to E: Computed tomography (CT) scan of the patient seen in Figure 5—(A and B) 3D CT scan showing LeFort II fracture with L angle mandible fracture (arrows); (C) Haziness of L maxillary sinus with disruption of sinus walls; (D and E) Gross displacement with overriding of fragments at L angle mandible

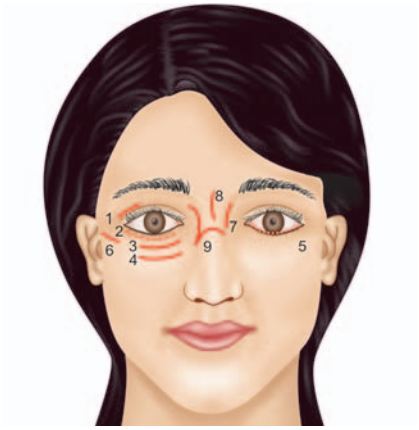


Fig. 32.7: Various facial incisions for exposure of midfacial skeleton

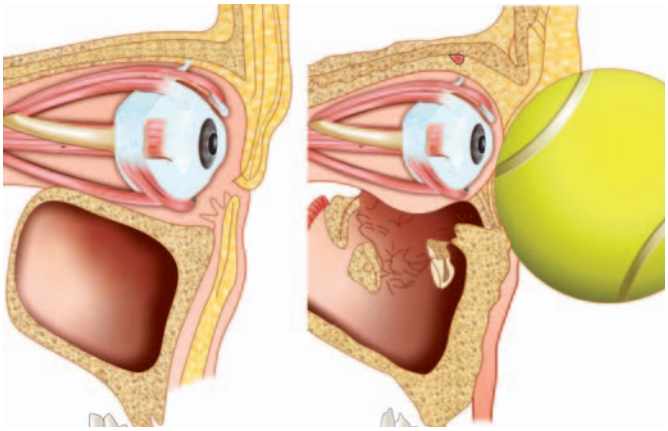
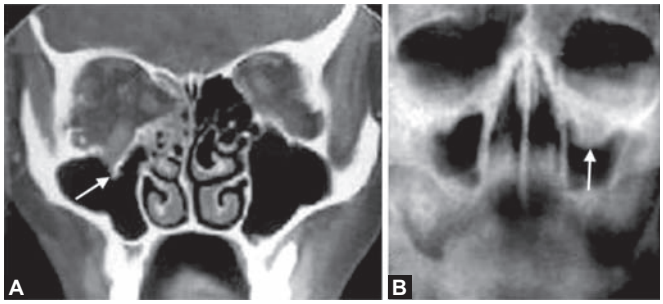


Fig. 32.8: Blow-out fracture of the floor of the orbit. A tennis ball aimed at the globe of the eye forces it posteriorly, compressing the periorbital fat and fracturing the thin orbital floor. Fractured fragments and herniation of periorbital fat will be seen in the maxillary sinus



Figs 32.9A and B: (A) Coronal computed tomography (CT) scan showing *trapdoor deformity* indicating blow-out fracture of R orbital floor; (B) *Hanging drop appearance in L maxillary sinus* indicating herniation of orbital contents in the sinus due to blow-out fracture

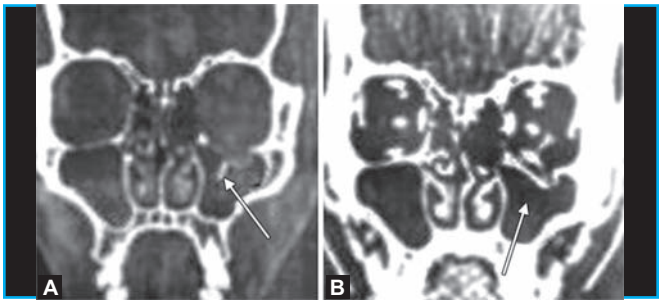


Fig. 32.10: Coronal computed tomography (CT) scan showing the blow-out fracture of the floor of the orbit. Herniation is seen in the maxillary sinus

4. Percutaneous approach: Hook is used or Carroll-Girard bone screw (Crow, 1952; Ginestat and Dautrey, 1960; Poswillo, 1976).
5. Intranasal transantral approach.
6. Towel clip reduction (Todd and Carter, 2005).
7. Endoscopic management (Harold Hopkins, 2008).
8. Modified Gilles's approach (Swanson, 2012) in the setting of bicoronal exposure.
9. Coronal/bicoronal approach.

The approach of Gillies, Kilner and Stone (1927) is popular for reduction of fractures of zygoma **(Figs 32.12 and 32.13, Fig. 32.15)**.

Gillies Temporal Approach

The temporal fascia is attached to the zygomatic arch and the temporal muscle passes downward medial to the fascia to be attached to the coronoid process. Between these two structures a natural anatomical space exists into which an instrument can be inserted and it can be utilized to elevate the displaced zygoma or its arch into position **(Figs 32.11 to 32.13 and Fig. 32.19)**.

Technique: The hair is shaved from the temporal region of the scalp. The external auditory meatus is plugged with cotton to prevent any fluid or blood getting inside. An incision about 2–2.5 cm in length is made, inclined

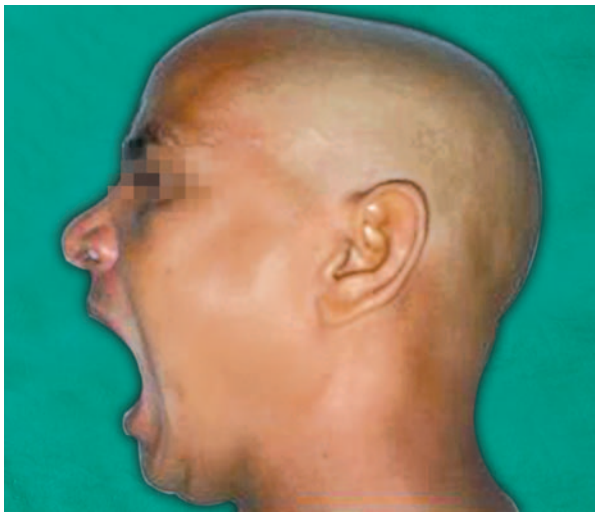


Fig. 32.11: Facial depression seen due to V-shaped fracture of zygomatic arch

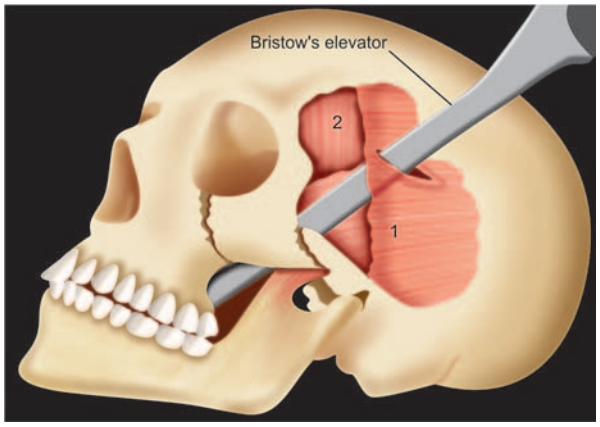


Fig. 32.12: Gillies temporal approach for reduction of zygomatic bone/arch fracture [(1) Temporalis fascia, (2) Temporalis muscle

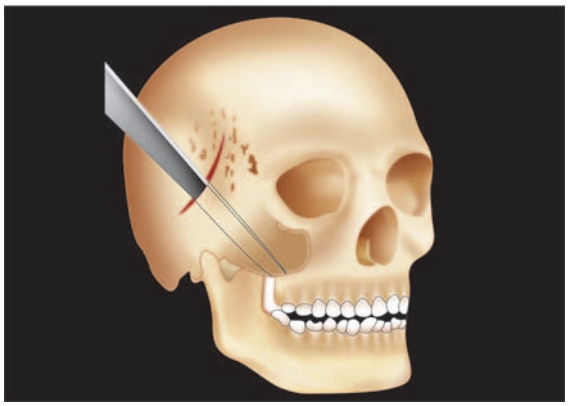


Fig. 32.13: Gillies temporal approach for reduction of zygomatic bone/arch fracture (diagrammatic representation)

forward at an angle of 45° to the zygomatic arch, well in the temporal region. Care is taken to avoid injury to the superficial temporal vessels. The temporal fascia is exposed which can be identified as white glistening structure. The incision is taken into the fascia and the fibers of temporalis muscles will be seen. Long Bristow's periosteal elevator is passed below the fascia and above the muscle **(Fig. 32.12)**. Once this correct plane is identified and instrument is inserted through it, downward and forward, the tip of the instrument is adjusted medially to the displaced fragment. A thick gauze pad is kept on the lateral aspect of the skull to protect it from the pressure of elevator while reduction is going on. The operator has to grasp the handle of the elevator with both hands and assistant has to stabilize the head of the patient. (During elevation procedure care should be taken that pressure is not exerted on the lateral surface of the skull to end up with depressed fracture of the skull). The tip of the elevator is manipulated upward, forward and outward. The snap sound will be heard as soon as reduction procedure is complete. Wound is closed in layers after withdrawing the elevator. Care is taken that after surgery at least for 5–7 days, no pressure is exerted on the area till the bone consolidates. Patient is instructed to sleep in supine position or not to sleep on the operated side **(Figs 32.14A to G)**.

Now many operators have modified their own elevators for reducing the fracture of the zygomatic complex, which are available in the market. Any one of these instruments is chosen by the operator and the reduction procedure can be modified changing the direction of the tip of the instrument, depending on the type of fracture. While the tip of the elevator rests on the medial surface of the zygomatic bone, the operator should keep on palpating the external contour with the hand and guide the manipulation till proper positioning of the fragments is achieved.

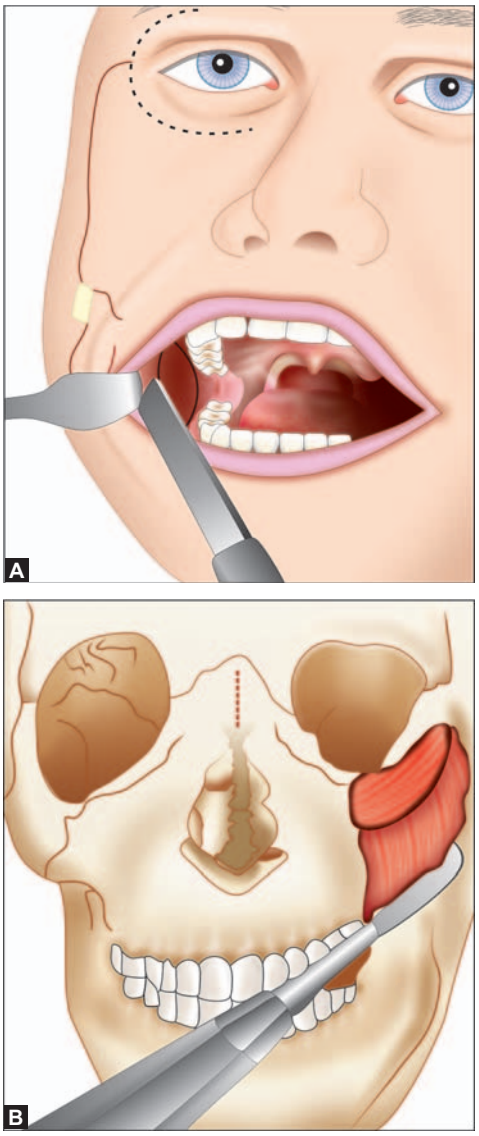
Intraoral Procedure

Keen's approach (1909): Introral buccal vestibular incision is taken in first and second molar region behind the zygomatic buttress. A pointed curved elevator (Monks' pattern) is passed supraperiosteally up beneath the zygomatic bone. The depressed bone is then elevated with an upward, forward and outward movement **(Figs 32.15 and 32.16)**.

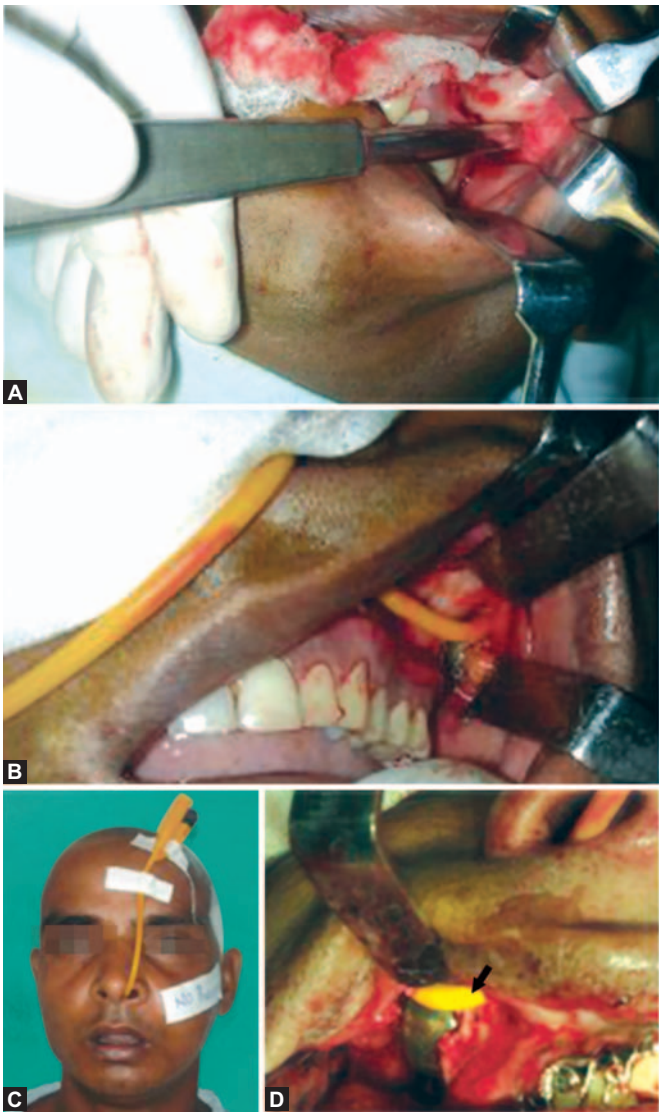
Alternate methods like intranasal elevation via intranasal antrostomy or oroantral elevations were suggested by opening at inferior meatus, with curved urethral sound, firm upward and downward pressure is applied. Direct extraoral elevation can be done by inserting a sharp curved hook directly through the skin below and above



Figs 32.14A to G: Clinical pictures of reduction of fracture zygomatic arch, by Gillies' temporal approach. (A) Depression in the left side of cheek; (B and C) Three-dimensional computed tomography (3D CT) scan showing L zygomatic arch fracture; (D and E) An incision to expose the temporal fascia and muscle; (F) Elevation of depressed fracture with bone elevator; (G) Final suturing after fracture reduction



Figs 32.15A and B: Intraoral Keen's approach for reduction of zygomatic bone/arch fracture



Figs 32.16A to D: (A) Intraoral reduction of zygomatic bone fracture by Keen's approach; (B) Stabilization of reduced fracture by using balloon catheter; (C) Postoperative photograph of the patient; (D) In another patient, support to the fractured zygomatic complex is given by balloon catheter (arrow)

the prominence of the zygomatic bone. Manipulation of the hook reduces the fracture **(Figs 32.17 and 32.18)**.

Temporary support after reduction can be given by antral pack or by inflatable balloon.

Approaches to the infraorbital rim for direct fixation by bone plates:

1. Existing skin laceration
2. Infraorbital rim incision
3. Subtarsal incision
4. Subciliary/blepharoplasty incision
5. Transconjunctival incision.

Approaches to the lateral orbital rim—eye brow incision or upper lid incision.

Complex associated panfacial fractures will have to be treated by coronal or bicoronal exposure.

Gross separation of the zygomaticofrontal suture *[Type 4(a), 4(b), 5(a), (b) and (c)]:* Extraoral incision is taken in the wrinkles, 1 cm above the outer canthus or in the line of the outer aspect of the eyebrow. Holes are drilled

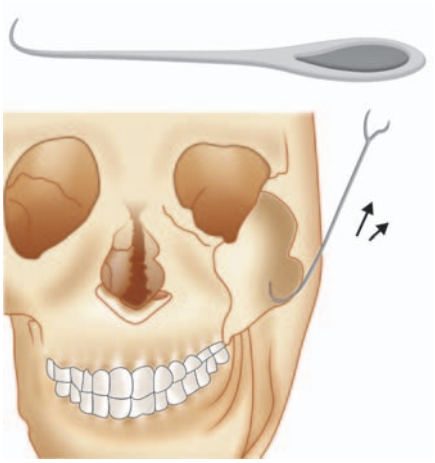


Fig. 32.17: Reduction of zygoma using zygomatic hook

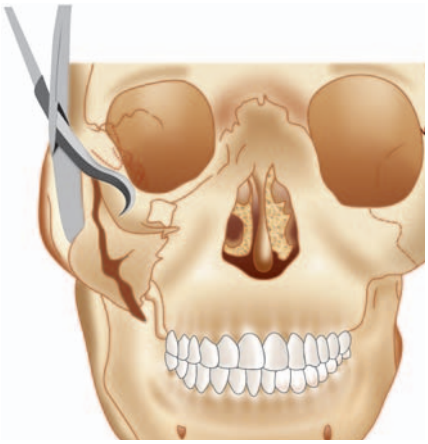
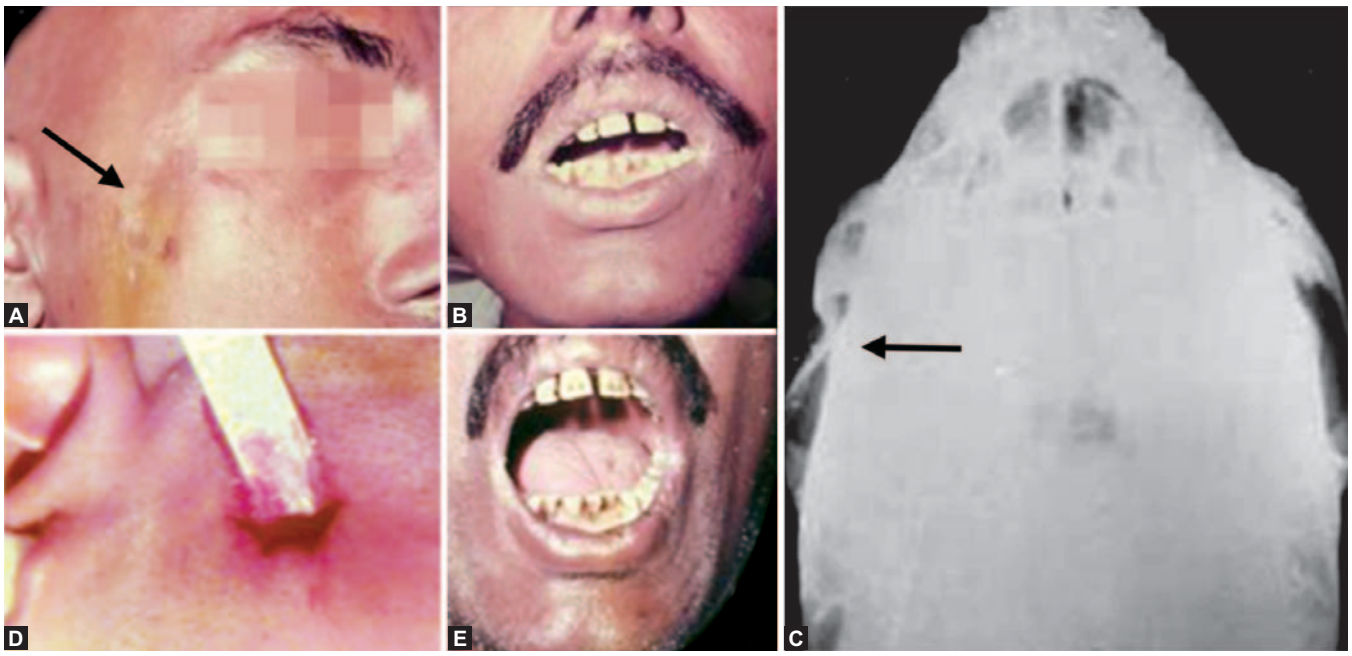


Fig. 32.18: Closed reduction of zygomatic bone fracture using towel clip

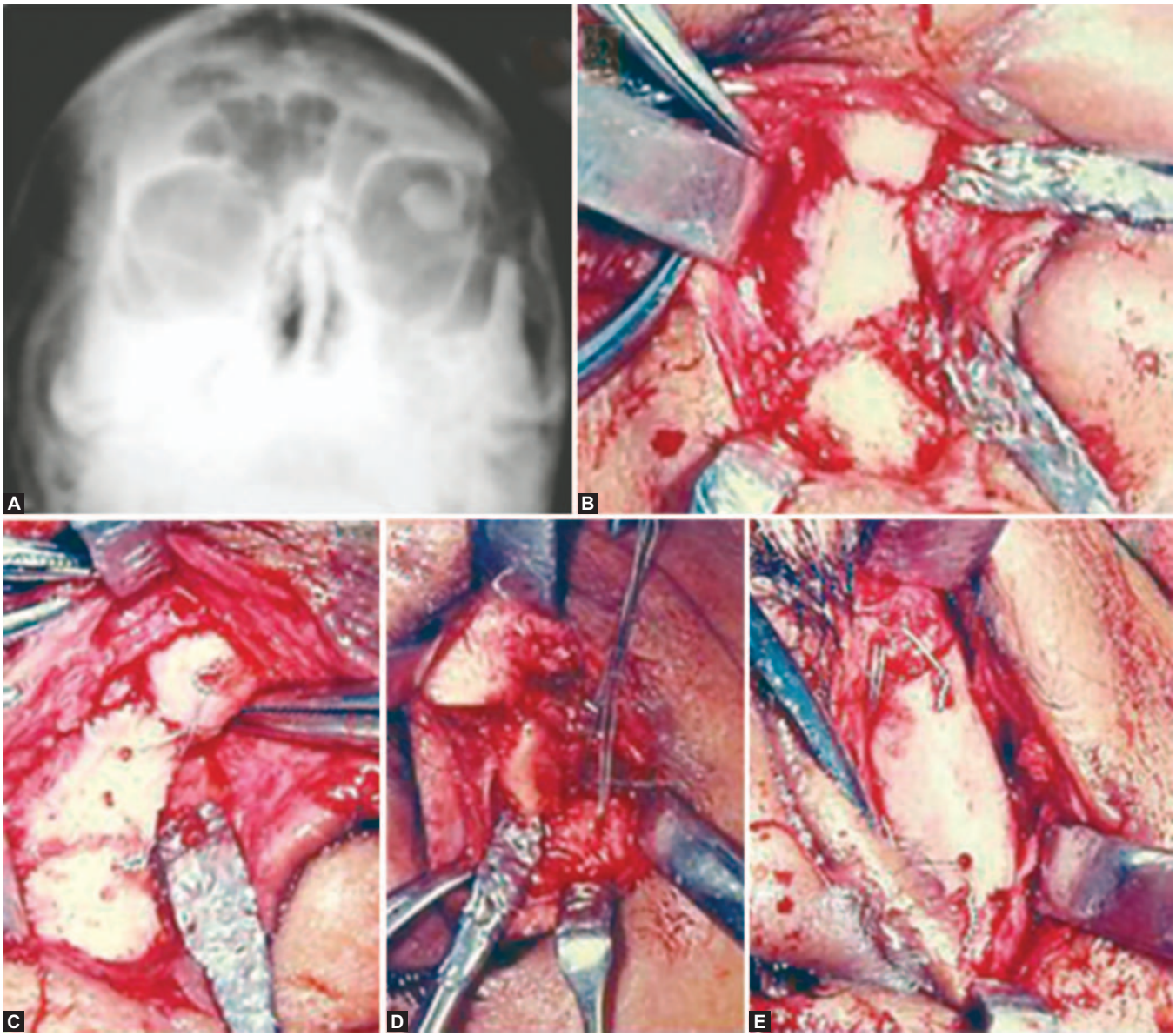


Figs 32.19A to E: Reduction of zygomatic arch fracture by Gillies' method: (A) Typical depression due to depressed V shaped fracture of R zygomatic arch; (B) Limited oral opening due to impingement on the coronoid process by fractured fragments; (C) Jug handle X-ray views *showing fracture of R zygomatic arch*; (D) Reduction by Gillies' method; (E) Improved oral opening after reduction

approximately 0.5 cm away from the fracture ends of the frontal and zygomatic bones. A periosteal elevator is placed on the medial aspect to protect the eye. The 26 gauge double wire is passed and twisted after passing through both the holes and approximation of the fragments. Instead of wire, 2-hole miniplates can also be used for direct fixation. Wound is closed in layers **(Figs 32.20 and 32.21)**.

Comminution of the orbital floor *[Type 6(a)]:* Use of antral pack or balloon catheter can be done which is previously described **(Figs 32.22A to G)**.

Comminution and displacement of the orbital rim *(Type 7):* Direct figure of eight intraosseous wiring can be done through extraoral infraorbital incision or semilunar orbital bone plate can be fixed **(Figs 32.23A to E)**.



Figs 32.20A to E: (A) PA view Water's showing gross displacement of both R and L zygomatic complex and nasal bones; (B) Surgical exposure of right side fractured frontal process of zygoma; (C) Fixation after reduction with intraosseous wiring on right side; (D) Surgical exposure on the left side frontal process of zygoma showing loss of bone; (E) Autogenous iliac crest bone grafting done

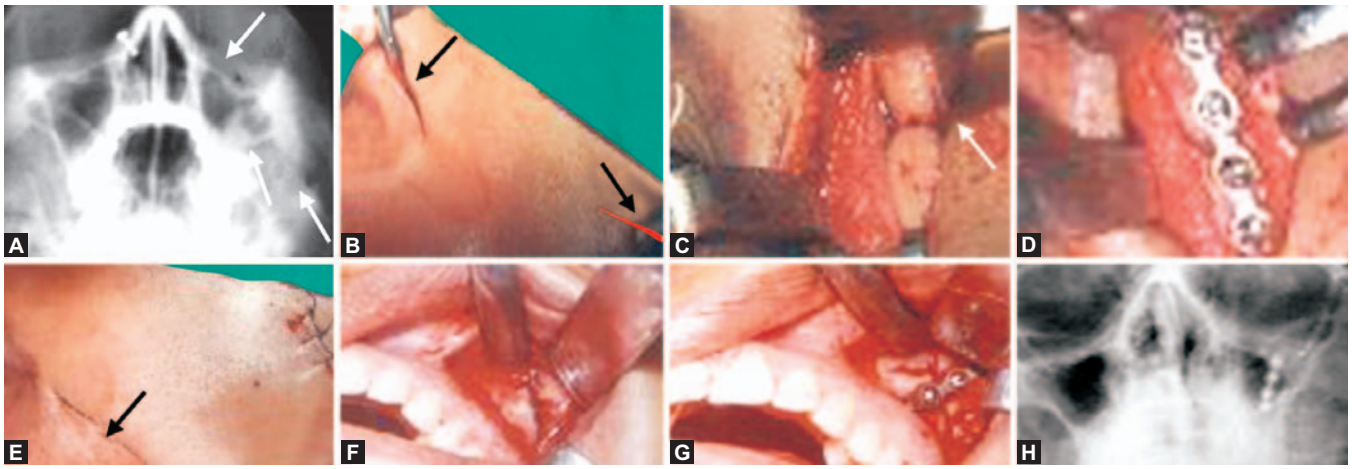
Associated coronoid fractures: No separate treatment is indicated. But if coronoid process is completely detached and causing limitation of the oral opening after reduction then it should be excised through intraoral incision.

Malunion of the Zygomaticomaxillary Complex

It will show following signs and symptoms:

- Cosmetic
- Neurological
- Antral
- Masticatory
- Ophthalmic.

Cosmetic: Loss of contour or prominence of cheek will be seen. Correction may be done either by surgical refracturing or camouflaging the deformity by means of onlay bone grafting or alloplastic material like hydroxylapatite blocks.



Figs 32.21A to H: Reduction of zygomaticomaxillary complex fracture. (A) Preoperative X-ray (B) Eyebrow incision and Gillies incision; (C) Fracture reduction at frontozygomatic suture; (D) Bone plate fixation; (E) Subcuticular suturing; (F) Intraoral vestibular incision to expose the fracture; (G) Intraoral bone plate fixation; (H) Postoperative X-ray



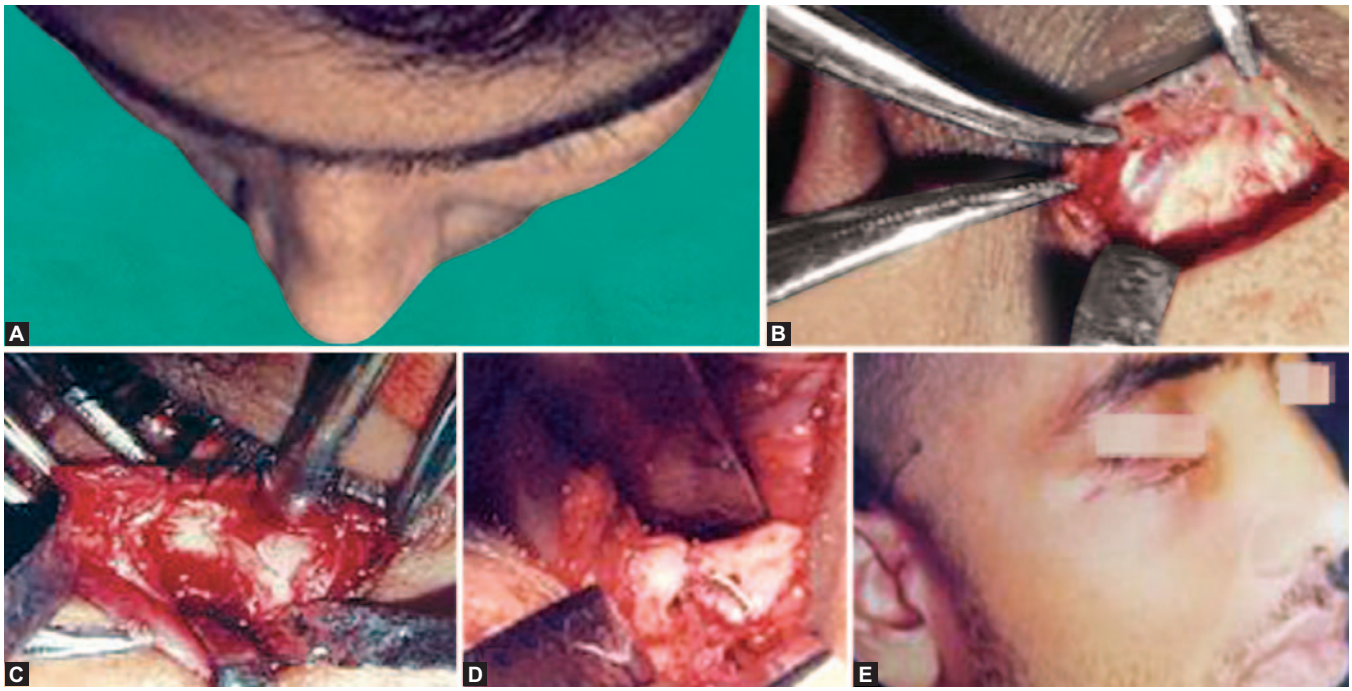
Figs 32.22A to G: Right zygomaticomaxillary complex fracture: (A) Preoperative front face; (B) Computed tomography (CT) scan; (C) PA view Water's X-ray; (D) 3D scan showing the displaced R zygomatic bone; (E) Intraoral reduction and stabilization using balloon catheter; (F) Postoperative facial view; (G) Postoperative CT scan showing the restoration of fractured anterolateral wall of maxillary sinus

Neurological: The paresthesia, dysesthesia or anesthesia may be present. Observation for recovery of infraorbital nerve should be done for 6–12 months, otherwise surgical exploration of the nerve can be done.

Antral: Persistent sinusitis may be due to the presence of loose necrotic bone pieces or a foreign body, which should be removed via Caldwell-Luc operation.

Masticatory: Depressed zygomatic arch fracture impinges on the coronoid process bringing about limitation of the mandibular movements and opening. In extensive fracture, via coronal incision the arch should be exposed, refractured and stabilized by direct fixation method. Osteotomy and bone grafting can be done if required.

Ophthalmic: Change of the ocular level, diplopia, enophthalmos, occulorotatory restriction are the residual deformities which are difficult to correct secondarily. Exploration and surgical correction can be attempted.



Figs 32.23A to E: (A) Typical appearance following fracture of the R zygomatic bone after dispersal of the initial edema. Note the loss of contour and flattening on right side of the face, (B) Gillies' approach for reduction; (C and D) Open reduction via infraorbital incision for reduction of infraorbital rim fracture and fixation by intraosseous wiring; (E) Postoperative facial appearance

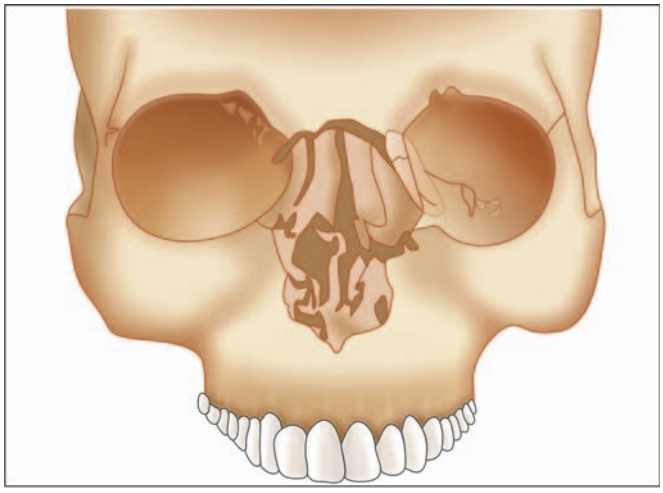


Fig. 32.24: Fractures of the nasal bone

FRACTURES OF THE NASAL BONE AND TREATMENT

Incidence of nasal fracture is quite high, because of the prominent position of the nose. Nasal fracture is usually the result of direct injury; it can occur as an isolated fracture or it may be combined with other facial fractures. Fractures of the nasal bones and septal cartilage result in not only cosmetic deformity, but also functional disturbance. If early treatment is instituted, reduction and fixation is achieved properly, the disturbance of function can be prevented. If treatment is delayed, then malunion will require more extensive surgical repair. Nasal fractures in children should be generally treated conservatively with closed reduction, because of the growth potential. The nasal fractures are often overlooked in multiple facial injuries. Nasal symmetry, proper appearance and adequate airway through the nose is important. Careful clinical examination, meticulous reduction and stabilization will give good result and no airway obstruction **(Figs 32.24 to 32.28)**.

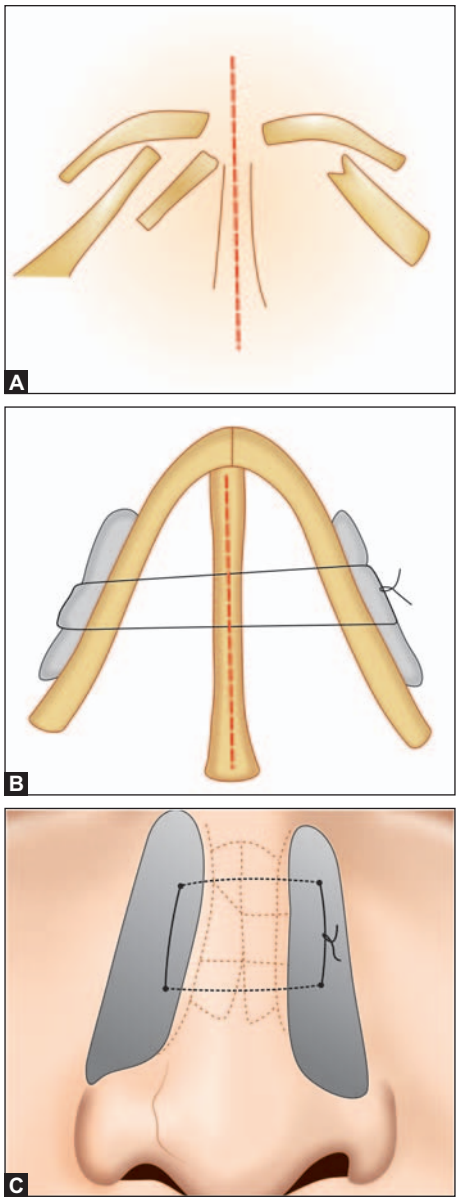
Anterior injuries: Direct, violent, and/or anterior force may result in smash fractures of the nasal bones, the frontal process of the maxilla, the lacrimal bones and the septum. Comminuted fragments may be driven laterally into the orbit or upward into the ethmoid region. Splayed nasal fractures may be associated with damage to the nasolacrimal ducts, the perpendicular plate of the ethmoid, the ethmoid sinuses, the cribriform plate and the orbital parts of the frontal bone. Widening of the



Figs 32.25A to D: Clinical picture of nasal fractures



Fig. 32.26: Reduction of nasal fractures



Figs 32.27A to C: (A) Gross displacement of nasal bones; (B and C) Following disimpaction, reduction of fragments, they are stabilized by a horizontal mattress suture of 0.5 mm diameter of stainless steel wire tied over lead plate. Soft tissues are protected by cotton wool rolls

intercanthal distance is known as traumatic telecanthus. Buckling of the nasal septum may be seen.

Lateral injuries: Force applied from the side, may involve only one nasal bone with medial displacement, but most commonly in adults, a violent blow from the side results in fractures of both nasal bones and fracture of nasal septum with lateral shifting of the entire bony framework. This is known as "open book" fracture. In most severe injuries, the septum may be fractured or displaced from the maxillary crest, from the vomerine groove or from its attachment at the anterior nasal spine of the maxilla, with displacement into the adjacent airway. Fractures of the septum occur in the vertical plane. There may be telescoping or overlapping seen **(Fig. 32.24)**.



Fig. 32.28: Nasal splint in position

Diagnosis of Fractures of Nasal Bones

A good history and careful clinical examination assisted by proper radiographic evaluation is mandatory and helpful from a medicolegal standpoint. History of previous nasal deformity, trauma, surgery or breathing difficulty should be asked for. Nature and direction of the trauma also should be asked. Patient's chief complaints are usually nasal bleeding, pain, swelling and difficulty in breathing through the nose. Sense of smell also may be lost or diminished. On clinical evaluation, obvious nasal deformities like depressed bridge of the nose, flattening or deviation of the nasal bone may be evident **(Figs 32.25A to D)**. In the fresh fractures, edema, hematoma, lacerations, subconjunctival hemorrhage may be seen. Nasal obstruction may be the result of edema, blood clots, swelling of the nasal mucosa, dislocated bone, cartilage, etc. Subcutaneous emphysema may be present, because of the patient's repeated attempts to blow the nose. Circumorbital ecchymosis will be present. CSF rhinorrhea may be present. On palpation, crepitation and tenderness will be there. Active bleeding or epistaxis should be taken care immediately.

Radiographic Evaluation

Lateral views of the nasal bones, 15° or 30° occipitomental projections can be taken. A lateral view taken with a small dental film against the side of the nose also provides an excellent detailed study. CT scan is helpful for higher level fractures of the nose.

Management

Closed reduction is the treatment of choice for most nasal bone and/or septal fractures. These fractures should be repaired within 7–10 days.

Closed reduction can be done under local anesthesia with or with/without sedation or general anesthesia. It should never be conducted under intravenous sedation alone. As reduction procedure will provoke bleeding, the trickling of the blood near glottis may provoke a dangerous laryngeal spasm.

If the local anesthesia and sedation are used, it is important to protect the airway by packing ribbon or strip gauze soaked with local anesthetic agent plus vasoconstrictor for hemostasis. The pack is placed in the posterior aspect of the nose with suture attached to it for retrieval. Local anesthetic agent is then injected with vasoconstrictor intranasally.

The two especially designed instruments that are used for repositioning the nasal bones are Asche's and Walsham's forceps. In general, bony fractures should be reduced first, followed by reduction of septal fractures or its dislocation from the maxillary groove. The reduction can be done by using a long, flat, narrow instrument such as Howarth's periosteal elevator. Inferiorly or medially displaced nasal bones are lifted upward and laterally, by using Howarth's elevator into normal position. The laterally displaced nasal bones are brought into normal position by using Walsham's forceps or digital pressure. Walsham's forceps are used with unpadded blade inside the nasal cavity deep to the nasal bones and the other padded blade externally on the skin over the fractured nasal bones. The bones are manipulated between the blades until adequate mobility is achieved. Anterior traction and medial rotation followed by lateral rotation to reposition the fragments is done **(Fig. 32.26)**. Operator will constantly check the external nasal contour with his palpating fingers. Asche's septal forceps are then introduced on either side of the septum along the floor of the nose and used to realign the septal cartilage in the groove in the vomer and having ironed out any deflection in the perpendicular plate of ethmoid or the vomer are slowly brought upward and forward to elevate the nasal bridge anteriorly. At the end of the reduction, previous nasal pack with the suture is removed. Following complete reduction, internal stabilization is done with nasal packing using half inch ribbon gauze saturated with antibiotic ointment. The pack is placed under direct vision in the superior nasal vault first and then packed inferiorly. Both the nostrils should be packed to support the nasal septum. The pack is removed after 3–4 days.

The external dressing consists of padding the area with cotton wool or gauze pieces and stabilizing it with adhesive tape in a "butterfly" manner secured to the forehead and crossing over the nasal bridge on either side. External splints that may be used include dental impression compound mold, plaster of Paris, metal splints, lead plates or acrylic or prefabricated splints such as Denver splint

(Figs 32.27 and 32.28). The external splints are usually left in place for 5–7 days after reduction. The splint provides support for the nasal bones as well prevents hematoma and edema of the nasal structures. Nasal fractures associated with maxillofacial injuries should be treated after stabilizing other fractures with miniplate system, so that IMF is not required and airway can be maintained through the oral route as the nostrils will be packed for 3–4 days postoperatively.

In extensive unstable fractures open reduction can be opted for. Open sky or bicoronal approach can be used and bone grafting, direct fixation of the fragments can be planned.

Points to Remember

Various incisions for exposure of midface skeleton

- Methods of reduction for midface fractures
- Various methods for treatment of fractures of the zygomatic bone
- Fractures of the nasal bone and treatment.

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CHAPTER 33 Applied Surgical Anatomy of the Mandible and Classification of Mandibular Fractures

INTRODUCTION

The mandible is the largest, heaviest and strongest bone of the face. The normal mandible provides a normal airway and proper facial contour. A solid movable mandible allows normal chewing, swallowing and speech. Even though, it is a very strong structure, it is prone to injury, because of its prominent position in the facial skeleton. It is a common site of election for receiving intentional or unintentional violence.

ANATOMY OF THE MANDIBLE

The body of the mandible has got horseshoe or parabola shape. Two rami project upward from the posterior aspect of the body. The angle curvature is 110–140°. The condylar processes of these rami articulate with the temporal bone to form the temporomandibular joints (TMJ). The mandible has been compared to an archery bow, which is strongest at its center and weakest at its ends, where it often breaks **(Fig. 33.1)**. Energy of 44.6–74.4 kg/m is required to fracture the mandible.

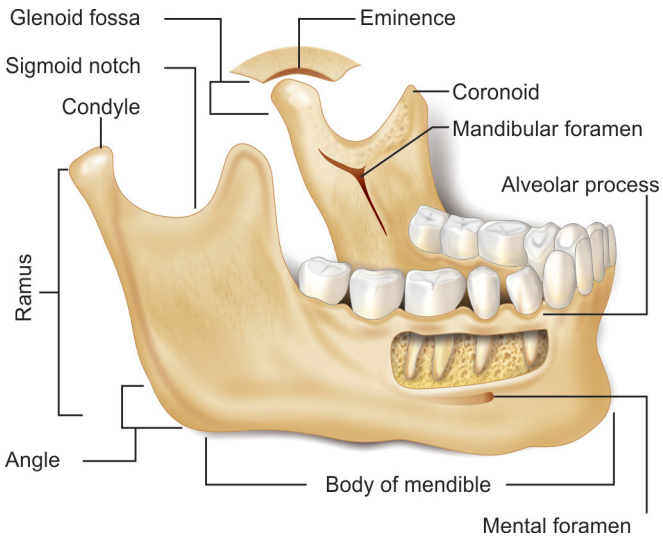


Fig. 33.1: The mandible

The lower jaw is a movable body, which carries the alveolar process and the teeth. The adult mandible is composed of a compact outer and inner plate of cortical bone and a central portion of medullary bone (spongiosa), whose trabeculae are distributed along the lines of maximum stress.

The lower portion of the body is heavy and thick and consists of dense cortical bone with little spongiosa and changes very little during adult life. The alveolar process has got lingual and buccal plate of compact but thin bone. The alveolar bone changes throughout the life of a person and becomes adapted to the movements of the teeth or to the loss of teeth. After extraction of teeth, the alveolar process undergoes marked atrophy. After total extractions, due to extreme atrophy, the mental foramen almost comes at the margin of the crest of the ridge. The body of the mandible is naturally strengthened by a strong system of buttresses which extend into the region of the rami.

On the lateral surface, the strong external oblique ridge extends from the body obliquely upward to the anterior border of the ramus. Medial surface is thinner than the lateral surface. But, it is also composed of dense, thick compact cortex. Here, the mylohyoid line extends from the area of the socket of the third molar diagonally downward and forward towards the genial tubercles at the midline. Bony chin is the most vulnerable endangered targeted area, but it is naturally strengthened by the mental protuberances. In childhood, the body of the mandible is weakened by the presence of developing buds of permanent teeth, but naturally protected due to the resilience of the bone.

The ramus consists essentially of two thin plates of compact bone, separated by a narrow portion of cancellous bone. The posterior border of the ramus is strong and rounded.

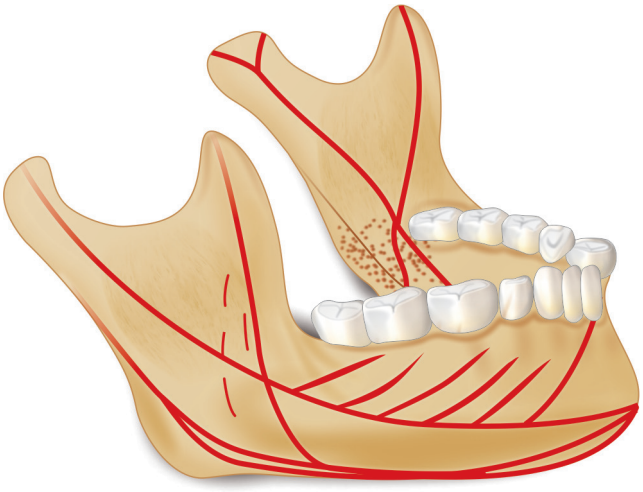


Fig. 33.2: The trajectories of the mandible. The mandible is strengthened by the development of massive compacta, as well as by the trajectories of the spongiosa, in response to the forces of the muscles of mastication

The bony trajectories transmit and disperse the forces of mastication towards the condyles from the body, thus preventing injury to middle cranial fossa **(Fig. 33.2)**.

Areas of Weakness (Vulnerable for Fracture)

- The junction of the alveolar bone and basal mandibular bone creates a line of weakness. Dentoalveolar fractures can be seen independently with or without the fracture of basal bone.
- Symphysis region is formed by the bony union of two halves in the center at 1st year of life. Symphysis fracture is seen at this line of weakness.
- Parasymphysis region lateral to the mental prominence is a naturally weak area susceptible for parasymphyseal fracture. This is because of the presence of the incisive fossa and mental foramen.
- The body of the mandible is considerably thicker than the ramus and the junction of these two portions constitutes a line of structural weakness. Angle fractures are commonly seen due to the curvature of trajectories in this region.
- Strength of the lower jaw also varies with the presence or absence of teeth. The presence of impacted lower third molars or excessive long roots of canines make the area more vulnerable for fracture. With the advancing age, the loss of teeth and resorption of alveolar bone leads to a decrease in the vertical height of the mandible, making it prone to fracture.
- The slender neck of the mandibular condyle renders it particularly liable to fracture as a result of direct violence applied to the chin. This anatomical weakness actually acts as a safety mechanism, as a fracture of the neck of the condyle prevents injury to the middle cranial fossa. Direct blow to the chin region can lead towards fracture of one or both condyles. Sideways blow can bring about fracture of the opposite condylar neck along with parasymphysis fracture at the same side of the blow.
- As the curve of the mandible becomes progressively more distorted by trauma, the outer and inner compact plates tend to fracture independently. When the fracture passes through the outer plate and reaches the lamina dura of the tooth root, it fractures the root and passes around the root, stripping the periodontal membrane. When the force arrives at the lingual plate, the fracture occurs obliquely at different level than the buccal plate. This deflection of the fracture line may cause an appearance of double fracture on the lateral oblique view radiograph.
- Fractures in the tooth bearing area have communication through the periodontal membrane. Therefore, the infection from the oral cavity can travel in the bone through the break. The tooth, denuded of periodontal membrane on some aspect of its root also constitutes a portal of entry of infection into the bone at the site of fracture, plus teeth can become nonvital due to trauma and are also susceptible for infection.

Blood Supply

- Central blood supply through the inferior alveolar artery
- Peripheral blood supply through the periosteum. When a fracture of the mandible occurs, blood vessels involved in the line of fracture are torn. The resultant effusion of blood into surrounding tissues produces ecchymosis and hematoma. If the periosteum on the lingual side is torn, it can lead to sublingual hematoma. The intact periosteum maintains the collateral blood supply. Before the antibiotic era, the teeth in the fracture line were extracted prophylactically to prevent infection (which is no more required).

In the severely atrophic mandible, there is greater dependence on periosteal blood supply than the central supply. Therefore, if open reduction is planned, stripping of the periosteum in such cases should be kept to a minimum.

Nerve Supply

Damage to the inferior alveolar nerve after fracture, results in the paresthesia or anesthesia of the lower lip on the affected side. If the nerve is completely severed, then recovery by regeneration takes 3–12 months, usually preceded by "tingling" sensation, paresthesia and hyperesthesia of the area. The rate of recovery will depend upon the following:

- Accurate approximation of the nerve ends (proper reduction of fragments)
- Elimination of infection
- Proper fixation (prevents undue mobility)
- Absence of any intervening hard or soft tissue in the inferior dental canal (muscle entrapment in the fracture line or foreign body or bone fragment).

Muscle Action

- The muscles of facial expression, which are attached on the outer aspect of the anterior part of the mandible and which are inserted into the skin, exert no effect on the displacement of the fragments following mandibular fracture.
- The muscles originating from the inner aspect of the mandible, the mylohyoid, geniohyoid, genioglossus and anterior belly of digastric exert their effect in centripetal manner. The fractured fragments, therefore, tend to collapse posteriorly or medially.
- The lateral pterygoid muscle is inserted into the medial fossa on the anterior aspect of the condyle. Therefore, in condylar fractures, the head is displaced anteriorly and medially and may also undergo lateral rotation due to the spasm of the muscle.
- The mandible anterior to a line passing through the anterior margin of the masseter muscle, is influenced by the depressor group of muscles, while the ramus is influenced by the elevator group.

Factors Influencing Displacement of a Mandibular Fracture

- Direction and intensity of the traumatic force
- Site of fracture
- Direction of the fracture line
- Muscle pull exerted on the fractured fragments
- Presence or absence of teeth
- Extent of soft tissue wounds
  - If the strong force is directed at particular site, it can result first into direct fracture and also into another indirect fracture on the opposite side. Depending on the direction of the fracture line and muscle pull exerting on the fragments, the resultant displacement will be brought about due to extensive tear of the ligaments as well as supporting soft tissues
  - The body of the mandible is only lightly covered by the muscles which offer very little protection. The ramus, however, is well-splinted by the masseter and medial pterygoid muscles. Therefore, an extensive comminuted fracture in this region shows minimum displacement
  - Presence or absence of teeth on the proximal segment of a fracture line can have influence on the total amount of displacement of proximal segment. Teeth which are present on the proximal segment may prevent displacement by occlusal contact with the maxillary teeth
  - Extent of supporting soft tissue wound is also an important factor. Severe tear of the musculature and overlying soft tissues permit wider displacement.

Symphysis Fracture

If the fracture line passes from the labial to the lingual surface in a straight line (rare), the fracture is fairly stable to the influence of the muscles which are attached to the genial tubercle.

If the fracture line runs obliquely, then varying degree of displacement or overlap will be seen. Medial displacement will be due to the action of the mylohyoid muscle and also due to imbalance of the muscles attached to the genial tubercles on either side.

Canine Region Fracture

Common site of fracture, partly due to the length of the canine root weakening the bone and also due to the maximum convexity of the curvature at this site. If the fracture is bilateral, then the total displacement will be much more and can be hazardous, because of the tongue fall and obstruction of the airway.

If the bilateral fracture line in this region runs obliquely forward and medially from the inner to outer cortical plate, then due to the pull of geniohyoid and genioglossus and anterior belly of the digastric muscles, the entire anterior section of the mandible is displaced posteriorly and this leads to tongue fall and airway obstruction.

Body Fracture of the Mandible

Here, if the fracture line is unfavorable, i.e. running from the alveolar margin downward and backward towards the inferior border, then the vertical displacement of the posterior fragment is not so pronounced due to the action of the elevator group of muscles, being counteracted to some extent, by the suprahyoid group of muscles. But, the medial or lingual displacement tends to increase.

Fractures of the Edentulous Mandible

Following extreme alveolar atrophy in the molar regions of the edentulous mandible, these areas are prone to fracture. The bilateral fractures of the body of the edentulous mandible can occur near the posterior attachment of the mylohyoid diaphragm. The mylohyoid muscle level appears to be higher up in this situation, because of extreme atrophy and loss of vertical height of the body of mandible. There is a downward and backward angulation of the anterior part of the mandible seen due to the influence of the digastric and the mylohyoid muscles. This extreme "bucket handle" displacement may bring about respiratory distress in an elderly patient. Early stabilization of this type of fracture is a must (Refer to Fig. 34.25 in the next chapter).

CLASSIFICATIONS OF MANDIBULAR FRACTURES

Fractures of the mandible are common in patients, who sustain facial trauma.

A study conducted by Hang et al. in 1983, showed the incidence in the ratio of 6:2:1 of mandibular, zygomatic, maxillary fractures respectively. Approximately two-thirds of all facial fractures are the mandibular fractures (nearly 70%) **(Tables 33.1 and 33.2)**.

Sex: Most mandibular fractures are seen in male patients. The ratio is approximately 3:1.

Age: Thirty five percent of mandibular fractures occur between the ages of 20-30 years.

Table 33.1: Location: As per Olson's study in 1982

Body fractures	38%	Symphysis	16%
Condyle fractures	29%	Rest of the body	22%
Angle fractures	25%	Ramus fractures	4%
Dentoalveolar fractures	3%	Coronoid fractures	1%

Table 33.2: Etiology of mandibular fractures

Vehicular accidents	43%
Altercation, assaults, battery, interpersonal violence	34%
Fall	7%
Sports injuries	4%
Industrial mishaps or work accidents	10%
Pathological fractures or miscellaneous	2%

Statistical Number of Fractures of the Mandible

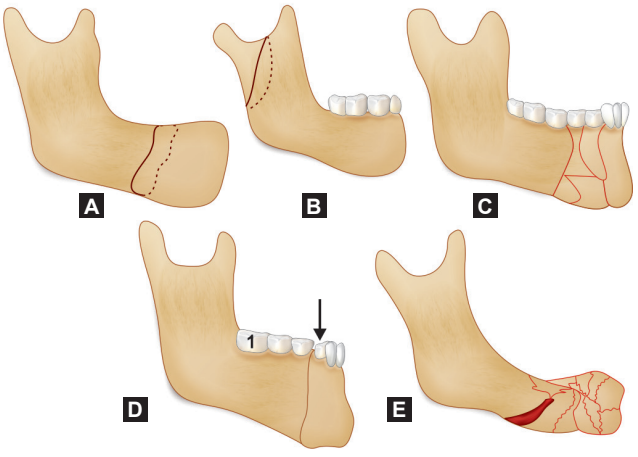
- Unilateral, single: 53%
- Bilateral, double: 37%
- Multiple fractures: 10%

Fifty percent of the patients have more than one fracture.

Classifications

There are several ways to classify the mandibular fractures:

1. General classification.
2. Anatomical classification.
3. Relation of the fracture to the site of injury.
4. Completeness.
5. Depending on the mechanism.
6. Number of fragments.
7. Involvement of the integument.
8. Shape or area of the fracture.
9. Direction of fracture and favorability for the treatment.
10. Presence or absence of teeth.
11. AO classification—relevant to internal fixation.



Figs 33.3A to E: (A) Simple fracture; (B) Greenstick fracture. Straight line fractured cortex. Dotted line bent cortex; (C) Compound comminuted fracture; (D) Compound fracture; Arrow-exposed bone; (E) Simple comminuted fracture

Kruger's General Classification (Figs 33.3A to E)

Simple or closed: The linear fracture, which does not have communication with the exterior or the interior. Such a fracture does not produce a wound open to the external environment either through the skin, mucosa or periodontal membrane. It may or may not be displaced.

Examples—fractures in the region of the condyle, coronoid process, ascending ramus, etc.

Compound or open: This fracture has communication with the external environment through skin or with the internal environment through mucosa or periodontal membrane. All the fractures involving the tooth bearing area of the mandible or where an external or intraoral wound is present involving the fracture line.

Comminuted: A fracture in which the bone is splintered or crushed into multiple pieces. These types are generally due to a greater degree of violence or high velocity impact. Gunshot wounds, where missiles are traveling at a high velocity can produce these fractures.

Complicated or complex: Fractures associated with the damage to the important vital structures complicating the treatment as well as prognosis, for example fractures with injury to the inferior alveolar vessels or nerve, facial nerve or its branches, facial vessels, condylar fractures with associated injuries to middle cranial fossa, etc.

Impacted: It is rarely seen in mandibular fractures and more commonly seen in maxilla. This is a fracture in which one fragment is firmly driven into the other fragment and clinical movement is not appreciable.

Greenstick: A fracture in which one cortex of the bone is broken with the other cortex being bent. It is an incomplete fracture seen in young children because of inherent resilience of the growing bone.

Pathological: Spontaneous fracture of the mandible occurring from mild injury or as a result of a normal degree of muscular contraction. This is because of weakness caused due to the pre-existing bone pathological processes.

Areas of structural weakness may result from the following:

- **Generalized skeletal disease**
  - Endocrinal disorders—hyperparathyroidism or postmenopausal osteoporosis.
  - Developmental disorders—osteopetrosis, osteogenesis imperfecta, etc.
  - Systemic disorders—reticuloendothelial diseases, Paget's disease, osteomalacia and severe anemia.
- **Localized skeletal disease**: Various cysts, odontomas, tumors, osteomyelitis, osteoradionecrosis in the local region, presence of impacted third molar, etc.

Anatomical Location

Rowe and Killey's classification:

- Fractures not involving the basal bone—are termed as dentoalveolar fractures.
- Fractures involving the basal bone of the mandible. Subdivided into following:
  - Single—unilateral
  - Double—unilateral
  - Bilateral
  - Multiple.

Dingman and Natvig classification by anatomic region (Fig. 33.4):

- Symphysis fracture (midline fracture).
- Canine region fracture.
- Body of the mandible between canine and angle.
- Angle region—triangular region bounded by the anterior border of the masseter to the posterosuperior attachment of the masseter.
- Ramus region—bounded by the superior aspect of the angle to two lines forming an apex at the sigmoid notch.

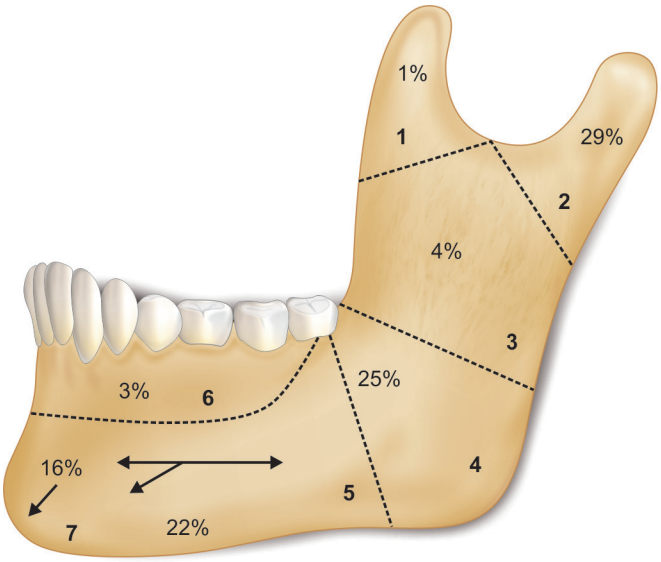


Fig. 33.4: Dingman and Natvig classification of mandibular fractures by anatomic region: 1. Coronoid process; 2. Condylar process; 3. Ramus region; 4. Angle region; 5. Body region; 6 Alveolar process; and 7. Symphysis region

F. Coronoid region.
G. Condylar fractures.
H. Dentoalveolar region.

Relation of the Fracture to the Site of Injury

- Direct fractures
- Indirect (contrecoup) fractures.

Completeness

Complete and incomplete fractures.

Depending on the Mechanism

- Avulsion fracture
- Bending fracture
- Burst fracture
- Contrecoup fracture
- Torsional fracture.

Number of Fragments

Single, multiple, comminuted, etc.

Involvement of the Integument

- Closed or open fractures
- Grades of severity I to V.

Shape or Area of the Fracture

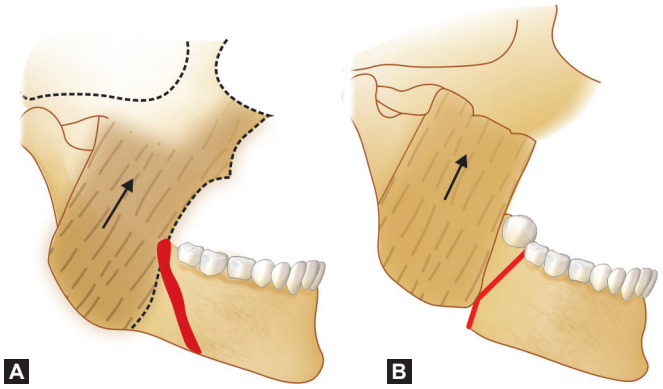
Transverse, oblique, butterfly, oblique surfaced.

According to the Direction of Fracture and Favorability for Treatment

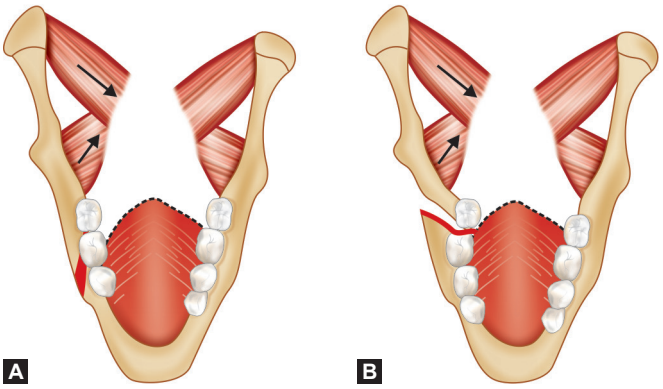
- Horizontally favorable fracture
- Horizontally unfavorable fracture
- Vertically favorable fracture
- Vertically unfavorable fracture.

This classification is aimed towards the angle fractures. Here, the direction of fracture line is important for resisting the muscle pull. When the muscle pull resists the displacement of the fragments, then the fracture line is considered as favorable. If the muscle pull distracts the fragments away from each other, resulting in displacement, then the fracture line is considered as unfavorable **(Figs 33.5 and 33.6)**.

The elevator group of muscles exerts an upward, forward and medial pull, while depressor group of muscles exert a downward and backward pull in an intact mandible. Whenever there is a break in the continuity at the angle region, then these two muscle groups loose their coordinated movements and have independent action.



Figs 33.5A and B: (A) Horizontally favorable line of fracture at the angle of the mandible; (B) Horizontally unfavorable line of fracture at the angle of the mandible



Figs 33.6A and B: (A) Vertically favorable line of fracture through the right angle of the mandible; (B) Vertically unfavorable line of fracture through the right angle of the mandible

In unilateral angle fracture, posterior ramus fragment is the lesser fragment, while the body of the mandible bearing the teeth becomes the greater fragment. The greater fragment's position is stabilized to certain extent by the occlusion of the teeth, while posterior ramal fragment can show displacement independently.

Here, the direction of the fracture line is responsible for resisting the muscle pull. When the mandible is viewed from the horizontal plane or studied by taking oblique lateral view mandible radiograph, then whether it is *horizontally favorable or unfavorable* line is decided.

- When the fracture line passes from the alveolar margin, downward and forward, then upward displacement of the posterior fragment is prevented by physical obstruction caused by the body of the mandible. Hence, such a fracture line is termed horizontally favorable.

- On the other hand, if the line of fracture passes downward and backward, then the upward movement of the posterior fragment is unopposed. This type of fracture is termed horizontally unfavorable. Sometimes the upward displacement can be prevented by the presence of a tooth on the posterior fragment, which comes into contact with maxillary tooth.
- When the angle fracture is viewed from above, or from the occlusal surface (in the vertical plane), then the buccolingual direction of the fracture line can be studied. Here, the displacement of the posterior fragment can be noticed in the medial direction due to the spasm of medial pterygoid and mylohyoid muscle. Here, the fracture line which passes from the outer or buccal plate obliquely backward and lingually, will tend to resist the muscle pull mentioned above and is thus termed a vertically favorable type of fracture.
- When the fracture line passes from the inner or lingual plate obliquely backward and buccally, inward movement of the posterior fragment will take place as a result of the medial pterygoid muscle pull. This type of fracture is termed vertically unfavorable.

This classification is of clinical importance for the treatment planning and fixation, the amount of displacement can be judged and the type of fixation device can be chosen.

According to Presence or Absence of Teeth in Relation to the Fracture Line

It is very essential to note the presence or absence of teeth in relation to the fracture line, also the periodontal status, as well as teeth size for planning fixation method. Dentition can be used as the guide for reduction procedure and also can be used for fixation and immobilization. In edentulous patients occlusal guidance is lost. Similarly in deciduous dentition, or mixed dentition, special splints need to be constructed as a "fixation or immobilization" device.

Kazanjian and Converse Classification

Class I: When the teeth are present on both sides of the fracture line.

- An adequate number of teeth of suitable shape and stability. Wiring—direct, continuous or multiple loop or interdental eyelet type, use of prefabricated arch bars.
- An inadequate number of teeth, whose shape or stability is unsuitable.

Lateral compression splint, arch bars, or cast metal cap splints.

Class II: When the teeth are present only on one side of the fracture line.

- Short edentulous posterior fragment
  - If favorable, immobilization of main fragment by interdental wiring or arch bars. Minor displacement can be accepted.
  - If unfavorable—open reduction with direct fixation is a must.
- Long edentulous posterior fragment
  - Without displacement—requires conservative treatment
  - With vertical and medial displacement—requires open reduction and fixation.

Class III: When both the fragments on each side of the fracture line are edentulous.

- Simple or compound fracture without much displacement in the body region—simple gunning type splints.
- Simple fractures which are unfavorable. Open reduction and fixation.
- Compound fractures—surgical intervention.

AO Classification (Relevant to Internal Rigid Fixation)

- F : Number of fracture or fragments
- L : Location (site) of the fracture
- O : Status of occlusion
- S : Soft tissue involvement
- A : Associated fractures of the facial skeleton

Such a classification is helpful in terms of:

- Patient selection and treatment planning
- Evaluation of therapeutic results
- Comparison of different treatment methods
- Information and communication.

These criteria can be objectified clinically and radiographically:

- F : Number of fracture
  - F0 : Incomplete fracture
  - F1 : Single fracture
  - F2 : Multiple fracture
  - F3 : Comminuted fracture
  - F4 : Fracture with a bone defect
- Categories of localization (site) L1–L8
  - L1 : Precanine
  - L2 : Canine
  - L3 : Postcanine
  - L4 : Angle
  - L5 : Supra-angular
  - L6 : Condyle

Fracture Formula

Right hemimandible		*Left hemimandible*		
FLO example		FLO		
Fracture category	Localization	Occlusion	Soft tissue	Associated fractures
FO	L1	O0	S0	A0
Incomplete fracture	Precanine	Normal occlusion	Closed	None

L7 : Coronoid
L8 : Alveolar process

- Category of occlusion: O0–O2
  O0 : No malocclusion
  O1 : Malocclusion
  O2 : Nonexistent occlusion: Edentulous mandible
- Categories of soft tissue involvement: S0–S4
  The risk of infection and healing depends on the condition of the soft tissues surrounding the fracture.
  S0 : Closed
  S1 : Open intraorally
  S2 : Open extraorally
  S3 : Open intra- and extraorally
  S4 : Soft tissue defect
- Categories of associated fractures A0–A6
  A0 : None
  A1 : Fracture and/or loss of tooth
  A2 : Nasal bone
  A3 : Zygoma
  A4 : LeFort I
  A5 : LeFort II
  A6 : LeFort III

Grades of Severity: I–V

- Grade I and II are closed fractures
- Grade III and IV are open fractures
- Grade V open fracture with a bony defect (gunshot).

Points to Remember

- Applied anatomy of the mandible
- Mandibular fractures-various classifications and clinical importance.

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CHAPTER 34 Management of Mandibular Fractures

INTRODUCTION

Mandibular fractures are common, because of its prominence and relative lack of support. The first description of mandibular fracture was as early as 1650 BC, when an Egyptian papyrus wrote the examination, diagnosis and treatment of mandibular fractures. Hippocrates was the first to describe reapproximation and immobilization via the use of circumdental wires and external bandaging. Since these earlier times the treatment modalities have changed. Many fractures previously treated with the closed reduction or open reduction with wire synthesis are now commonly treated with open reduction with plate and screw fixation.

MANDIBULAR FRACTURES IN CHILDREN

Incidence of facial fracture is less than 2% prior to 5th year of life. However, mandibular fractures in children are most common. Total percentage of facial fractures is less in children, because of the following:

- Sheltered atmosphere, protection given to children
- Decreased facial mass and proportion
- Soft consistency of bone
- Pliable cancellous bone has got greater proportion with thin buccal and lingual plates
- Taut periosteum offers protective mechanism against fracture and its displacement
- **The factors to the child's advantage are as follows:**
  - Faster healing and early bony union. Excellent osteogenic and remodeling capacity
  - The ability for adaptation as the deciduous teeth are shed and permanent teeth erupt. Clinical symptoms are same as those of fractures of the lower jaw in the adult. Pain, swelling, malocclusion are the leading symptoms. Abnormal mobility, step deformity in the dental arch will be seen.

The radiographic examination is usually difficult in uncooperative child.

Conservative Therapy

Conservative therapy: Supervised spontaneous healing:

Greenstick fractures are self-retentive. In crack fractures or greenstick fractures with no malocclusion, there is no need for fixation. Closed reduction is simple and an attractive solution for them. Patient is advised to take lot of fluids and soft food for 10–14 days.

Conservative Treatment with Splints

Lateral compression splints: These are prepared and fixed to the mandibular body with circummandibular wiring (for the children with complete deciduous dentition or with mixed dentition).

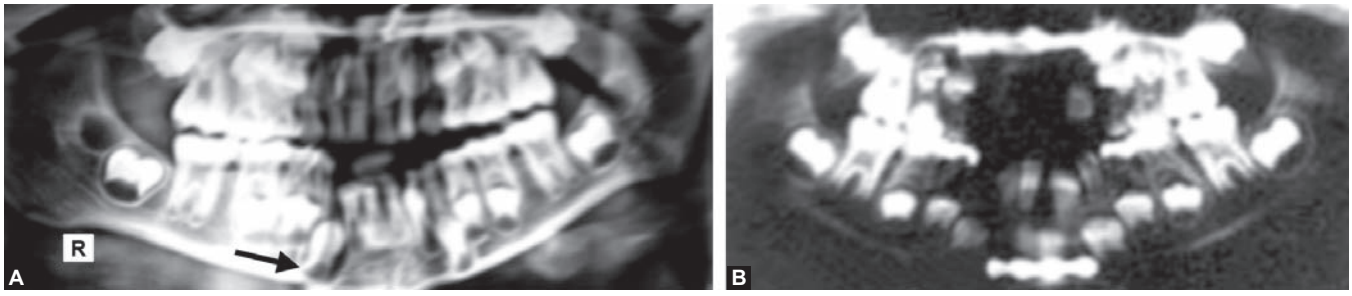
Open Reduction

Open reduction is not usually necessary. But, in multiple displaced fractures especially, at the angle and parasymphysis region, open reduction may be needed. Intraosseous wiring or bone plating should be done at the lower border of the mandible without damaging the developing teeth buds **(Figs 34.1A and B)**.

MANAGEMENT OF MANDIBULAR FRACTURES IN ADULTS

Closed Reduction

Most of the mandibular fractures can be treated by closed reduction. It is often advocated, because of its relative simplicity, low cost and noninvasive nature of treatment. A significant degree of displacement does not preclude the use of a closed reduction to repair a mandibular fracture.



Figs 34.1A and B: Minibone plating for a symphysis fracture in a child patient

The presence of teeth provides an accurate guide for reduction. Teeth may on occasion be brought into contact during reduction, yet be occluding incorrectly owing to lingual inclination of the fractured fragments. Whenever the occlusion is used as an index of accurate reduction, it is important to recognize any pre-existing occlusal abnormalities, such as anterior open bite, etc. Wear facets on the teeth, can provide valuable clues to previous contact areas **(Table 34.1** and **Figs 34.2A and B)**.

Table 34.1: Management of mandibular fractures

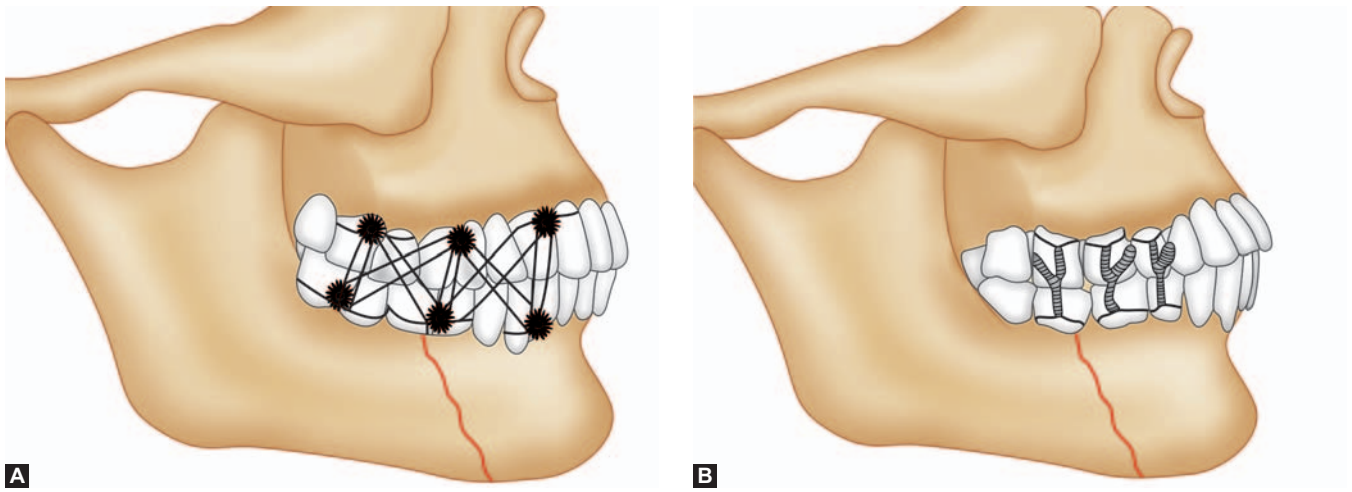
1844	Erich and Austin	Preantibiotic era, closed reduction
1847	Buck	Transosseous silver wiring
1943	Gordon	Wire suturing, stainless steel intraosseous wiring plus maxillomandibular fixation (MMF)
1970	Spiessel	AO/ASIF—compression plate
1973	Michelet	Noncompression monocortical screws with miniplate system
1978	Champy	Ideal osteosynthesis lines

Indications

- Nondisplaced favorable fracture
- Grossly comminuted fractures
- Severely atrophic edentulous mandible
- Lack of soft tissue overlying the fracture site
- Fractures in children with developing teeth buds
- Coronoid process fractures.

In closed reduction procedure, either dental wiring or arch bars are applied to individual dental arches and satisfactory occlusion is gained after reduction and intermaxillary fixation (IMF) is carried out. The recommended immobilization period for mandibular fractures correlates with the bony callus stage of secondary bone healing. The average recommended immobilization period for mandibular fractures is 6 weeks. In old age in edentulous mandibular fractures, a longer period of IMF is required.

In edentulous patients, Gunning type of splint can be used. Many times in mandibular body fractures, there is no need for IMF, only horizontal type of fixation will be



Figs 34.2A and B: (A) Closed reduction for mandibular body fracture; (B) Intermaxillary fixation (IMF) with Gilmer's wiring after closed reduction of the body mandibular fracture

sufficient. Risdon's horizontal wiring, Erich's arch bar fixation with additional figure-of-eight wiring for adjoining teeth at the fracture site will give adequate fixation. Cap splints can be constructed whenever possible. Lateral compression splint also is of help in some of the cases, where enough number of teeth are not present for adequate fixation. This type of conservative closed reduction without closing the patient's mouth is very rewarding for the patient.

Advantages of Open Reduction and Direct Fixation

- Reduction and fixation is done under direct vision
- Stable fixation is achieved by better approximation of fractured fragments.

Indications for Open Reduction

Open reduction of mandibular fractures previously was reserved for displaced fractures in the angle and nontooth-bearing regions of horizontal mandible. But with the advent of antibiotic era and improved fixation methods, a new paradigm has emerged. Open reduction and rigid or stable fixation may be indicated as the procedure of first choice, when one or all of the following conditions are present:

- Displaced unfavorable fractures
- Multiple fractures
- Associated midface fractures
- Associated condylar fractures
- When IMF is contraindicated or not possible
- To preclude the need for IMF for patient comfort
- To facilitate the patient's early return to work.

Contraindications for Open Reduction

Open reduction may be contraindicated, when:

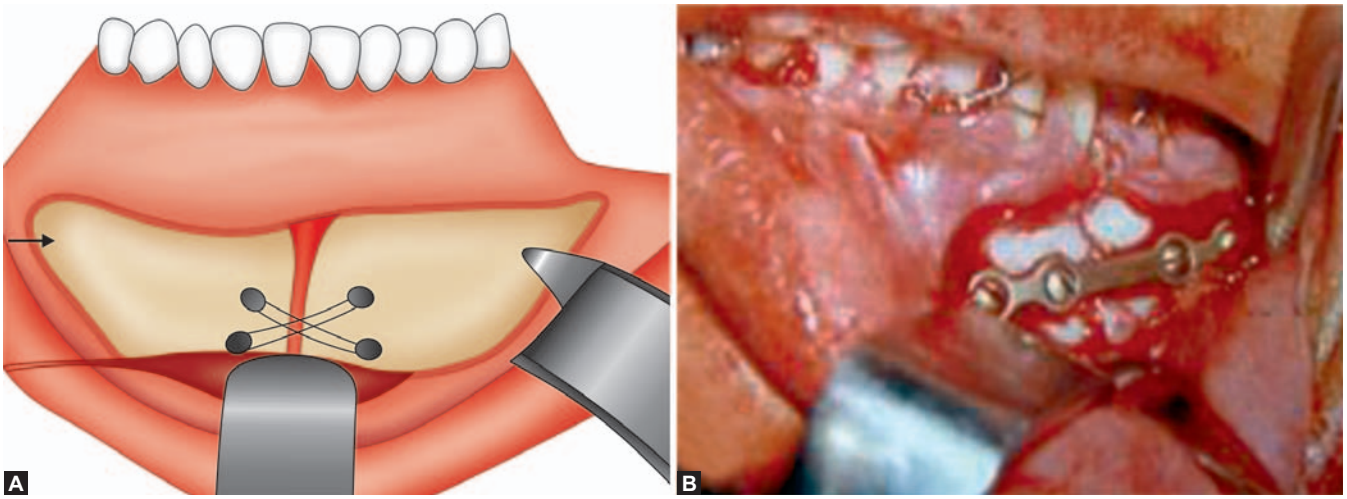
- General anesthesia or a more prolonged procedure is not advisable
- Severe comminution with loss of soft tissue
- Gross infection at the fracture site
- Patient refusing open reduction.

SURGICAL APPROACHES TO THE MANDIBLE

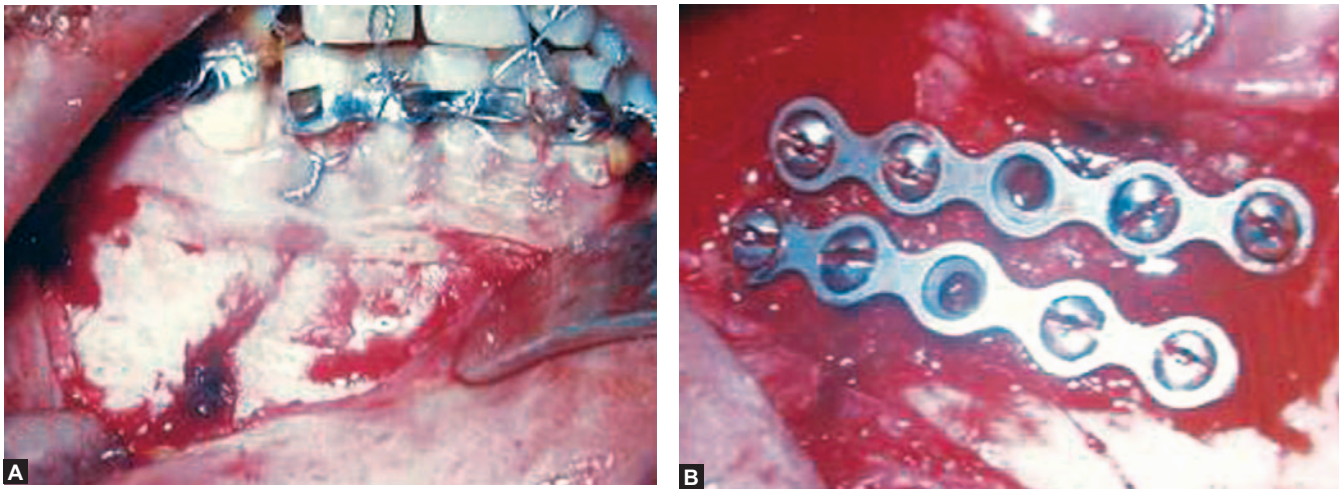
Adequate exposure of a fracture site allows anatomic reduction of the fragments and proper placement of the hardware. Proper incision design allows adequate access to the fractured mandible with minimum morbidity. In some instances, lacerations provide direct access to the fractured mandible **(Figs 34.3 to 34.13).**

Intraoral Approach: Symphysis and Parasymphysis Region

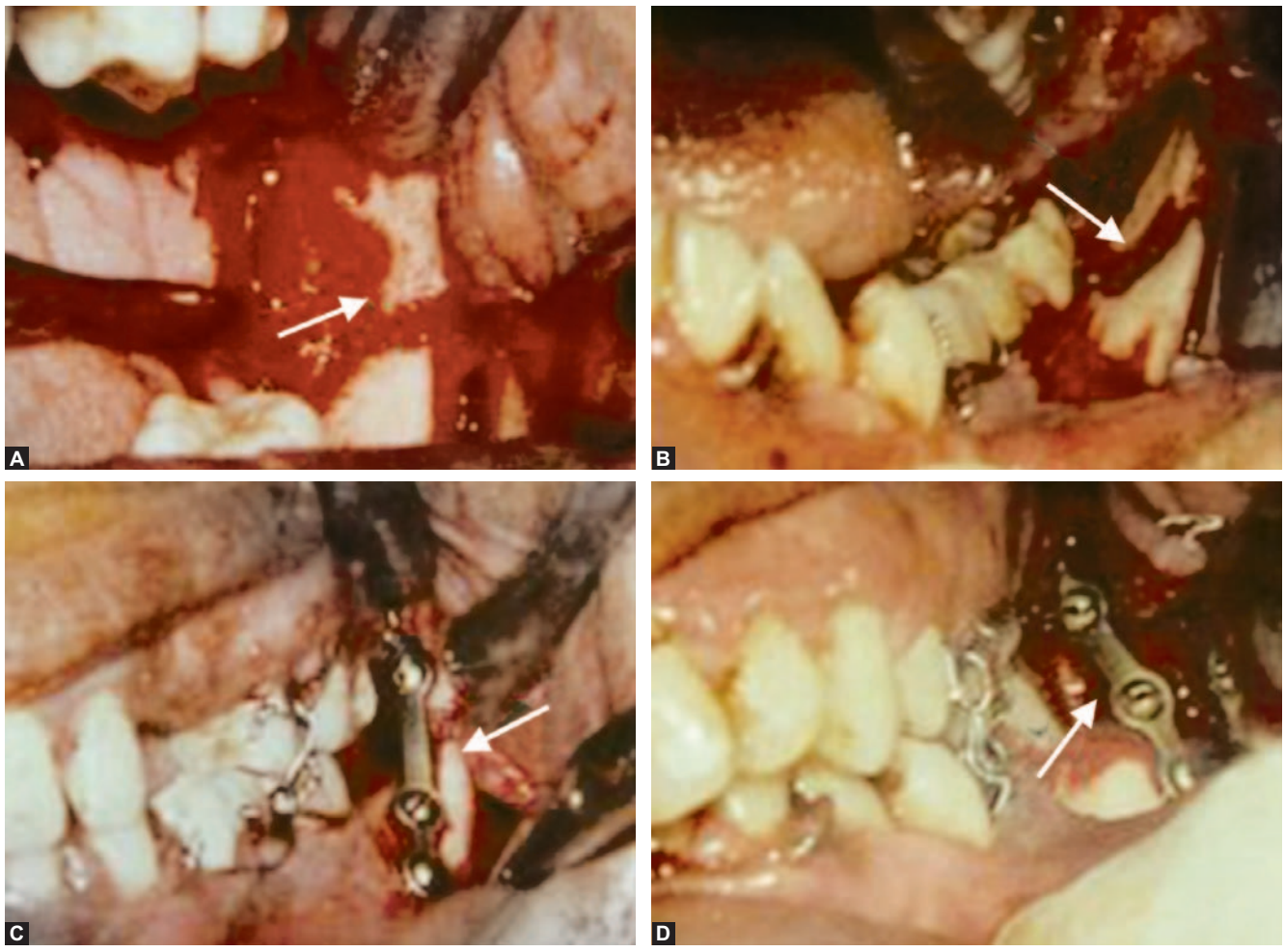
Termed as anterior, vestibular approach or "degloving incision". The lower lip is everted and an incision is created at the depth of the vestibule in the mucosa with a scalpel or electrocautery. Incision is curvilinear and extends anteriorly into the lip. The mentalis muscle will be visible and the fibers are divided in an oblique fashion, leaving a margin of the muscle attached to the bone for closure. The periosteum is divided and a subperiosteal dissection is done to identify the mental nerves.



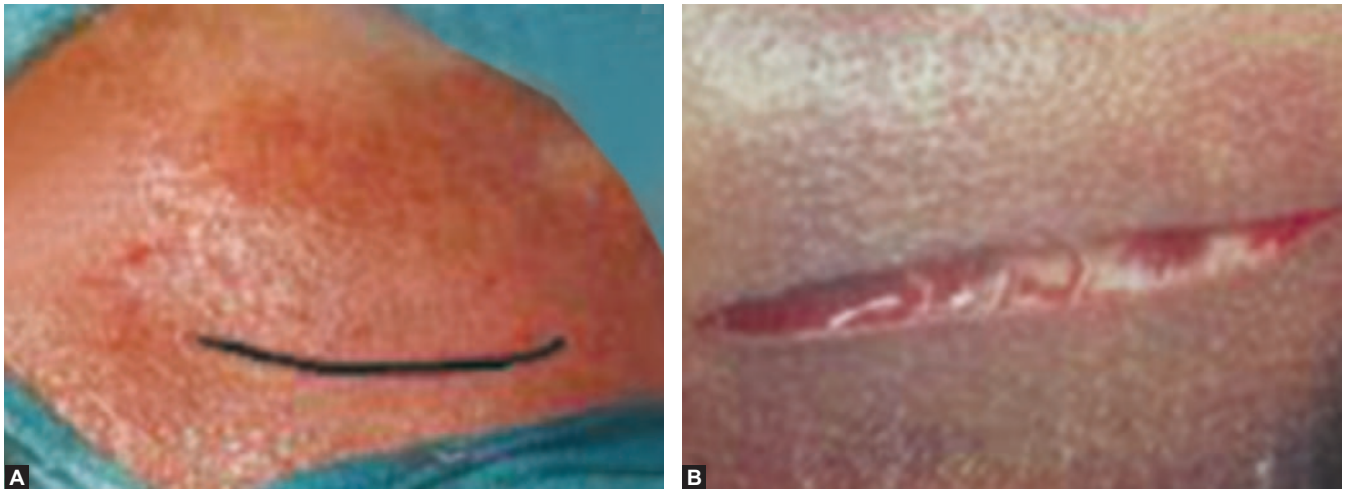
Figs 34.3A and B: (A) Degloving incision for open reduction of body fractures of the mandible; (B) Minibone plating for L parasymphysis fracture fixation via intraoral degloving incision



Figs 34.4A and B: (A) Right parasymphysis fracture reduction via intraoral degloving incision. Temporary intermaxillary fixation (IMF) is done to hold the fragments in position; (B) Double bone plating done to withstand the torsional forces in symphysis region. IMF is released after bone plate fixation



Figs 34.5A to D: (A and B) Reduction of left angle fracture mandible through intraoral transbuccal incision. Fracture fragments brought into approximation and temporary IMF done; (C and D) Bone plate fixation done.



Figs 34.6A and B: Submandibular Risdon's incision

Reduction and bone plate fixation is done. Closure is completed in layers. A pressure dressing is secured to the area to prevent hematoma formation and maintain the position of the mentalis muscle **(Figs 34.4A and B).**

Intraoral (Body, Angle, Ramus Region): Transbuccal Incision

Dissection in this region begins with a mucosal incision, which is started with a scalpel or electrocautery, 3–5 mm below the mucogingival junction. The incision is created perpendicular to the bone to avoid the mental nerve and it extends over the external oblique ridge. The level of the incision at the external oblique ridge should not be carried superior to the mandibular occlusal plane to avoid herniation of the buccal fat pad. The incision is carried through the periosteum and a subperiosteal dissection is performed. Periosteal elevator is used to expose the lateral border of the ramus. L-shaped retractors can be used during the procedure. To protect the facial nerve, facial artery and vein, the dissection should not violate the periosteal envelope. Reduction and fixation is done. Closure is completed in one layer **(Figs 34.5A to D).**

Extraoral Submandibular Risdon's Incision

This incision is used to access the mandibular ramus, angle and posterior body **(Figs 34.6A and B).** Patient is prepared and draped in routine surgical manner. Important landmarks—the corner of the mouth and the eyeglobe must be visible. Head of the patient is turned sideways. The incision is marked 2 cm below the inferior

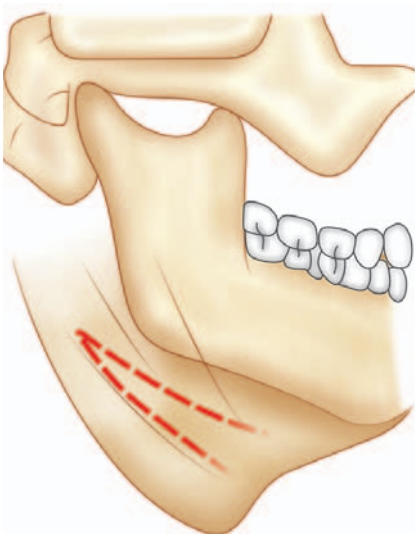


Fig. 34.7: Extraoral incisions are planned following Langer's lines to give cosmetic scar

border of the mandible to avoid damage to the marginal mandibular branch of the facial nerve. Ideally the incision is placed in a relaxed skin tension line (the Langer's lines) **(Fig. 34.7)**. The skin and subcutaneous tissues are incised with a scalpel down to the level of the platysma, and undermining of the skin to allow improved retraction is accomplished with scissors. The platysma is then sharply divided exposing the superficial layer of the deep cervical fascia. The plane of the dissection is carried out through this layer over the superior surface of the submandibular gland. The facial artery and vein are identified **(Fig. 34.8)**.

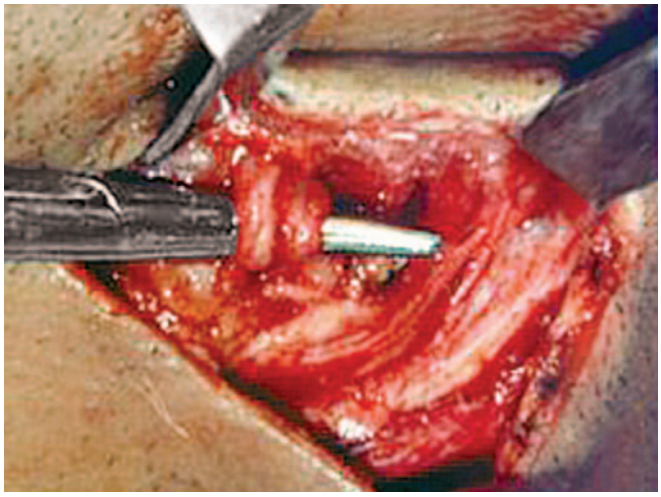


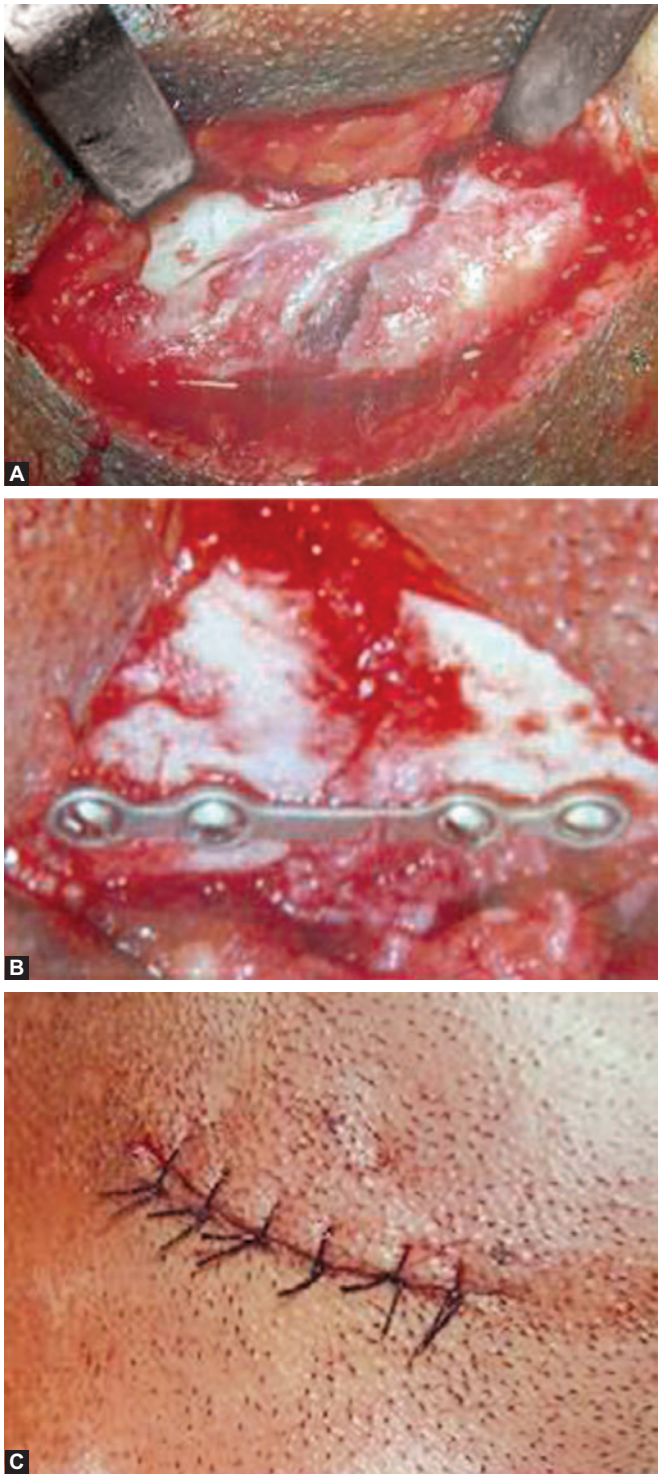
Fig. 34.8: Submandibular incision. Facial artery and vein exposed during dissection, which will be cut and ligated

They are clamped, divided and ligated. The dissection continues towards the mandible, exposing the pterygomasseteric sling posteriorly. Division of this layer is done to expose the inferior border of the mandible after cutting through the final periosteal layer. Subperiosteal dissection is performed anteroposteriorly and the desired area of the mandibular body, angle or ramus is accessed. The desired procedure is carried out. Closure is done in layers **(Figs 34.9A to C)**.

Transosseous Wiring (Intraosseous Wiring)

Direct wiring across the fracture line is an age old and effective method of fixation of jaw bone fractures. Transosseous wiring can be done through intraoral or extraoral approach. In principle, holes are drilled in the bony fragments on either side of the fracture line, after which a length of 26-G stainless steel wire is passed through the holes and across the fracture. After this initial preparation, the fracture must be reduced independently with the teeth in occlusion before the free ends of the wire are lightened and twisted. The twisted ends are cut short and tucked into the nearest drill hole. The single strand wire fixation in this horizontal manner is the simplest form of fixation with intraosseous wiring. But this can be modified in various ways depending on the need. The variations of the basic technique will depend on the following:

- Position of fracture
- Muscle forces acting on the fragments
- Degree of comminution



Figs 34.9A to C: (A) Right angle fracture opened via extraoral submandibular incision; (B) Bone-plate fixation done (C) Interrupted suturing done

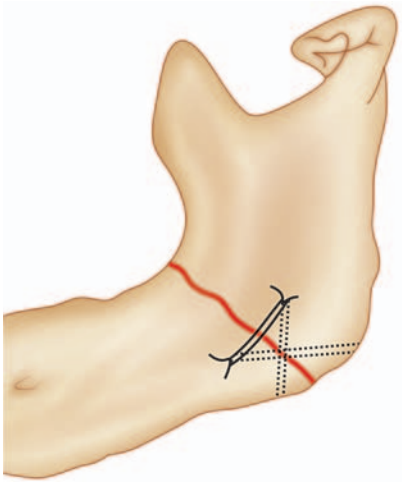


Fig. 34.10: Hayton-William's figure-of-eight transosseous wiring

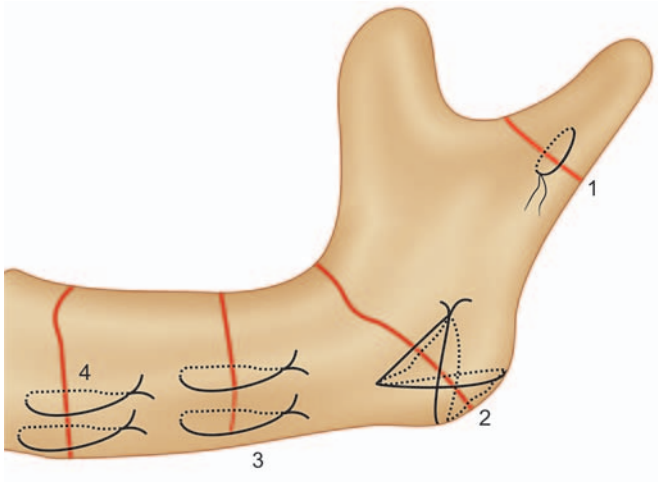


Fig. 34.11: Intraosseous or transosseous wiring (1) For fixation of subcondylar fracture; (2) For fixation of angle fracture; (3 and 4) For fixation of parasymphysis fractures

- Number of fragments to be fixed
- Nature of the fracture line—oblique, straight, etc.

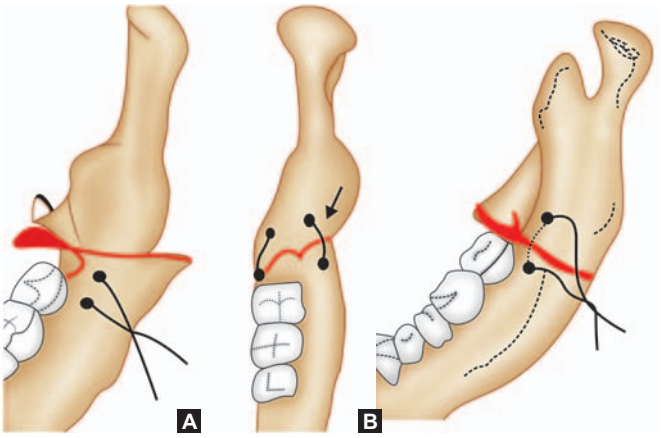
The variations can be two-hole, four-hole, three-hole technique. Obwegeser's figure-of-eight wiring, Hayton-William's modification of figure-of-eight wiring, etc **(Fig. 34.10)**. These variations are mainly used at the inferior border of the mandible through extraoral incision **(Fig. 34.11)**. The intraoral incision for fixation of transosseous wiring at the upperk border is chosen for the fractures at the angle with minimum displacement or for the edentulous areas of the body fracture.

Indications for extraoral incision with transosseous wiring at the inferior border:

- Unfavorable, grossly displaced fracture at the angle of the mandible
- Severe overriding of the fragments
- Triangular comminuted fracture at the inferior border associated with angle fracture
- Fracture of edentulous mandible
- Malunited fractures
- Nonunion of the fracture
- Fractures with large extraoral lacerations.

Intraoral Transalveolar or Upper Border (Superior Border) Wiring

It was first advocated by Sir William Kelsey Fry to control the posterior fragment by drilling a hole through the alveolar process of each fragment. Here, the wire is passed through the extraction socket of the third molar tooth, which

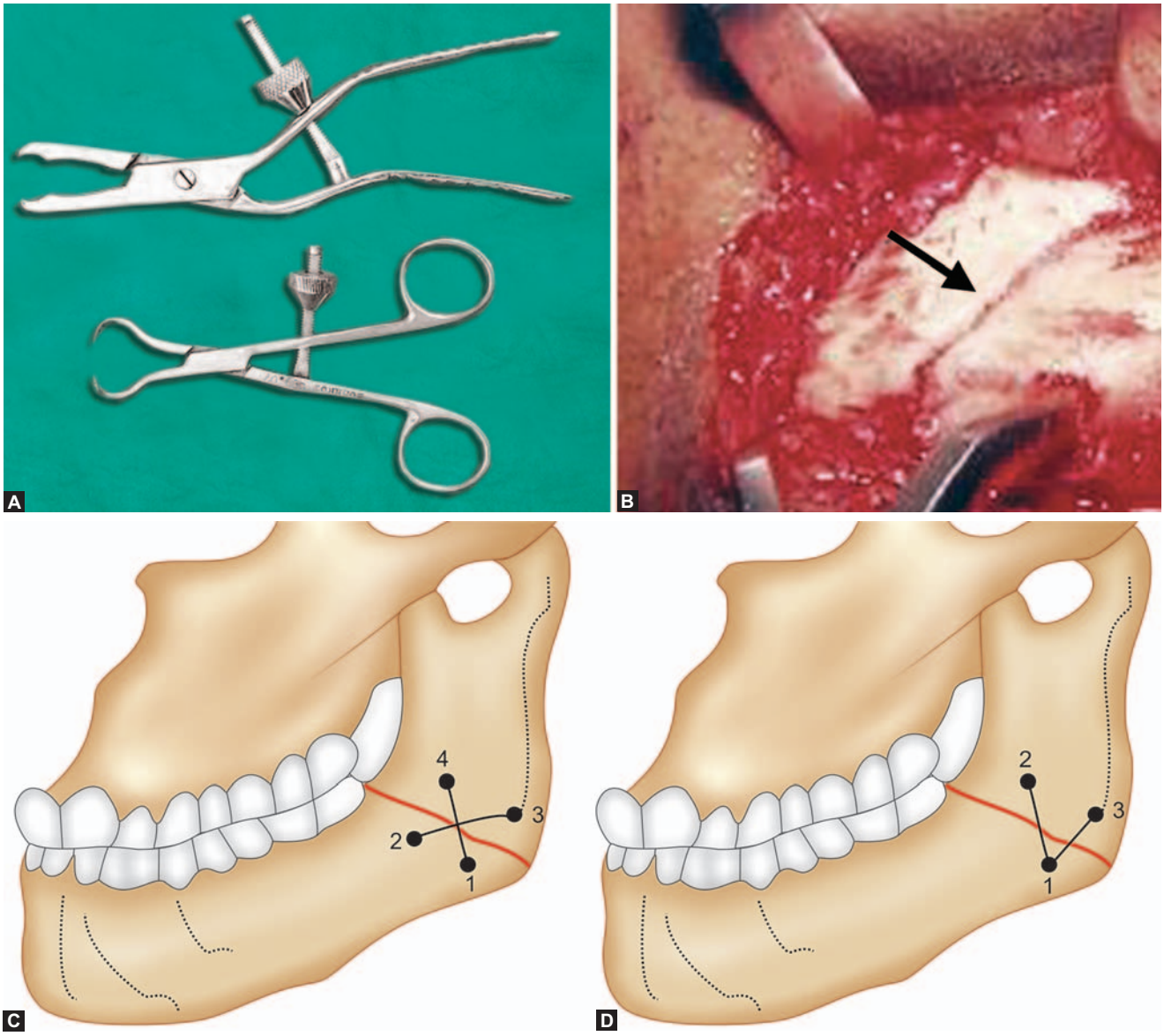


Figs 34.12A and B: Superior border transosseous wiring (intraoral). (A) Superior border wiring engaging both buccal and lingual cortices; (B) Superior border wiring engaging only buccal cortex

is invariably involved in the fracture line. Many times, simple loop through only the buccal plate may be adequate. But for better fixation both buccal as well as lingual plates of the alveolar process should be involved and the horizontal mattress type of wiring provides optimum stability. While drilling the holes on either side of the fractured fragments at the alveolar crest, one has to select the site for drilling the holes carefully, so that during final twisting, the thin alveolar bone should not get crumbled down. While drilling the hole on the lingual plate, protection of the lingual nerve should be done by placing periosteal elevator. This type of wiring is always combined with some form of IMF **(Figs 34.12A and B).**

Extraoral Lower Border (Inferior Border) Transosseous Wiring

Fractured fragments are exposed under direct vision through Risdon's incision **(Figs 34.10, 34.11 and 34.13).** After cutting through the pterygomasseteric sling and periosteal layer, the bony fragments are located. The periosteum and tissues on the medial surface are also stripped from the bone for a distance of one centimeter. The end of each fragment is secured with bone-holding forceps (Crocodile bone-holding forceps, or Kocher's forceps, or Rowe's modified forceps, or Harrison's bone-holding forceps) and fractured fragments are brought into approximation by manipulating the bone-holding forceps **(Figs 34.13A and B)**. If some soft tissue is entrapped between the fragments or any other debris should be separated or removed. A flat ribbon retractor or tongue depressor is placed under the medial side at the inferior border to protect the underlying soft tissue structures. The entire area should be well exposed by using L-shaped



Figs 34.13A to D: (A) Bone holding forceps; (B) Fracture mandible reduced and fragments held in position using bone-holding forceps; (C and D) Transosseous wiring procedure with its variations

retractors at the upper edge of the incision. The holes should be drilled using small round bur with electrical engine and handpiece with constant irrigation of saline solution **(Fig. 34.13C)**. The first hole should be drilled in the anterior fragment slightly away from the inferior border (No. 1) and at least 0.5 cm from the fracture site. The bur hole should be through and through the buccal and lingual cortex. Care should be taken that the hole should be drilled away from inferior alveolar nerve. If four-hole technique is to be used, then another hole (No. 2) is drilled above the first hole in the anterior fragment. The ribbon retractor is then repositioned under the posterior fragment. One hole is placed near the inferior border (No. 3) 0.5 cm from the fracture site. Another hole (No. 4) is placed as high as possible above the first one and just below the inferior alveolar canal. Two separate double wires of 26-G are cut and one wire is passed from No. 1 hole from buccal cortex to lingual cortex and passed at the posterior fragment to lingual cortex and brought out over buccal cortex from hole No. 4. Then another wire is passed from hole No. 2 and brought out from hole No. 3. Both these wire's ends are twisted individually in crisscross manner after approximating the fragments and ends cut and finished.

Before final tightening of the wires, the assistant should check the occlusion or temporary IML should be carried out. The wires are checked for their tightness and bone-holding forceps removed and fracture reduction is inspected. Wound closure is done in layers.

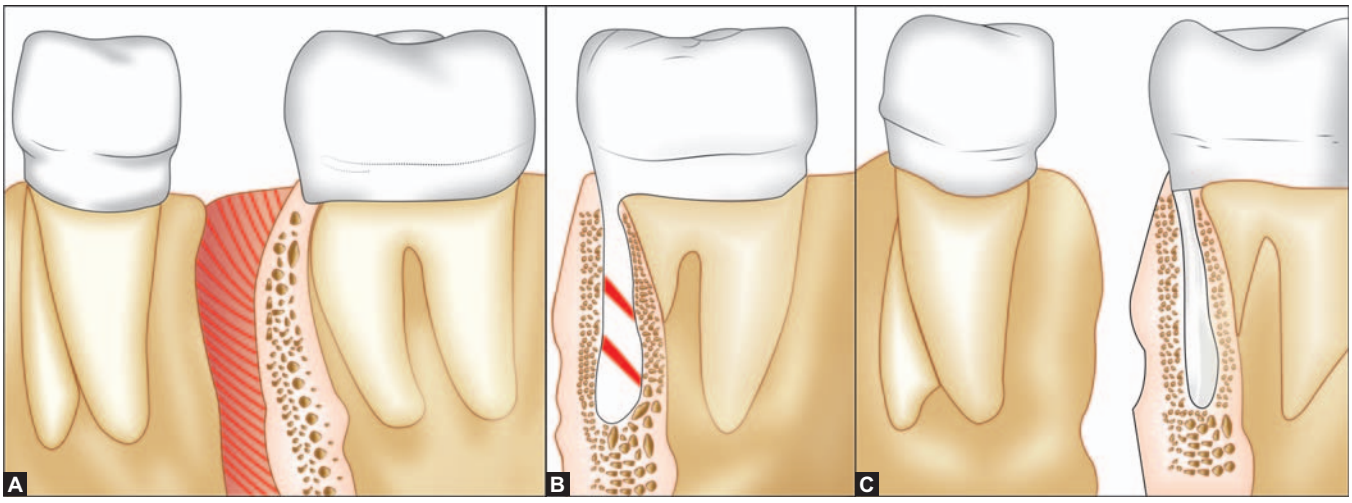
Temporary IML should be removed prior to extubation, if the procedure is done under GA. In the immediate postoperative period, no IML should be given. Next day IML can be done. The sutures should be removed on 5th–7th day. The stainless steel wires remain within the bone permanently and their removal is not necessary, since it is an inert substance and does not give rise to inflammation or irritation of the tissues, unless sepsis has been introduced.

Detached fragments of bone: During surgical procedure, detached portions of the cortical bone may be occasionally encountered, which was not obvious clinically as well as radiologically. Provided that they are attached to periosteum or muscle, they may be wired back into position.

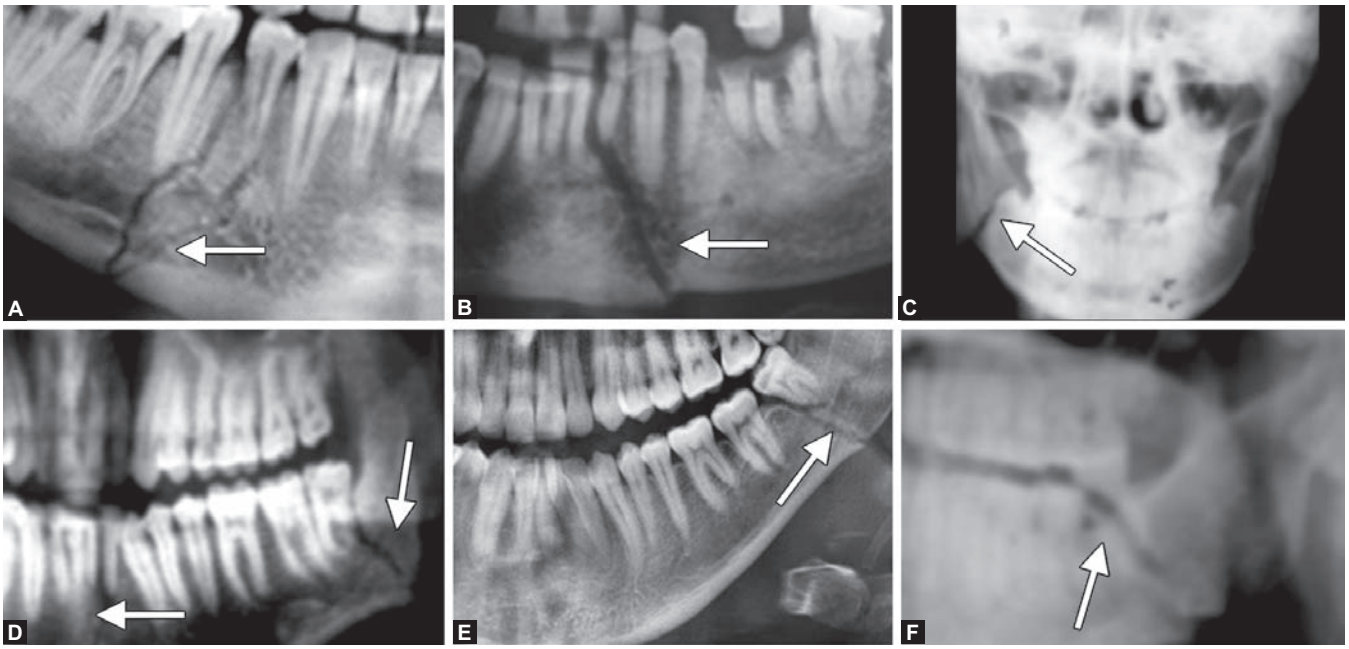
On the other hand, small portions of bone devoid of such attachments with loss of blood supply should not be retained, because they may lead to sequestration at a later date. Such pieces should be therefore removed. However, if a segment of bone removal will lead to a big defect between the bone ends which would lead to nonunion, then in such cases the bone should be replaced back and wired in position as a free graft.

Teeth in the fracture line (Figs 34.14 to 34.17): As per the old concepts teeth in the line of fracture, were considered as a potential impediment to healing for the following reasons:

- The fractures in the tooth bearing areas are always compounded via periodontal membrane.



Figs 34.14A to C: Teeth in the fracture line. (A) Completely enclosed teeth near the fracture line can be retained; (B) Teeth with the root fractures, which are exposed in the fracture line are extracted; and (C) Teeth with the exposed roots, devoid of bone encasement are extracted or preserved after root canal treatment



Figs 34.15A to F: Teeth in the fracture line: (A) OPG showing R parasymphysis fracture with broken root tip of first mandibular premolar and another fracture line near second premolar. Endodontic treatment of both the teeth is indicated after fracture reduction and plate fixation; (B) OPG showing parasymphysis fracture line passing between two mandibular incisors; (C) PA view showing R angle fracture involving impacted lower third molar, which should be removed at the time of reduction; (D and E) OPG showing L symphysis and angle fracture, involving L lateral incisor and L third molar, (F) OPG showing L side fracture mandible and root fracture of lower third molar,such a tooth should be extracted prior to fracture reduction

- Due to trauma the tooth can become nonvital
- The previous periapical pathology may be present.

The infection can reach the fracture line as a result of any of the above. This will complicate the healing or even lead to a nonunion. In preantibiotic era, therefore, all teeth in the line of fracture were extracted.

Presently, the protocol which is followed is—a tooth in the line of fracture which is structurally not damaged, not subluxated and in functional position in the dental arch should be retained and antibiotics administered.

Controversy also exists with regards to functionless third molars involved in mandibular fractures. If such a tooth helps in stabilizing the fracture, it should be retained **(Figs 34.14 to 34.17)**.

Management of teeth retained in fracture line

- Good quality intraoral periapical radiograph to assess the status and plan the treatment is needed
- Proper use of antibiotic therapy should be started
- Splinting of tooth, if luxated or mobile should be carried out
- Endodontic therapy is carried out, if necessary
- Immediate extraction, if fracture becomes infected.

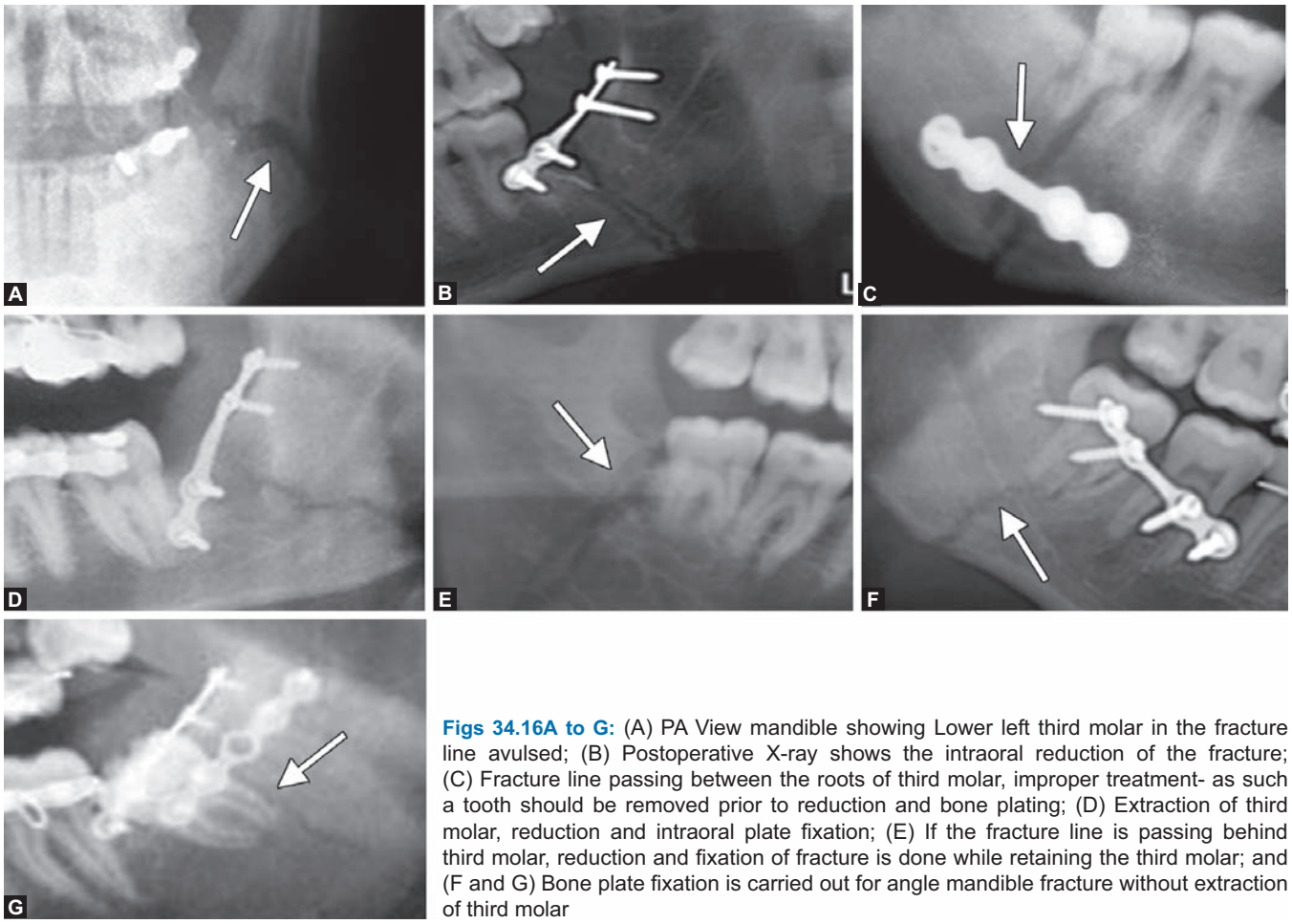
Absolute indications for removal of a tooth in the fracture line:

- Longitudinal fracture involving the crown and the root, splitting the tooth
- Complete subluxation of the tooth from its socket
- Pre-existing large periapical pathology
- Grossly infected fracture line
- Bad periodontal status of the tooth and third degree mobility due to periodontitis
- Functionless teeth
- Advanced caries
- Root stumps.

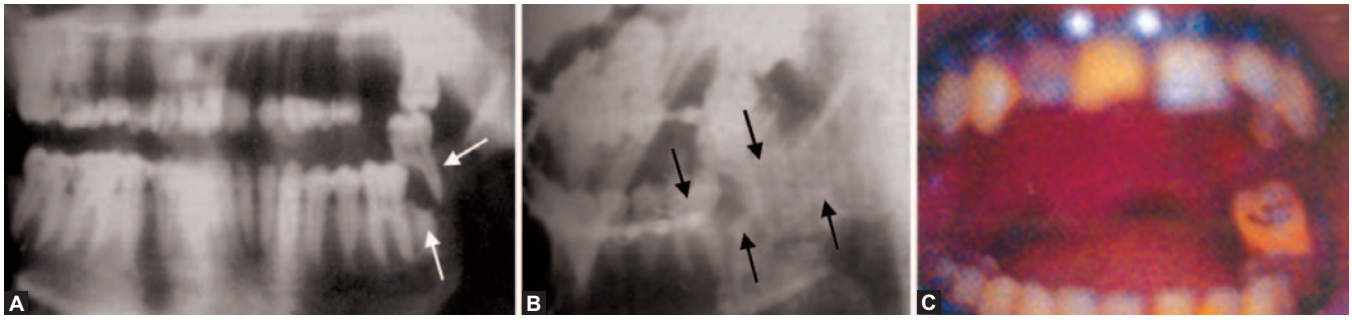
BONE PLATING IN MANDIBULAR FRACTURES

Advantages

- Rigid or stable fixation
- Obviates the need for immobilization of the mandible
- Early return to home and work



Figs 34.16A to G: (A) PA View mandible showing Lower left third molar in the fracture line avulsed; (B) Postoperative X-ray shows the intraoral reduction of the fracture; (C) Fracture line passing between the roots of third molar, improper treatment- as such a tooth should be removed prior to reduction and bone plating; (D) Extraction of third molar, reduction and intraoral plate fixation; (E) If the fracture line is passing behind third molar, reduction and fixation of fracture is done while retaining the third molar; and (F and G) Bone plate fixation is carried out for angle mandible fracture without extraction of third molar

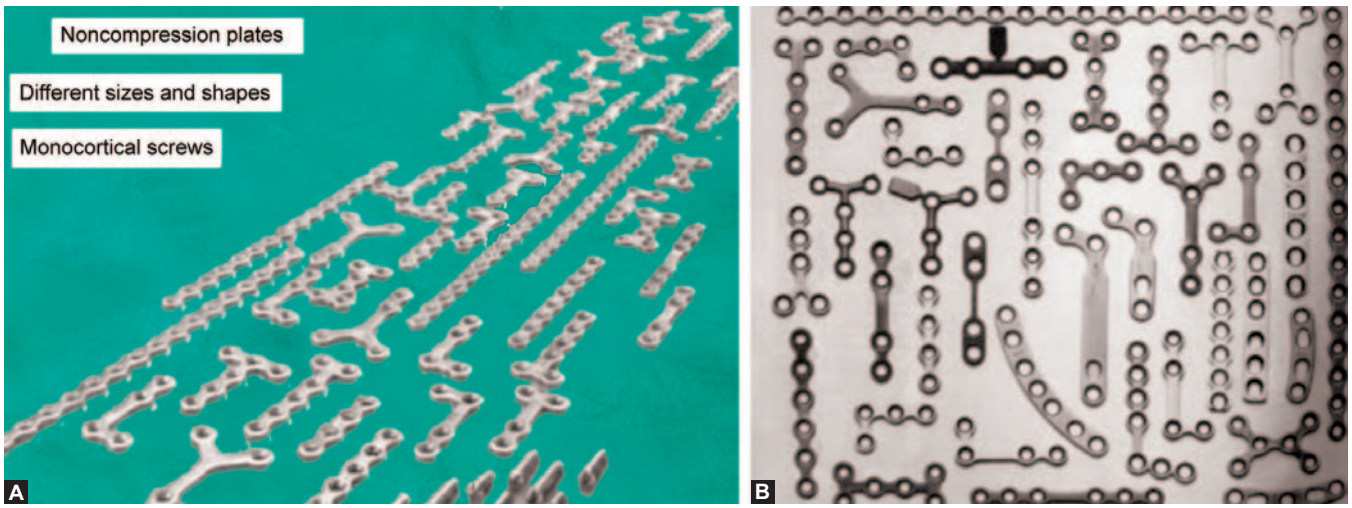


Figs 34.17A to C: (A) OPG showing Left side fracture mandible with the displacement of posterior fragment upwards and medially. Root fracture of second left lower molar is seen and the crown is in contact with upper second molar preventing further displacement of posterior fragment; (B) Lateral oblique view left side note the step deformity; (C) Intraoral picture showing the occlusal deformity

- Soft diet can be taken
- Maintenance of oral hygiene
- Useful in mentally challenged, physically handicapped patients
- Maintenance of airway in multiple fractures.

Simple Noncompression Bone Plates

Champy's system made up of stainless steel or titanium can be used with monocortical screws which are self-tapping. It is preferable to use screws 2 mm in diameter and 10 mm in length with titanium plates in order



Figs 34.18A and B: Different types of monocortical noncompression plates and screws

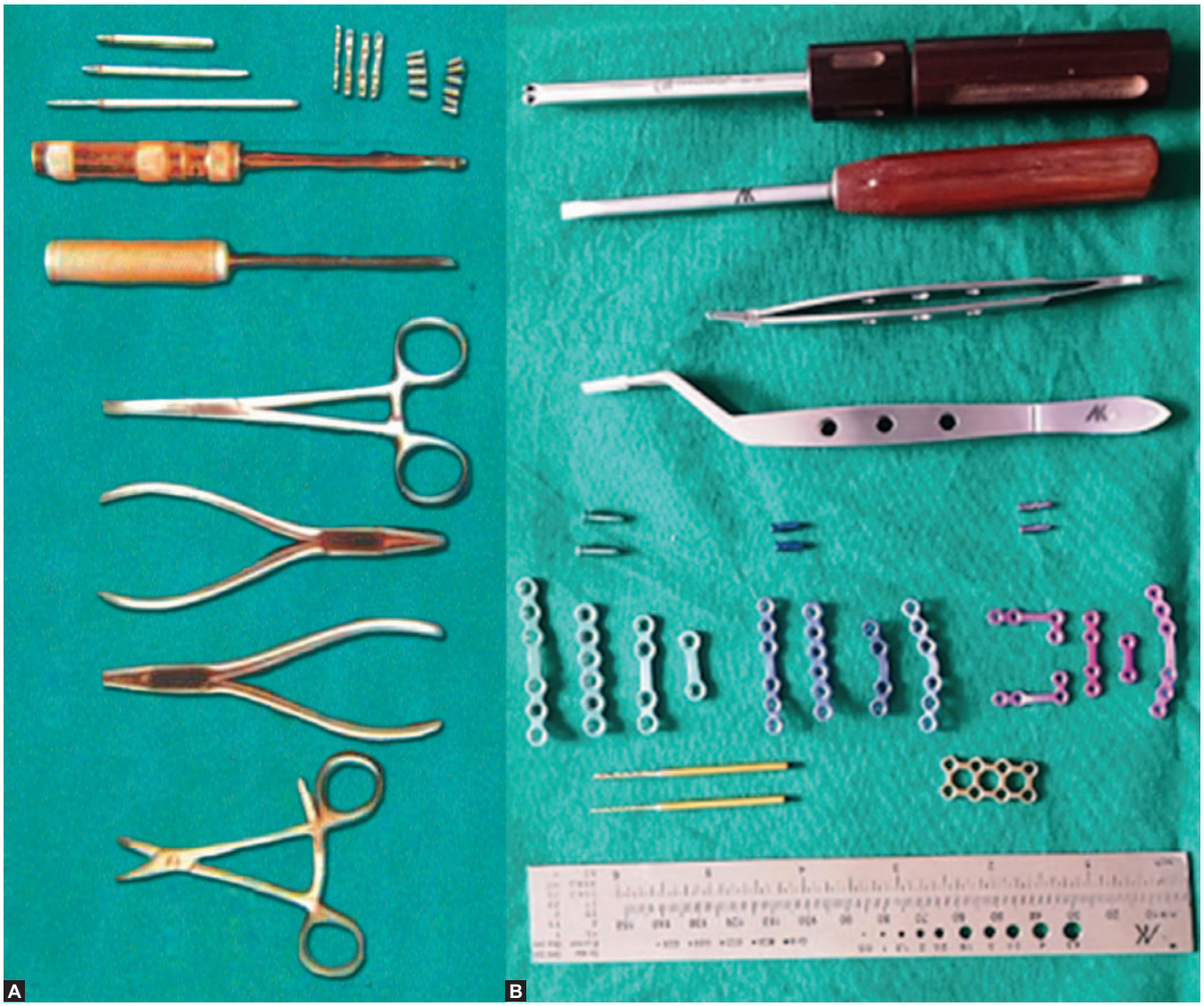
to improve the rigidity of the fixation. The plates are available in various sizes and shapes. Suitable selection of the plate should be done depending on the site and type of fracture to be fixed **(Figs 34.18A and B)**.

Miniplate Osteosynthesis

Instrumentation is shown in **Figures 34.19A and B.** For the adaptation of the plate to external cortex of the bone, a plate bending pliers and a plate bending lever is needed **(Fig. 34.20)**. The bending pliers allow the plate to be adapted over margins and surfaces by virtue of the special indentations in the plate. With the side cutting shears, the plates may be cut to the desired length. The screwdriver incorporates a spring lock device, so that the screws can be easily picked up from the screw rack and screwed into the mandibular bone. The tightening of the screw is finished with another small screwdriver. The screws and plates are made up of the same metal. The mechanical properties of the osteosynthesis material ensure that the induced tension and torsion forces are neutralized. In general, however, physiologic forces acting directly on the bone can be tolerated.

The plates available are—4 hole, 6 hole, 8–16 hole plates, in addition to 4–6 hole plates with an intermediate bar segment. The plates have a thickness of 0.9 mm. The minimum diameter of the hole is 2.1 mm with a bevel of 30 degree. Self-tapping conical screws are available in lengths of 5–15 mm. The screw thread has a diameter of 2 mm, one turn of the screw corresponds to 1 mm penetration into the bone. The diameter of the screw head is 2.8 mm, the counter sinking of the head corresponding to the 30° beveled drill hole in the plate. The drill which is used to prepare hole in the bone has a diameter of 1.6 mm and so is 0.4 mm smaller than the screws used. The difference of 0.4 diameter ensures firm anchorage of the self-tapping screws **(Fig. 34.21)**.

Application of miniplate osteosynthesis (Fig. 34.2*2):* Correct fracture fixation with miniplates is ensured in completely dentulous jaws as well as in edentulous jaws. As a rule, the approach is always intraoral, even in cases in which jaw injuries are compounded externally. In multiple mandibular fractures, the precise reduction and the establishment of occlusion is more difficult, hence it is advisable to secure the occlusion by interdental wiring, before the osteosynthesis is performed. In the edentulous jaw, manual reduction is generally sufficient. Following reduction, the osteosynthesis lines should be considered. The adaptation of the bone plate should be carried out by using bending pliers **(Fig. 34.20)**. The adapted bone plate should lie passively on the contour of the external cortex, without any gap between the plate and the bone. The plate is adjusted in such a way that minimum two screws can be fixed on either side of the fracture line. The drilling is then performed through the holes in the plate perpendicular to the surface of the bone. The miniplate is fixed in position with the screws. In the case of fractures of the angle of the mandible, the plate should be located on the posterior fragment, medial to the external oblique line, so that it is bent over the surface and the posterior screws are placed in a nearly sagittal direction. In certain cases—with simultaneous fractures of the alveolar process or when impacted wisdom teeth are present, the plate may be fixed



Figs 34.19A and B: Instruments set for minibone plate osteosynthesis

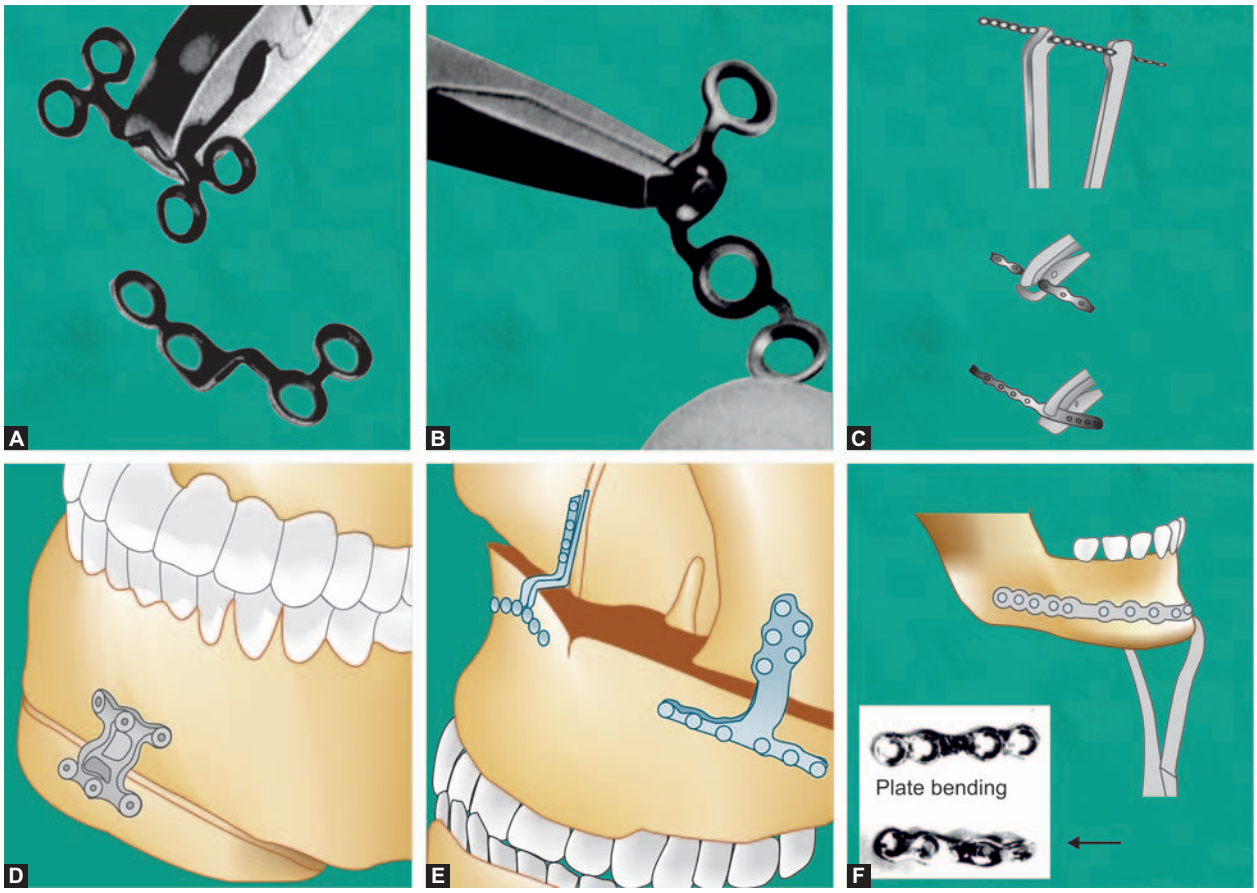
to the outer surface of the mandible corresponding in position to the course of the line of tension.

With fractures between the canine and premolars, the mental nerve may be damaged by the application of the plate. It is therefore advantageous to place the concave section of the plate between the screw holes precisely over the exit point of the nerve. In exceptional cases transposition of the nerve to a lower level may be indicated. To neutralize torsional forces in the symphysis region in between the mental foramina, it is necessary to use two parallel plates. The gap between them should be 4–5 mm. It is recommended that the lower plate be fixed first and the subapical plate to be fixed later. In the comminuted fractures or where there are detached triangular pieces of bone, longer plates with six or more screws should be used. In multiple fractures of the body of mandible, after reduction, the fragments are held firmly by temporary IMF. The osteosynthesis is performed first in the teeth bearing section of the jaw, e.g. in midline and angle fracture, the midline fracture is fixed first, this makes it easier to avoid malocclusion.

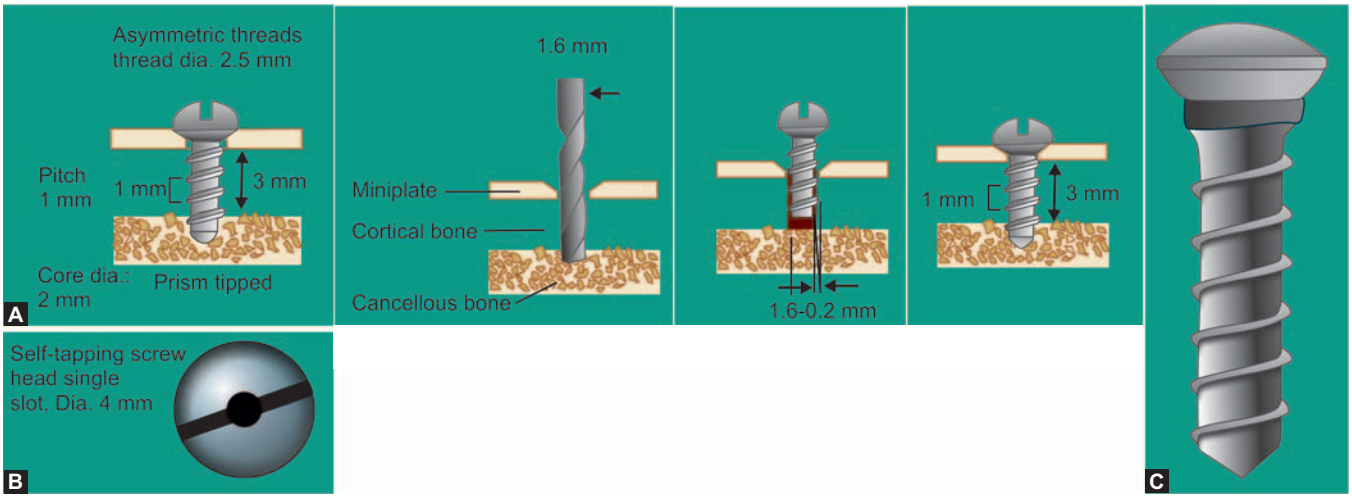
Complications and management:

Suture dehiscence: It is found if the surgery for osteosynthesis is delayed due to some reasons:

- Timing of surgery.



Figs 34.20A to F: Plate bending—using a plate bending plier and a plate bending lever to adapt to bone contour



Figs 34.21A to C: (A and B) Drill diameter is 1.6 mm, which is the same as the core diameter of the screw. The screw thread measures 2 mm across. The holes drilled should be monoaxial; (C) All screws are of self-tapping type, with a pitch of 1 mm. For average mandibular cortex thickness of 3 mm, three turns of the screw will provide adequate anchorage

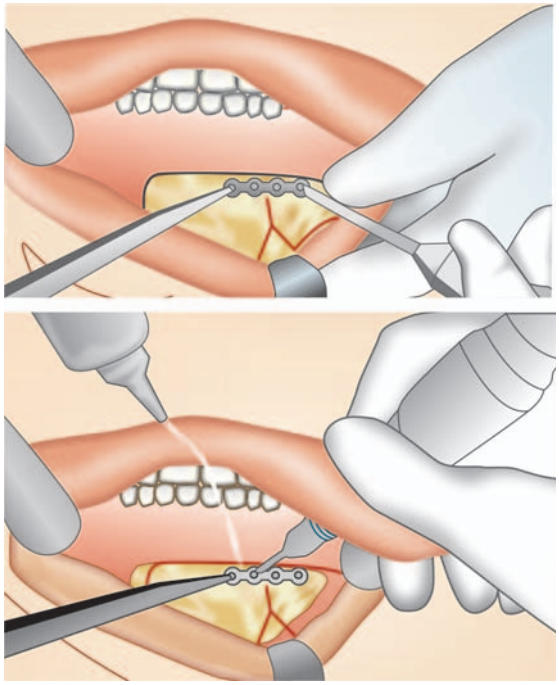


Fig. 34.22: Surgical procedure for the fixation of minibone plates and screws

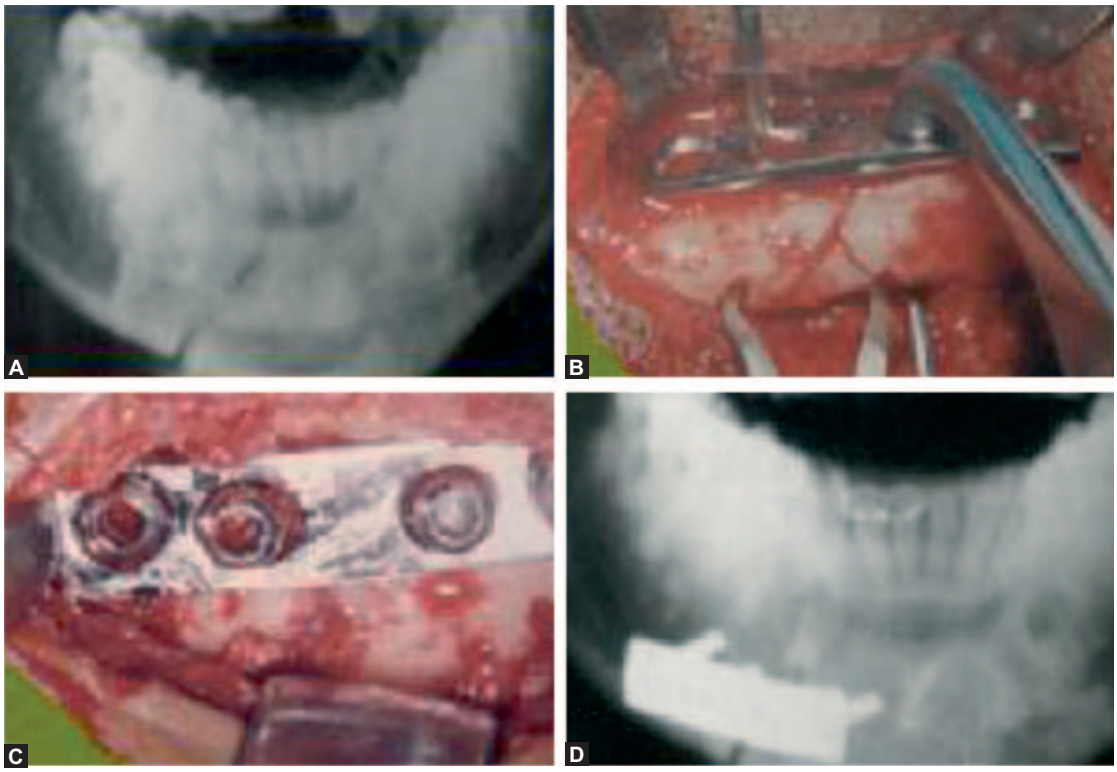
- Due to inappropriate incision in the region of the attached gingiva, on 4th or 8th postoperative day, the gap will be noticed. In such a case, the sutures are removed and cleaning of the wound with 15% hydrogen peroxide is done. Frequent mouthwashes are encouraged. Wound is allowed to heal with secondary intention.

Postoperative infection: This may be due to the following:

- Inadequate number of screws applied
- Incorrect placement of the bone plates, outside the osteosynthesis lines
- Proximity of the plates to the apical region
- Inadvertent placement of the screws in the teeth bearing area
- Lack of maintenance of oral hygiene postoperatively.

Compression Plates

Whenever the plate is applied to the convex surface of the mandible at its lower border, there is a tendency for the upper border and lingual plate to open up with the final tightening of the screws. This leads to distortion of occlusion as well as opening of the fracture line on the other side, in case of bilateral fractures. To overcome this problem and



Figs 34.23A to D: (A) Preoperative X-ray showing fracture line; (B) Extraoral open reduction— Compression bone plate adaptation and fixation after reduction; (C) Compression bone plate fixed with bicortical screws; (D) Postoperative X-ray showing rigid fixation

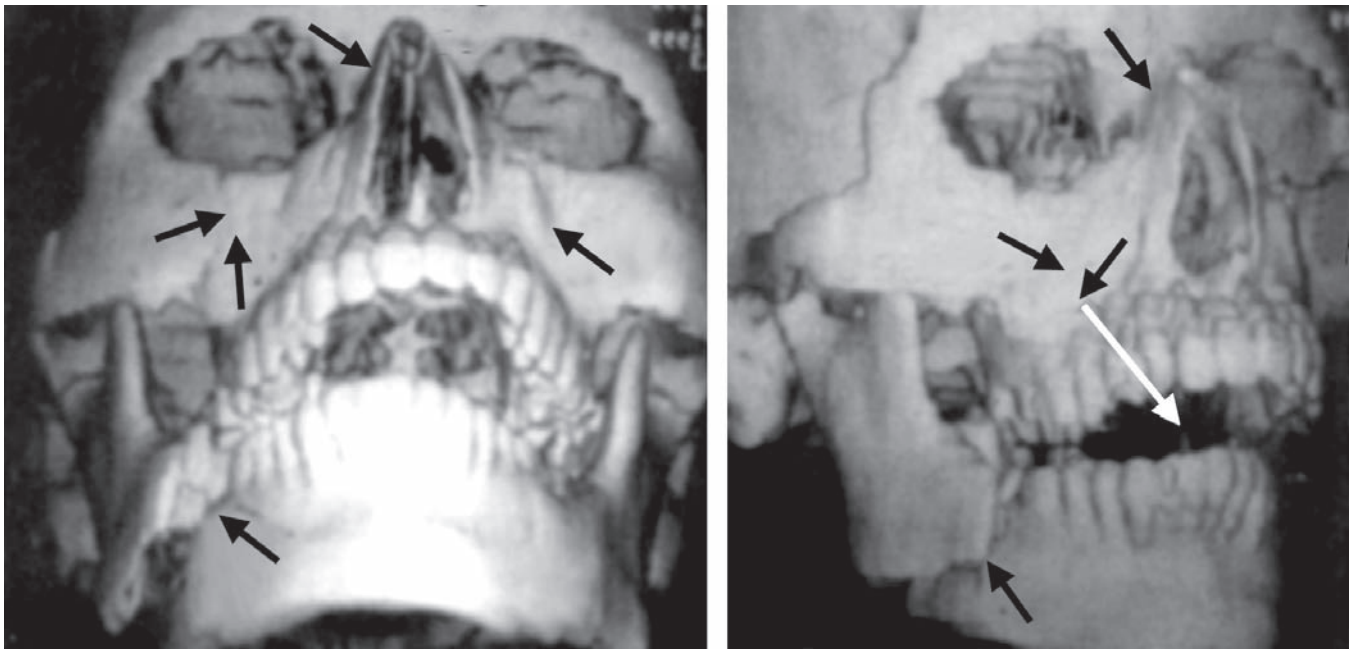


Fig. 34.24: Three-dimensional scan showing panfacial fractures. LeFort II, right zygomatic bone, nasal fractures are seen. Right angle mandibular fracture showing gross displacement with overriding of the fragments. Note the loss of occlusion with severe anterior open bite

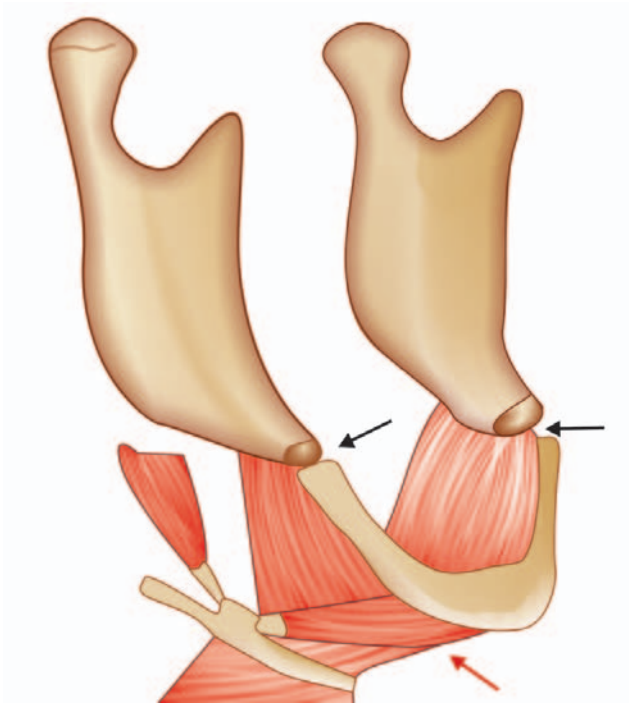
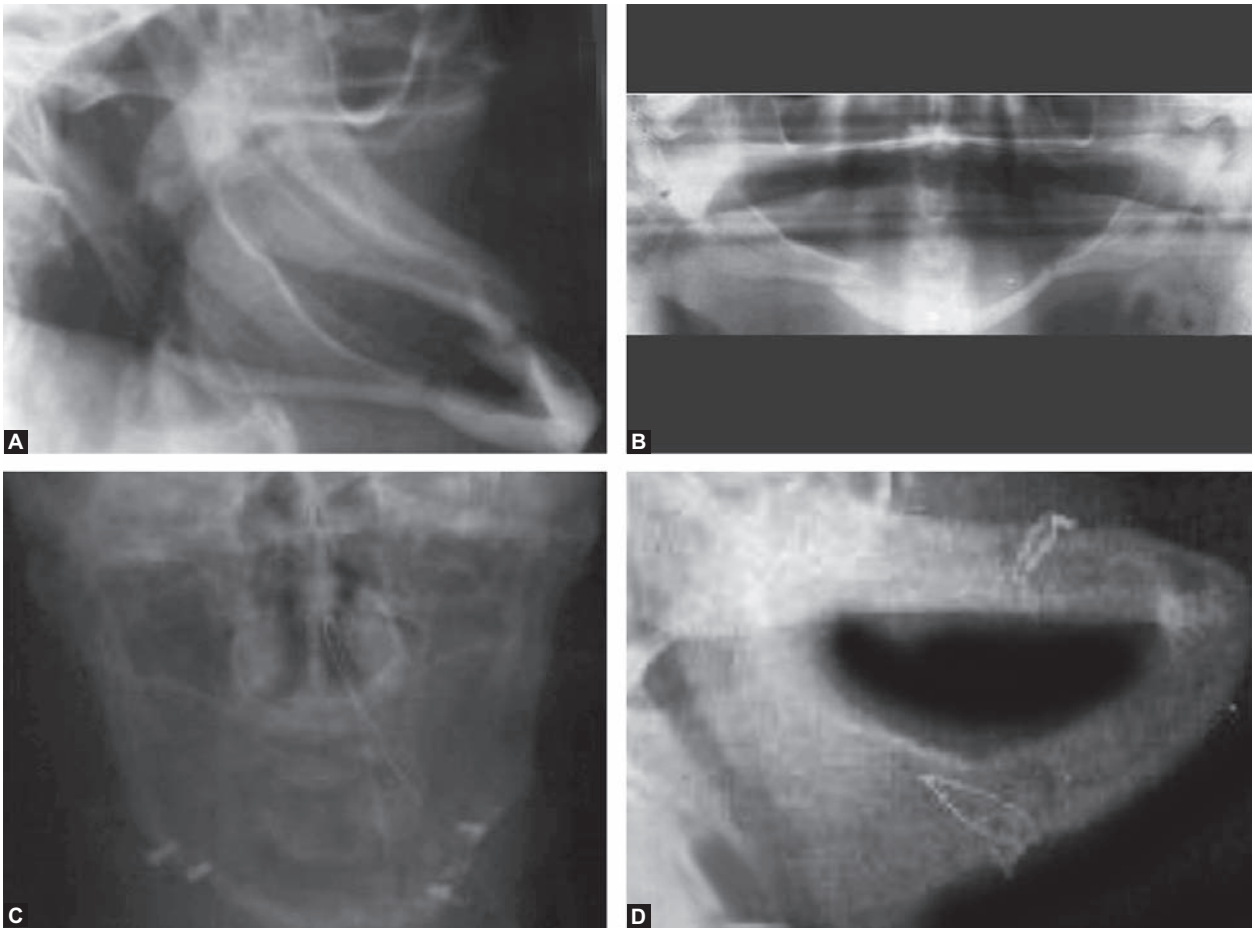


Fig. 34.25: Possible mechanism of producing 'bucket handle' type of fracture of atrophic edentulous mandible. The fracture is seen in the resorbed body of the mandible in front of the posterior attachment of the mylohyoid muscle (red arrow)

to produce more rigid fixation Spiessel in 1972, Schilli in 1977 devised various designs of compression plates. These compression plates include at least two-pear shaped holes. The widest diameter of the hole lies near the fracture line. The screw is inserted in the narrow part of the hole and at the final movement of tightening, its head comes to rest in the widest diameter of the hole, which is countersunk to receive it. The compression holes in the plate may be positioned one on each side of the fracture line (Spiessel, DCP—Dynamic compression plate).

Eccentric Dynamic compression plate (EDCP): Schilli designed a plate with oblique lateral holes, which direct the compressing force towards the upper border, so that when the plate is screwed firmly into the place, there is no tendency for the fracture line to gape **(Figs 34.23A to D)**.

The entire procedure is too precise and lengthy. Extraoral route is needed. The various complications associated with the use of these bulky plates are metal fatigue, fracture of the plate, necrosis of the bone ends, osteoporotic changes, etc. With the advent of miniplates, the use of original compression osteosynthesis is not done frequently. Though theoretically it offers the most rigid fixation.



Figs 34.26A to D: (A and B) Lateral oblique view mandible and OPG showing a bilateral fracture of a thin edentulous mandible with typical 'Bucket handle' type of displacement; (C) Open reduction and fixation was done. Postoperative posteroanterior view mandible, showing the proper reduction and fixation of the bilateral fractures; and (D) Intraosseous wiring fixation in another patient for stabilizing bucket handle fracture

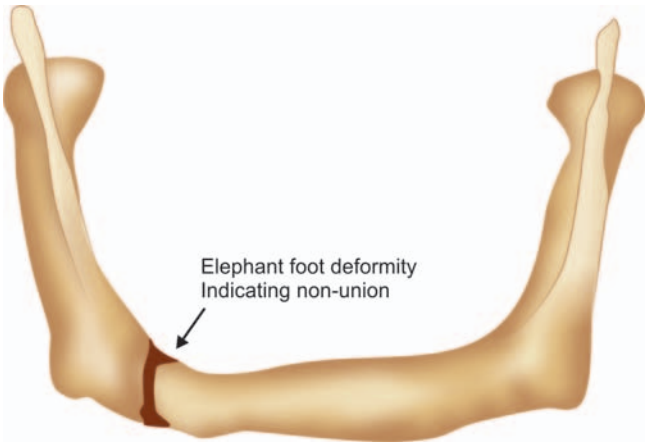


Fig. 34.27: Elephant foot deformity, indicating nonunion of fracture of the edentulous mandible

Mandibular fractures associated with multiple other facial fractures (Fig. 34.24): The old adage—"inside out and from bottom to top" sequence to be followed, when treating multiple facial fractures. Mandibular fractures should be treated first to restore the lower facial height as well as to achieve the continuity of the lower arch (for guiding the reduction of other fractures).

Edentulous mandibular fractures: With associated medical problems in these patients, there is special challenge in treating these fractures:

- Alveolar resorption is four times greater in the mandible than in the maxilla
- Inferior alveolar vascular supply to the bone is greatly compromised
- Too little cancellous bone for repair (osteoblastic endosteum)

- Normal healing potential is retarded
- Open reduction amounts to stripping of periosteum, which impairs osteogenesis, as there is greater dependence on periosteal supply in atrophic mandible.

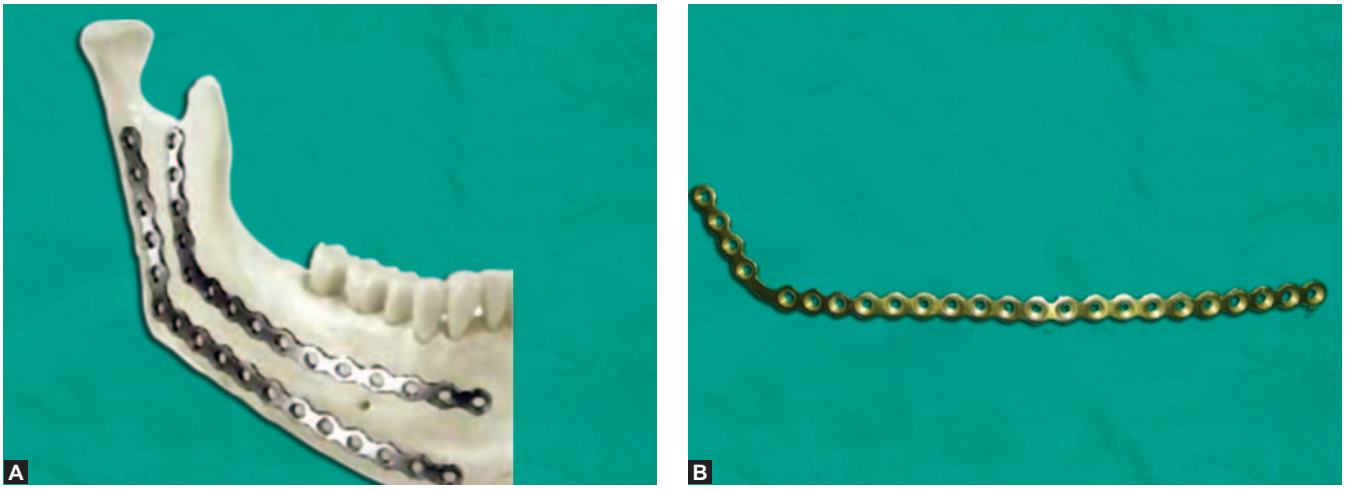
However, small bone discrepancies (nonanatomic alignment by closed reduction) are usually of no consequences by maturation of the bone.

But, sometimes, due to extreme alveolar resorption, the molar areas may be more prone to fracture. In some cases, it is possible to have bilateral fracture of the body of the edentulous mandible, each occurring near the posterior attachment of the mylohyoid muscle. In the edentulous mandible, the mylohyoid muscle attachment is relatively higher up on the lingual side. Under the influence of the diagastric and mylohyoid muscles pull, there is extreme downwards and backwards angulation of the anterior fractured fragment. This creates a typical "bucket handle" type of displacement, which is highly unstable. This type of extreme displacement at times, may cause respiratory distress in an elderly patient. Early stabilization of the fracture is mandatory **(Figs 34.25 and 34.26)**.

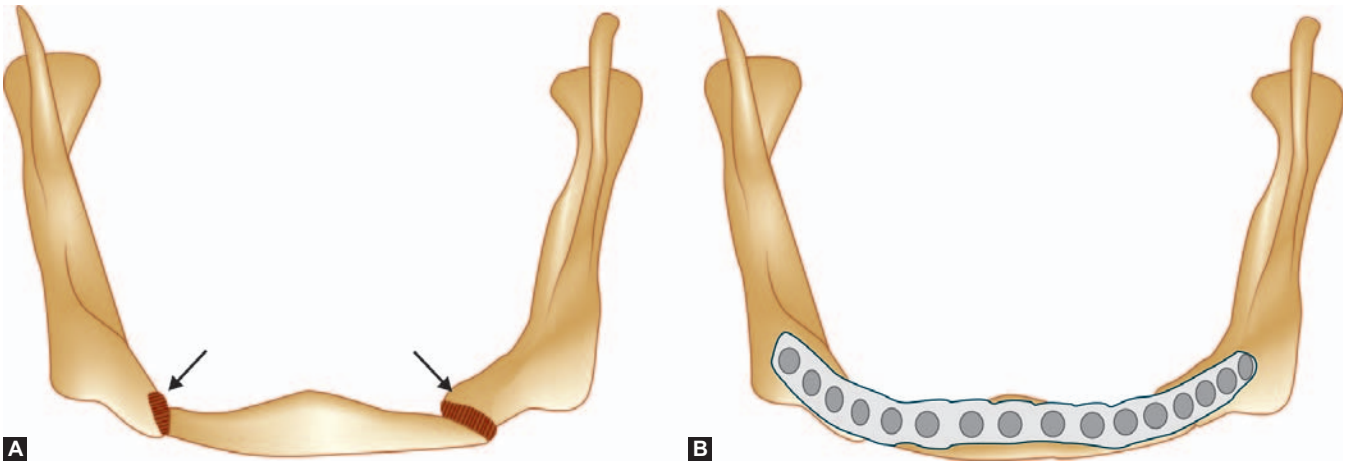
Treatment plan for edentulous mandible fractures

- Closed reduction with mandibular prosthesis held in place by circummandibular wiring
- In nonunion or delayed healing, open reduction with titanium mesh
- Severely atrophic edentulous ridge fracture, open reduction with primary bone grafting.

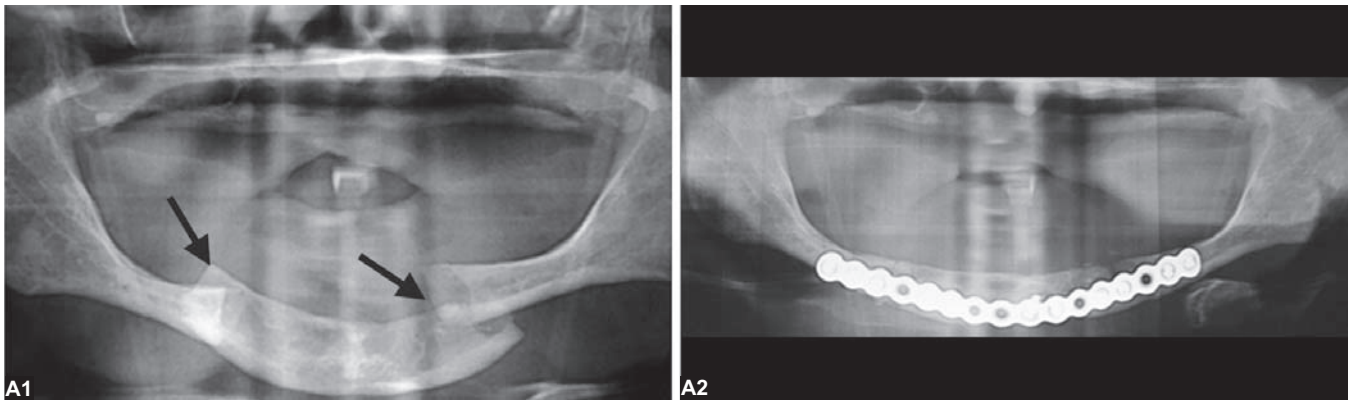
In case of edentulous mandible fractures, many times, nonunion of the fracture is seen due to impaired blood supply or presence of infection, after conservative



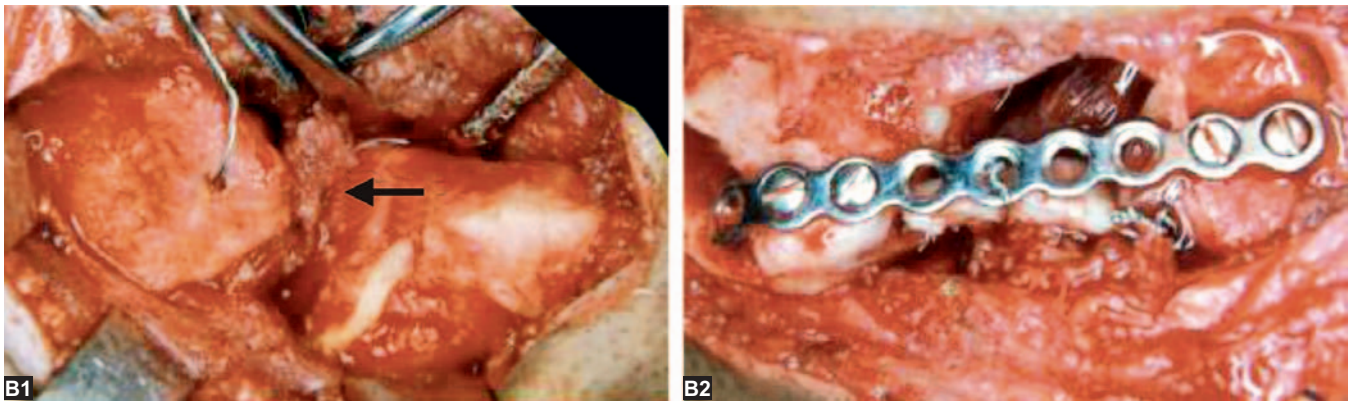
Figs 34.28A and B: Angled reconstruction plates for mandible



Figs 34.29A and B: (A) Bilateral fracture of edentulous atrophic mandible; (B) Fracture reduction and fixation with reconstruction plate



Figs 34.30A1 and A2: (A1) OPG showing Bucket handle bilateral fracture in edentulous atrophic mandible; (A2) Anatomical reduction with load bearing reconstruction plate fixation



Figs 34.30B1 and B2: (B1) Nonunion of the mandibular body fracture. Note the soft tissue entrapment between the fractured fragments; (B2) Sliding inferior border bone grafting. Fixation with reconstruction plate

treatment. During the open reduction procedure, there is typical "eburnation" of the ends of the fractured fragments is noticed. This is the process, where the outer and inner cortex heals at both the fractured ends of the fragments. Many times soft tissue entrapment is also found between the fracture ends leading to nonunion. In the radiograph, this eburnation is seen as "elephant foot deformity" in the edentulous mandible fracture (nonunion). In such a situation both the fractured ends should be freshened up, soft tissue entrapment is cleared off and then the fixation should be carried out **(Fig. 34.27)**.

Reconstruction Plates

These are capable of temporary load bearing and therefore useful in comminuted fractures, defect fractures and infected fractures. It is also useful in the case of severely displaced angle fractures. Reconstruction plate absorbs all functional loads to restore the continuity and permits early mobilization, despite extensive fragmentation of the bone. It also spans the comminuted area to preserve the original shape, length and strength of the mandibular arch.

Reconstruction plates must be accurately contoured to avoid fracture displacement and a subsequent malocclusion during tightening of the screws. The use of template simplifies the bending process of the large reconstruction plates. When using a reconstruction plate, the most posterior screw holes to the fracture site, should be placed at least 1 cm away from the fragment end and four screws in each segment provide the maximum resistance to deformation **(Figs 34.28 to 34.30)**.

Complications of mandibular fracture management: Untoward sequelae such as infection, bleeding, lip numbness, malocclusion, nonunion, malunion,trismus, tooth loss, paresis and cosmetic compromise are reported to range as high as 40% or more.

Employment of proper surgical protocols will reduce postoperative complications.

Complications during primary treatment

- **Infection**—Lowering the patient's local or general resistance will predispose to infection. Pathological fracture, debilitated patients, diabetics and patients on steroid therapy are more prone to infection.
- **Nerve damage**—Anesthesia of the lower lip due to neuropraxia or neurotemesis of the inferior alveolar nerve is the most common complication. Facial nerve damage may be seen due to penetrating injuries.
- **Displaced teeth and foreign bodies**— may be swallowed. Chest radiograph should be done and if needed, bronchoscopy should be carried out. Foreign bodies like glass pieces, fragments of teeth can get buried in the soft tissues of the lip. They should be explored and removed.
- Pulpitis
- Gingival and periodontal complications.

Later complications

- **Malunion**—results due to improper fixation method, early removal of immobilization device, tissue entrapment in the fragments, etc.
- **Delayed union**—due to local factors such as infection or general factors such as osteoporosis or nutritional deficiency.
- **Nonunion**—radiologically, rounding off and sclerosis of the bone ends is seen. This condition is called as "eburnation". This is caused by:
  - Infection at the fracture site
  - Inadequate immobilization
  - Unsatisfactory approximation with tissue entrapment.
  - The ultrathin edentulous mandible in an elderly debilitated patient
  - Considerable loss of bone and soft tissue
  - Inadequate blood supply after radiotherapy
  - The presence of bone pathology like tumors, etc.
  - General diseases, e.g. osteoporosis, nutritional deficiency, disorders of calcium metabolism.
- Sequestration of bone.
- Traumatic myositis ossificans—rare.
- Scars.

Points to Remember

- Mandibular fractures in children along with their management
- Management of mandibular fractures in adults
- Surgical approaches to the mandible
- Bone plating in mandibular fractures
- Complications of mandibular fracture management.

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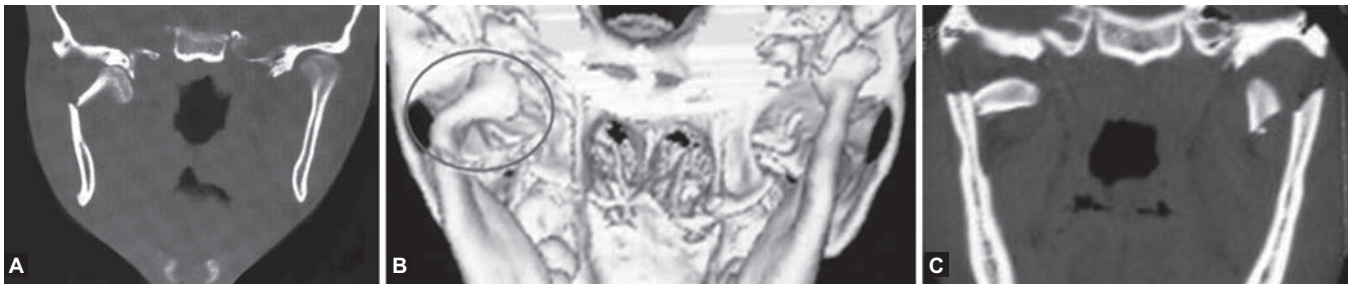
CHAPTER 35 Fractures of the Condylar Process of Mandible and its Management

INCIDENCE OF CONDYLAR FRACTURES

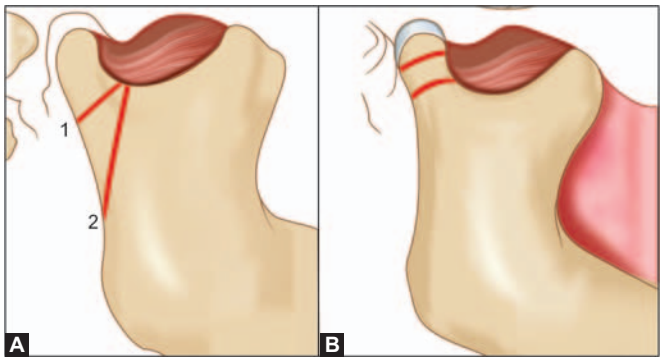
Incidence of the condylar fracture reported in the literature varies from 5% to 8% among all mandibular fractures. The condylar fractures may be a result of direct or indirect impact.

CLASSIFICATION OF CONDYLAR FRACTURES

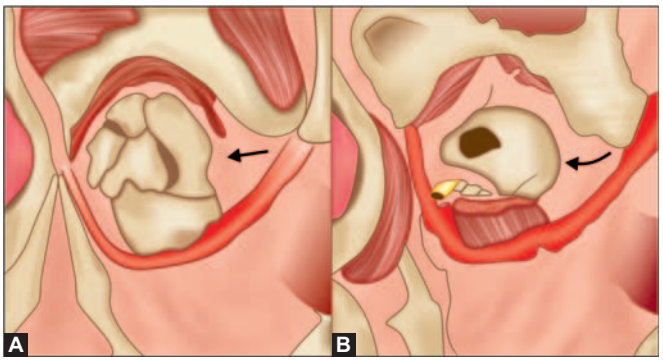
1. **Unilateral or bilateral condylar fractures (Figs 35.1A and B)**
2. **Rowe and Killey's classification**
   - Simple fractures of condyle
   - Compound fractures of condyle
   - Comminuted fracture associated with zygomatic arch fractures
3. **Rowe and Killey's classification (1968) (Figs 35.2A and B)**
   - Intracapsular fractures or high condylar fractures **(Figs 35.3A and B)**
     - Fractures involving the articular surface (rare)
     - Fractures above or through the anatomical neck, which do not involve the articular surfaces.
   - Extracapsular or low condylar or subcondylar fractures: Here the fracture runs from the lowest point of curvature of the sigmoid notch, obliquely downwards and backwards below the surgical neck of the condyle to the posterior aspect of the upper part of the ramus
   - Fractures associated with injury to the capsule, ligaments and meniscus
   - Fractures involving the adjacent bone, e.g. fracture of the roof of the glenoid fossa or the tympanic plate of the external auditory meatus.
4. **Clinical classification by MacLennan (1952) (Figs 35.4A to E)**
   - **No displacement:** A crack fracture is seen without alteration of the normal relationship of the condylar head to the glenoid fossa or of the neck of the condyle to the ramus
   - **Deviation:** Simple angulation exists between the condylar neck and the ramus
   - **Displacement:** Overlap occurs between the condylar process and the ramus. The obliquely fractured condylar fragment lies lateral to the ramus
   - **Dislocation:** Disruption takes place between the condylar head and the glenoid fossa. The condylar fragment gets pulled anteriorly and medially by the lateral pterygoid muscle.



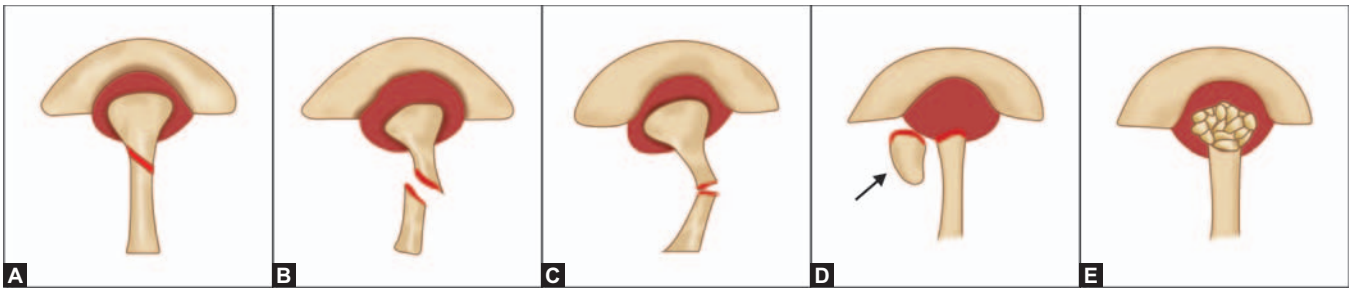
Figs 35.1A to C: Condylar process fracture classification: (A) and (B) CT scan of unilateral fracture; (C) CT scan of bilateral fracture



Figs 35.2A and B: Rowe and Killey's classification for condylar fractures. (A-1) Intracapsular or high condylar fracture and (A-2) Extracapsular or low or subcondylar fracture; (B) First fracture line is above the attachment of lateral pterygoid muscle. Second fracture line is at or below the attachment of lateral pterygoid muscle, where condylar head is always prone to displacement due to the contraction of the muscle



Figs 35.3A and B: Intracapsular fractures. (A) Fracture involving articular surface; (B) Fracture above or through the anatomical neck without, involvement of the articular surface, (Mushroom type)



Figs 35.4A to E: MacLennan's classification of condylar fractures. (A) No displacement; (B) Displacement; (C) Deviation; (D) Dislocation; and (E) Comminution (Multiple fragmentation)

5. **Wassmund's classification (1934)**
   - **Type I:** Fracture of the neck of the condyle with slight displacement of the head. The angle between the head and the axis of the ramus varies from 10° to 45°. These type of fractures tend to reduce spontaneously
   - **Type II:** An angle of 45° to 90° is seen between the head and the ramus. There is tearing of the medial portion of the joint capsule
   - **Type III:** The fragments are not in contact. Head is displaced medially and forward due to the pull of lateral pterygoid muscle and spasm. The fragment is generally confined within the area of the glenoid fossa. The capsule is torn and head is outside the capsule. Open reduction is advocated
   - **Type IV:** Fractured head articulates on or forwards to the articular eminence
   - **Type V:** Vertical or oblique fracture through the head of the condyle—rare.

6. **Comprehensive classification:** Proposed by Lindhal (1977), this required radiographs in two planes at right angles to each other

   To describe a condylar fracture under this system, the following details must be noted:

   1. **Fracture level:** This may be as follows **(Fig. 35.5)**:
      - A. **Condylar head fracture, (intracapsular):** By definition a condylar head fracture is within the capsule and is therefore termed intracapsular
        - Vertical (anteroposterior sagittal split)
        - Compression (producing a mushroom type of expansion)
        - Comminuted
        - A horizontal subdivision would be difficult to differentiate from next category.
      - B. **Condylar neck:** The radioconstriction representing the condylar neck corresponds anatomically to region of inferior attachment of joint capsule.

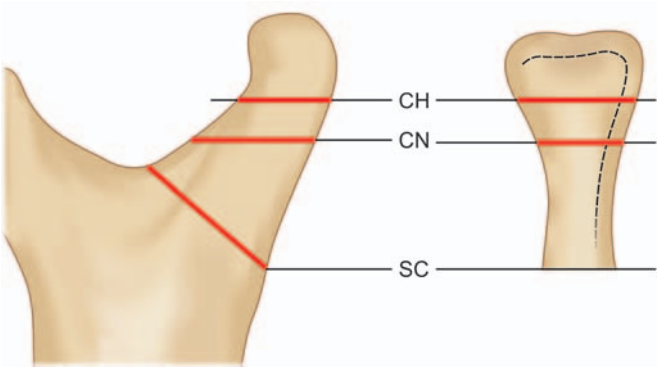
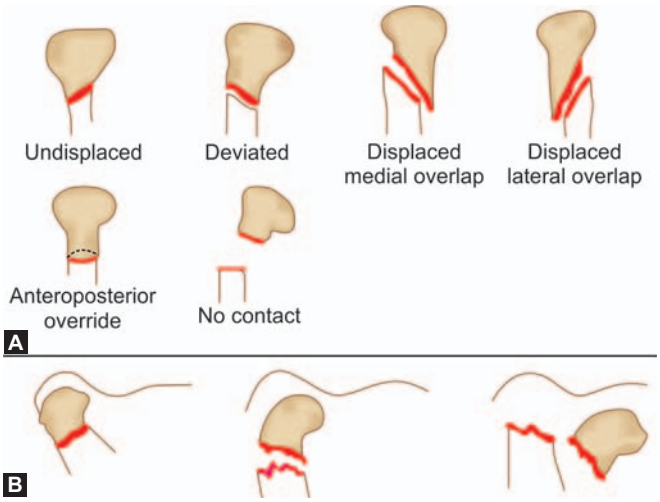


Fig. 35.5: Lindhal's classification: CH— condylar head-intracapsular fracture, CN— condylar neck fracture, SC— subcondylar fracture



Figs 35.6A and B: Relationship of the condylar fragment. (A) To the mandible ramus stump; (B) To the glenoid fossa

C. **Subcondylar:** This is the region below the neck, extending down to the most inferior part of the sigmoid notch anteriorly while its posterior limits situated more inferiorly corresponding to the point of maximum curvature of natural concavity of posterior border of the mandible in that region

2. **Relationship of condylar fragment to mandible (Fig. 35.6A):**

   This may be as follows:
   - **Undisplaced** (or fissure fracture)
   - **Deviated:** This is a simple angulation of the condylar process in relation to main mandibular fragment without overlap
   - **Displaced with medial overlap** of the condylar fragment
   - **Displaced with lateral overlap** of the condylar fragment
   - **Anteroposterior overlap** is possible, but infrequent
   - **Without contact between the** fragments

3. **Relationship of condylar head to fossa (Fig. 35.6B)**

   The following relationship may be observed:
   - No displacement—joint space appears normal
   - Displacement—joint space is increased, but condyle is still related to the glenoid fossa. Lindhal subdivided this into slight displacement and moderate displacement, but quantification is difficult.

- **Injury to meniscus**: It may be torn, ruptured/herniated in forwards/backwards direction.

7. **Thoma (1945) classified** fractures in a simple way taking into consideration the direction of displacement.
   - **Condylar fractures**
     i. Without displacement of condyle
        - Greenstick fracture
        - Intracapsular
        - Extracapsular

     ii. With displacement of condyle
        - Lateral
        - Medial
        - Forwards
        - Backwards

     iii. With overriding of fragments
     iv. With dislocation in lateral or medial direction
        - Intracapsular
        - Complete fracture dislocation
        - Complete dislodgement of the condyle
        - Dislocation of the fractured part of the head of the condyle

     v. With dislocation in forward direction
        - Anteriorly from the articular eminence
        - Posteriorly from the articular eminence
        - With dislocation and displacement of the meniscus
        - With comminution

     vi. Old fracture with deformities
        - Pseudoarthrosis
        - Ankylosis

   - **Subcondylar fractures**
     - Without displacement of fragment
     - With displacement of fragment

     Fracture line either extending through head or base of the condyle or neck has been called condylar fracture by Thoma, whereas in

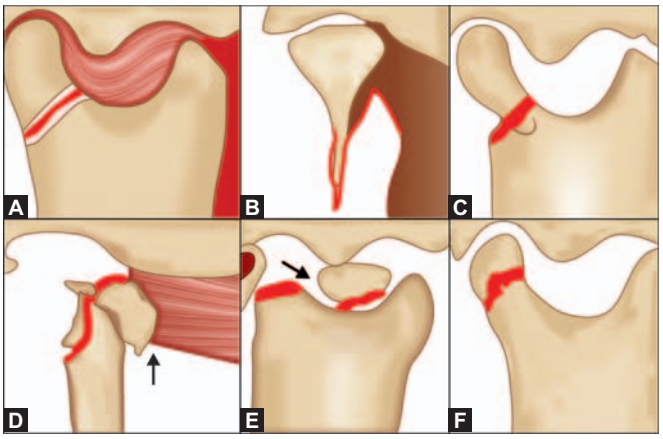
subcondylar fracture, the line runs transversely over ascending ramus.

8. **Spiessel and Schroll classification [1972 (Figs 35.7A to F)]**
   - Nondisplaced fracture
   - Low neck fracture with displacement
   - High neck fracture with displacement
   - Low neck fracture with dislocation
   - High neck fracture with dislocation
   - Head fracture

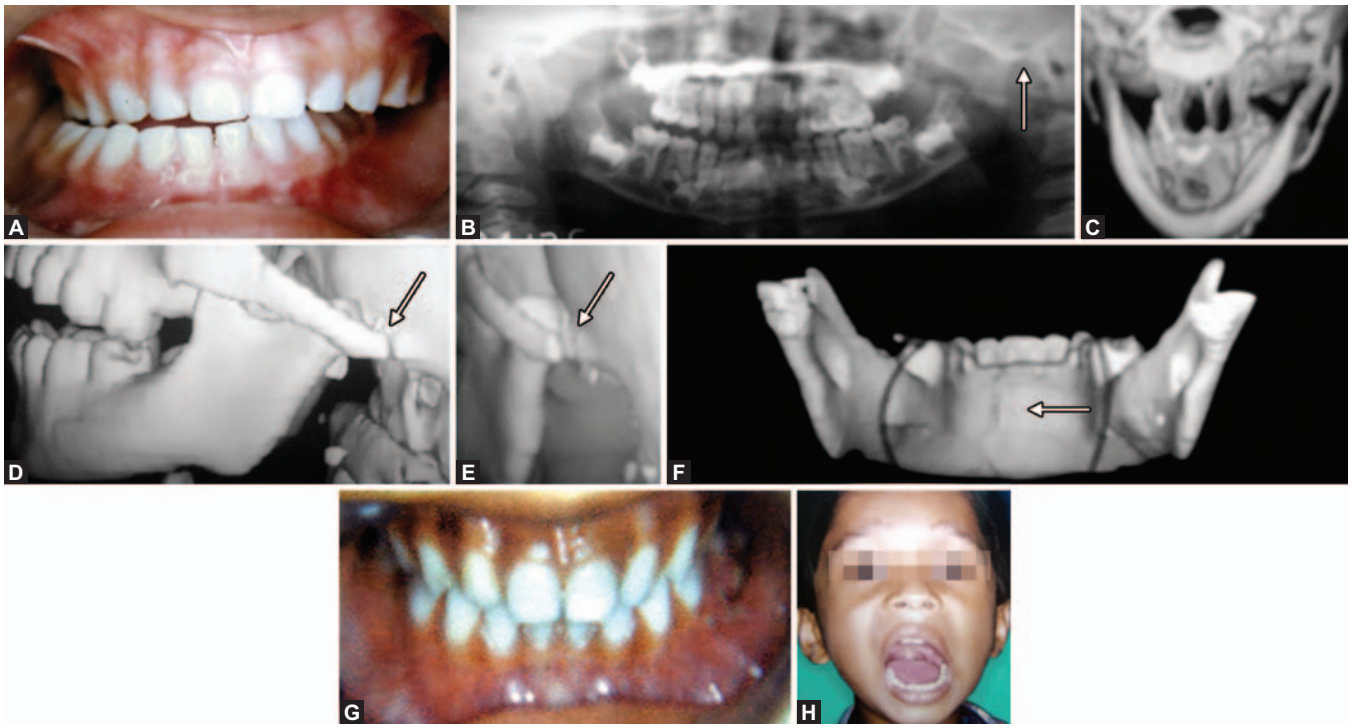
ETIOLOGICAL FACTORS LEADING TO CONDYLAR FRACTURES

Etiological factors leading to condylar fractures may be grouped as:

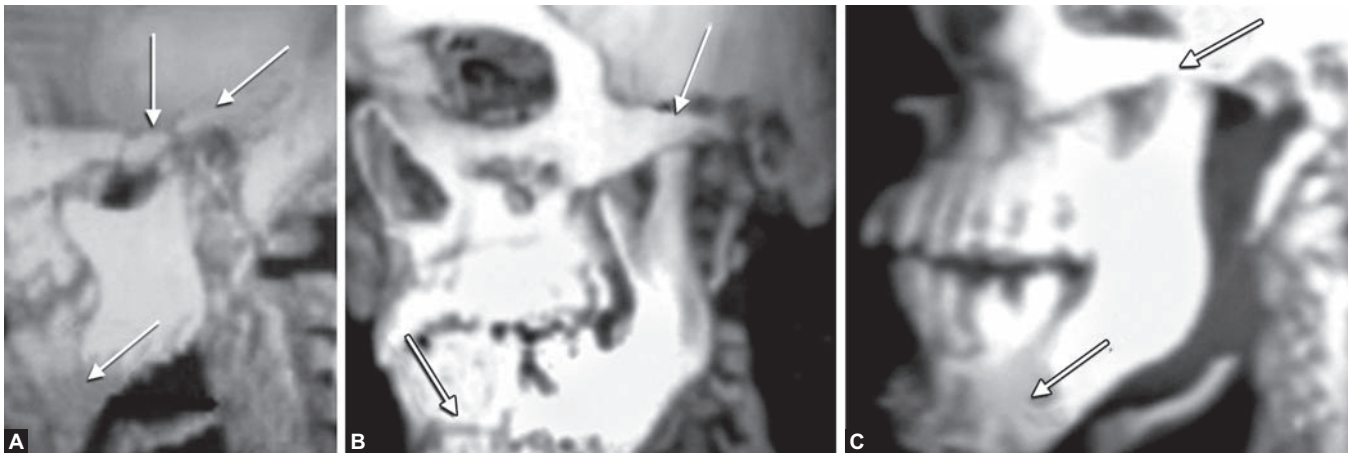
- Intentional trauma—interpersonal violence/fist fight, etc.
- Unintentional trauma—motor vehicular accidents, fall on the chin, sports injuries, industrial mishaps, etc.



Figs 35.7A to F: Spiessel and Schroll classification. (A) Nondisplaced fracture; (B) Low neck fracture with displacement; (C) High neck fracture with displacement; (D) Low neck fracture with dislocation; (E) High neck fracture with dislocation; and (F) Condylar head fracture



Figs 35.8A to H: Dislocation of condyle with zygomatic arch and parasymphysis fracture: (A) Six years old boy came with the history of fall, C/O teeth not occluding and inability to open the mouth wide; (B) OPG showed dislocation of L condyle. Under sedation reduction was tried without success; (C to E) 3D CT scan showing left zygomatic arch fracture at the base, which was not seen in OPG; (F) L parasymphysis fracture seen in 3D CT, mandible with medial rotation and disarticulation; (G) Under GA again intraoral reduction was attempted with failure. E.O preauricular approach was taken to reduce the dislocation of the condylar head back into fossa. Zygomatic arch fracture was reduced and fixed with 2 hole minibone plate. Normal occlusion was achieved; (H) Normal oral opening



Figs 35.9A to C: (A) L zygomatic arch fracture associated with dislocation of condyle and L malunited parasymphysis fracture; (B and C) Another patient with L parasymphysis malunited fracture with dislocation of condyle, which often goes unnoticed

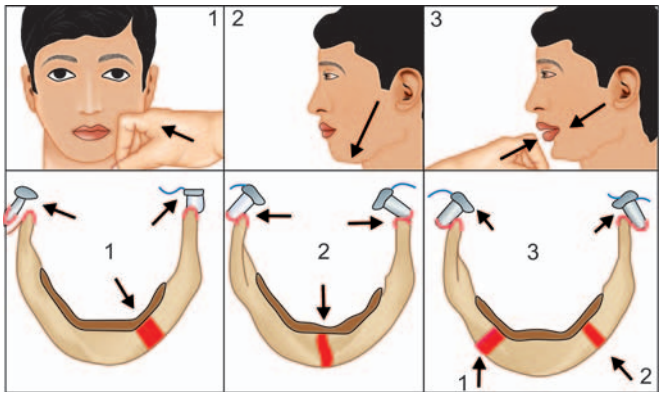


Fig. 35.10: Mechanism of injury to the condyles: (1) Blow; (2) Ground fall; and (3) Dashboard RTA injury

Whenever a blow is received on the lateral side of face, the zygomatic arch protects the condyle and coronoid process. Under these circumstances, the arch may fracture and may be associated with fracture or dislocation of the condyle **(Figs 35.8 and 35.9)**.

When a blow is given on the face resulting in fracture of the mandibular condyle, the position of the fractured condyle in relation to the remainder of the ramal stump will depend on certain factors:

- The direction and degree of force
- The precise point of application of force
- Whether the teeth were in occlusion at the time of injury.
- Whether the patient is partially or fully edentulous **(Fig. 35.10)**.

Fracture with little or no displacement occurs when adequate natural or artifical molar support exists and the teeth are in occlusion at the time of impact.

A variable degree of displacement will take place, if the teeth are separated or the force is received from a lateral direction. Full force of impact will be transmitted to the condyles, resulting in a variable degree of fracture dislocation, if the mouth is widely open or there is inadequate molar support at the time of injury.

If a hard blow is received on the mandible, the force is transmitted on the teeth, which are in occlusion. When the blow on the face results during posterior or lateral movements, then the indirect stress results in the fracture of the slender neck of the condyle. On the other hand, if the patient receives a blow on the chin, the force of the impact is transmitted upwards and backwards along the length of the mandible. If the blow is delivered with great force, it would force the condylar head through the glenoid fossa, into the middle cranial fossa. This calamity is prevented in majority of the cases, because the slender neck of the condyle fractures due to impact and prevents the condyles from entering into the middle cranial fossa.

When the blow is received in the center of the chin, the distribution of force is equal to both the condyles, resulting in a bilateral indirect fractures through the necks, accompanied by a direct fracture at the symphysis (countercoup type of fractures). This type of injury is more often seen in an epileptic patients or soldiers who fall on the face during parade.

If the patient is wearing a denture or is having the posterior teeth in occlusion at the time of injury, the contact between the upper and lower teeth would minimize the consequences of the impact, but if such protection is not possible, then the patient may sustain a severe fracture dislocation of one or both the condyles.

DIAGNOSTIC FINDINGS OF CONDYLAR FRACTURES

- Evidence of facial trauma, especially in the area of the mandible and symphysis
- Localized pain and swelling in the region of the temporomandibular joint (TMJ)
- Limitation in mouth opening
- Deviation, upon opening, towards the involved side
- Posterior open bite on the contralateral side
- Shift of occlusion towards the ipsilateral side with possible cross bite
- Blood in the external auditory canal
- Pain on palpation over the fracture site
- Lack of condylar movement upon palpation
- Difficulty in lateral excursions as well as protrusion
- The occurrence of anterior open bite with bilateral subcondylar fractures. This is associated with posterior gagging of the occlusion
- Persistent cerebrospinal fluid leak through the ear is indicative of an associated fracture of the middle cranial fossa (otorrhea).

The diagnosis of fracture of the condyle is usually made on clinical examination and confirmed by radiographic findings.

Clinically, it will be noted that there is asymmetry of the face on the involved side due to, shifting of the mandible posteriorly and laterally towards the affected side (deviation of the mandible). Premature occlusion on the involved side is caused by upward pull of the elevator muscles of the mandible. This results in a class I lever with the fulcrum on the molar teeth on the involved side **(Figs 35.11A to C)**.

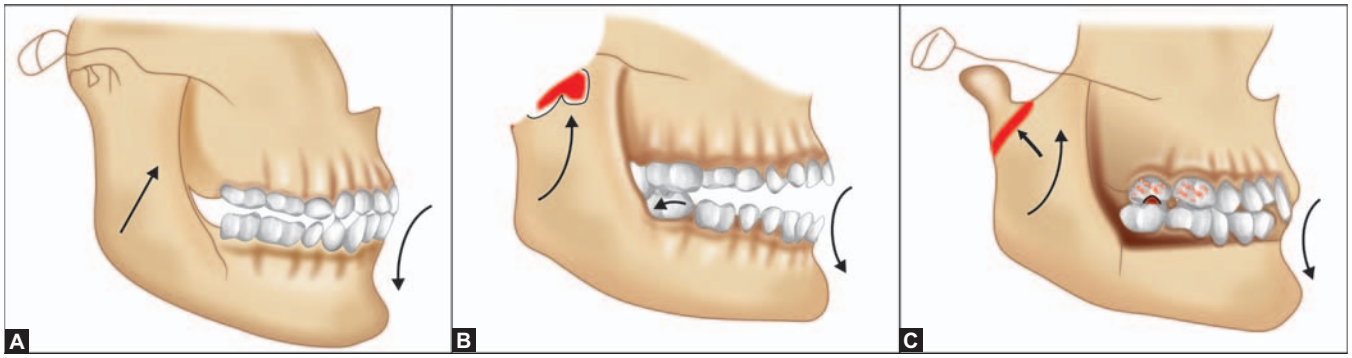
An open bite deformity anteriorly and on the opposite side of the mandible is noted. In case of bilateral fractures of condyles, the patient will have anterior open bite deformity with premature contact only on the posterior teeth. This is caused by upward displacement of ramus and telescoping of the fractured fragments, due to contractions of the lateral pterygoid muscles. In bilateral condylar fracture, which occurs below the attachment of the lateral pterygoid muscles, the patient is unable to protrude the mandible. In unilateral fractures at the same level, the patient is unable to perform lateral movements to the opposite side, as the lateral pterygoid muscle is out of function on the affected side **(Figs 35.12 and 35.13)**.

Fractures above the level of the lateral pterygoid muscle insertion do not exhibit displacement, as there is absence of contracting muscle attached to the proximal segment. The patient may complain of severe pain in the TMJ and it will be noted that the teeth are separated and do not come into the occlusion on the affected side, because of the hemarthrosis in the joint, which forces the condyles downwards. It may be few weeks before the teeth come into their normal occlusal relationship. In this type of fractures, especially in children, active early mobilization of the joint is a must; the parents should be warned about the possibility of the development of ankylosis of the TMJ, if proper treatment is not initiated.

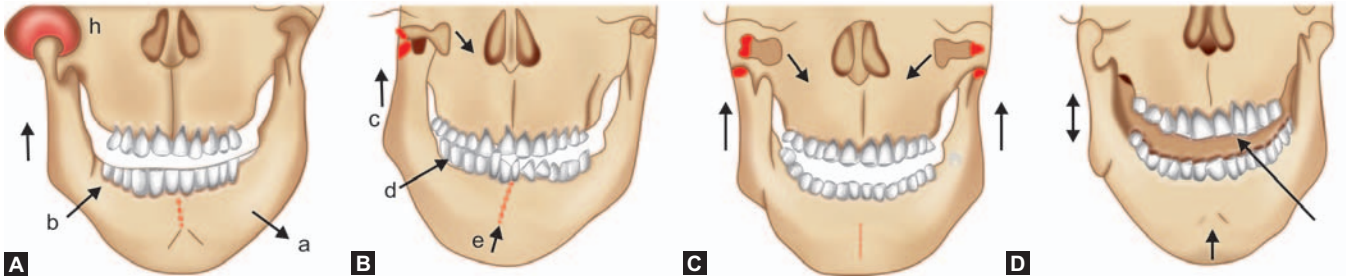
TREATMENT OF CONDYLAR FRACTURES

The management of condylar fractures is divided into: (1) Nonsurgical and (2) Surgical treatment.

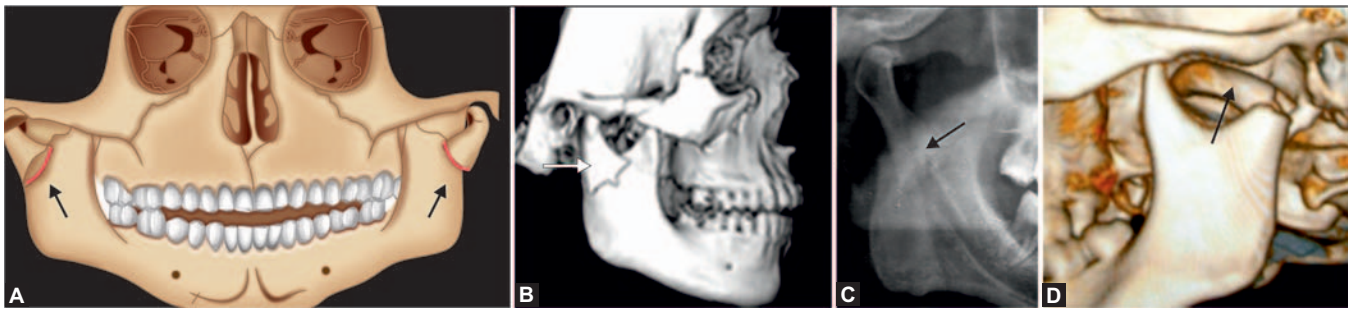
Because of the complexity of the functional anatomy of this region, there is a lot of controversy related to the specific treatment modalities. The decision will vary depending on the age of the patient, the type of fracture, concomitant injuries and associated anatomical findings.



Figs 35.11A to C: Lever principle applied to the mandible



Figs 35.12A to D: Signs of injury to the temporomandibular joint. (A) Effusion, h— hemarthrosis, a— midline shift to contralateral side, b— unilateral posterior open bite; (B) Unilateral fracture dislocation, c— telescoping, d— posterior premature contact, e— midline to ipsilateral side; (C) Bilateral fracture dislocation with anterior open bite and (D) Bilateral dislocation of the condyles without fracture. Note the total inability to occlude



Figs 35.13A to D: (A) Diagram—bilateral condylar fractures with anterior open bite; (B) 3D CT scan showing right subcondylar fracture with overriding and associated zygoma arch and body fracture; (C) OPG showing overriding condylar fracture; and (D) 3D CT scan showing completely dislocated condylar fracture

Nonsurgical Management of Condylar Fractures

Most cases of the condylar fractures are best managed through nonsurgical means. The obvious advantage is the avoidance of morbidity and complications associated with surgery.

Conservative method varies from no fixation to employing various fixation devices:

- Condylar fractures without displacement or with minimum displacement, without much occlusal disturbance and functional range of motion do not require any active treatment. Patient is asked to restrict the movements and semisolid soft diet intake for 10–15 days followed by active movements.
- In case of deviation on mouth opening without much occlusal discrepancy, a simple muscle training in front of a mirror is adequate. On the involved side, class II elastic traction and on the normal side, vertical elastic forces may be beneficial.
- In cases, where condylar fragment overriding is seen with alteration in ramus height, producing malocclusion, initially elastic traction is given to correct the malocclusion, followed by intermaxillary fixation (IMF) for 2–3 weeks.

Early mobilization is advocated in cases of young children to avoid ankylosis of TMJ.

Surgical Correction of Condylar Fractures

Many a times, ankylosis, malocclusion, continued pain, dysfunction are examples of residual difficulties associated with the conservative management with condylar fractures.

Absolute Indications for Open Surgery

- Fracture dislocations in the auditory canal or middle cranial fossa (rare)
- Anterior dislocation with restricted mandibular movements
- Bilateral condylar fractures associated with a comminuted LeFort III type with craniofacial dysjunction.

Relative Indications (Figs 35.8 to 35.13)

- Subcondylar fractures with overriding of the fragments with anterior open bite
- Anterior and medial displacement of the condylar fragment
- In case of delayed treatment, where there is pain and dysfunction associated with malunited fracture
- Unilateral or bilateral fractures with loss of the posterior teeth, in either upper jaw or both the jaws
- Cases in which position of the condylar fragment interferes with normal function of the jaws.

Surgical Approach to the Condyle

The preauricular approach historically has had a relatively high incidence of facial nerve involvement. Modifications of this approach include an approach to the joint region through a subtemporal fascial-periosteal envelope. Such an approach allows avoidance of the facial nerve branches by staying first posterior and then deep to the nerve. Postramal approach is better for subcondylar fractures.

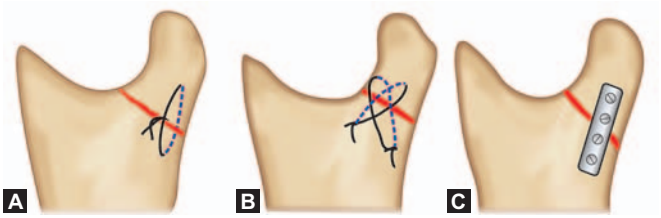
Methods of Fixation of Condylar Fractures (Figs 35.14 and 35.15)

It can be done by using transosseous wiring or bone plating with miniplating system.

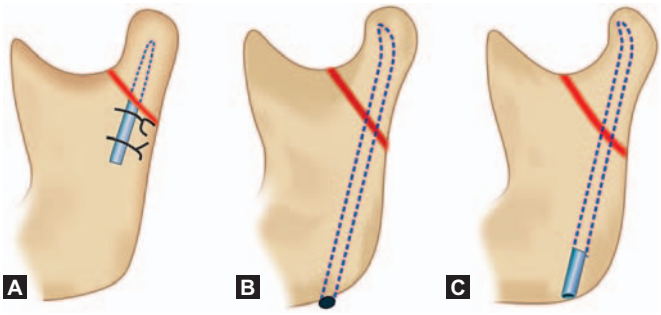
Various methods using threaded pins have also been described. One of the simplest methods is to use a Kirschner wire or lag screw that is passed from the inferior aspect upwards into the condylar head. Prior to surgery upper and lower arch bars or any other type of wiring to be fixed, so that the actual surgical time is cut down.

Preparation of the patient: The temporal region is shaved preferably the day before surgery. The skin of the preauricular region and the ear are prepared in the usual manner. The patient should be placed on the table so that the sagittal plane of the head is parallel with the table. This often requires that the shoulder be raised with a flat sandbag. Sandbags are also used to maintain the head in the correct position.

Operative procedure: Access to the TMJ is done for high condylar fracture via modified preauricular incision and for subcondylar through postramal approach. Blunt retractors are inserted and the zygomatic arch is located. The depression in the inferior border of the arch denotes the location of the mandibular joint. The mandible at this point may be moved by the assistant, which may produce movement of the fragments and so helps in locating them. As one proceeds, the transverse facial artery and vein may



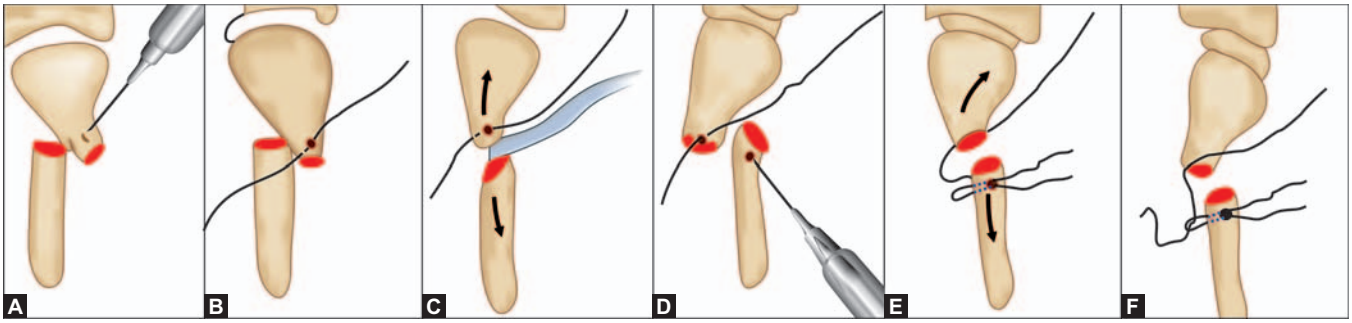
Figs 35.14A to C: Methods of fixation of condylar fracture. (A) Intraosseous wiring; (B) Double intraosseous wiring; (C) Bone plating



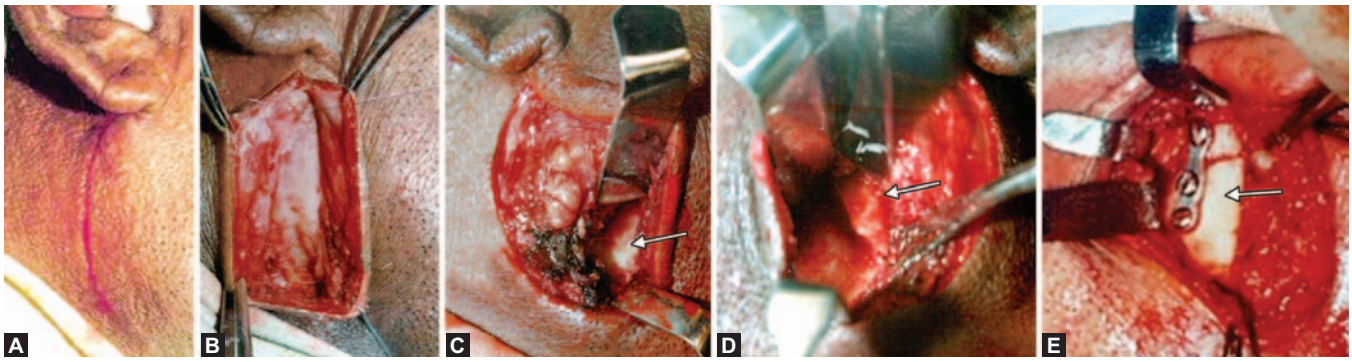
Figs 35.15A to C: Various methods of fixation of condylar fracture. (A) Any long metal tube or hypodermic needle or Steinmann pin is cut and inlaid into the ramus segment and fixed with wires; (B) Long pin or lag screw is threaded through the ramus into the condylar segment; (C) Petzel introduced a sophisticated technique of fixation. He drilled a hole from the inferior surface through the ramus and then inserted a pin into the condylar segment. After the reduction is done, the pin is cut and a nut is placed at the end of the pin and tightened to offer a compression effect at the fracture site

be encountered, cut and tied. Inverted L-shaped incision is taken from the lower border of the zygomatic arch to the outer surface of the ramus.

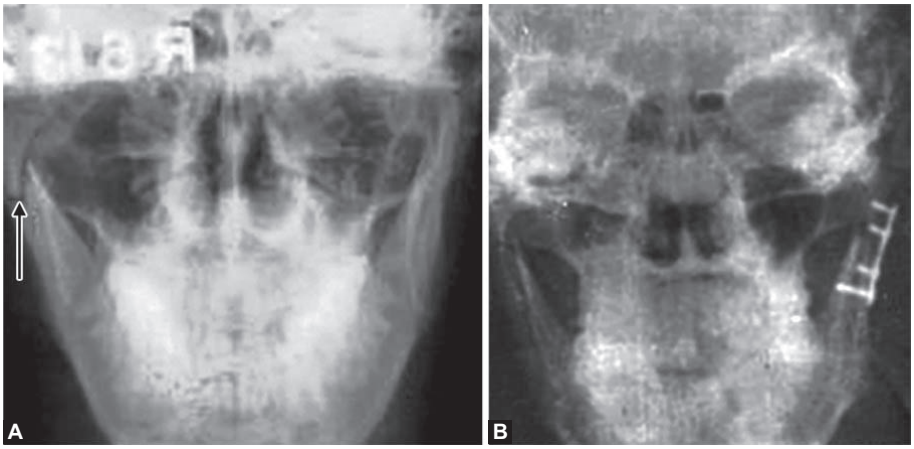
The procedure from here depends on whether the condyle is displaced laterally or medially, which is already determined from the radiographs. If the condyle is laterally displaced, then the periosteum of the neck of the condyle is stripped off with a periosteal elevator. The condylar retractor is now inserted from the posterior border going medially to protect the vital structures **(Figs 35.16A to F)**. The hole is drilled through the outer cortex till the inner cortex. The 26-G double wire is passed through the hole and grasped with the hemostat from the medial aspect. The mandibular fragment is located next, since the fragment is under the condyle (if submandibular or postramal approach is taken, then small hole is made at the angle at the inferior border of the mandible, through which double wire is passed and grasped



Figs 35.16A to F: Diagrammatic representation of reduction and fixation with intraosseous wiring for condylar fracture

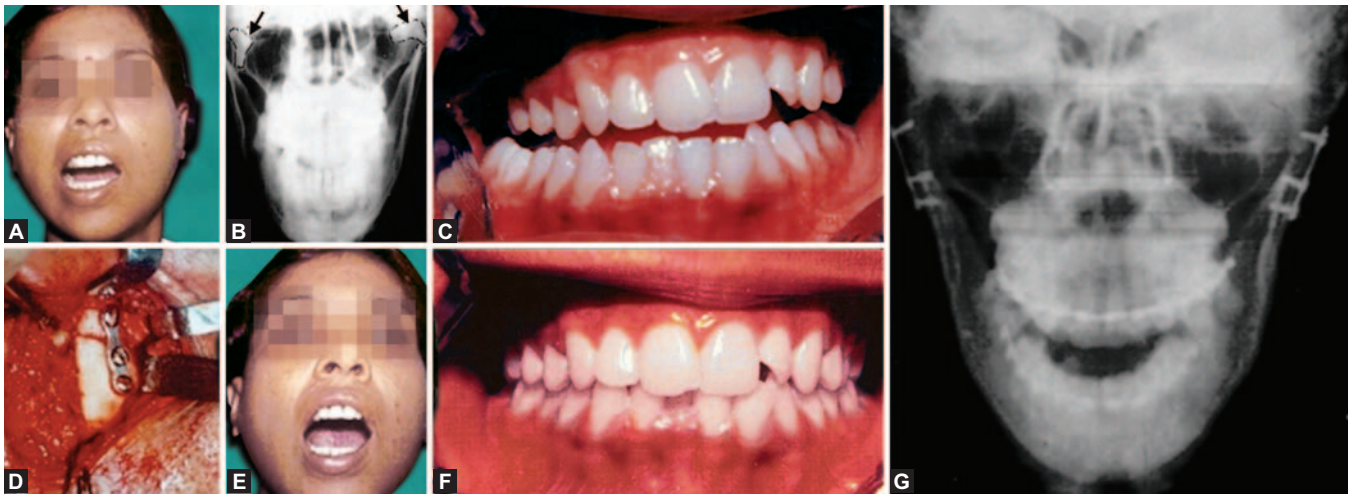


Figs 35.17A to E: Bone plating. (A) Postramal or retromandibular incision, (B) Exposure of parotidomasseteric fascia, (C) Exposure of angle of mandible, (D) Laterally displaced fractured fragment, (E) Reduction and fixation with bone plate

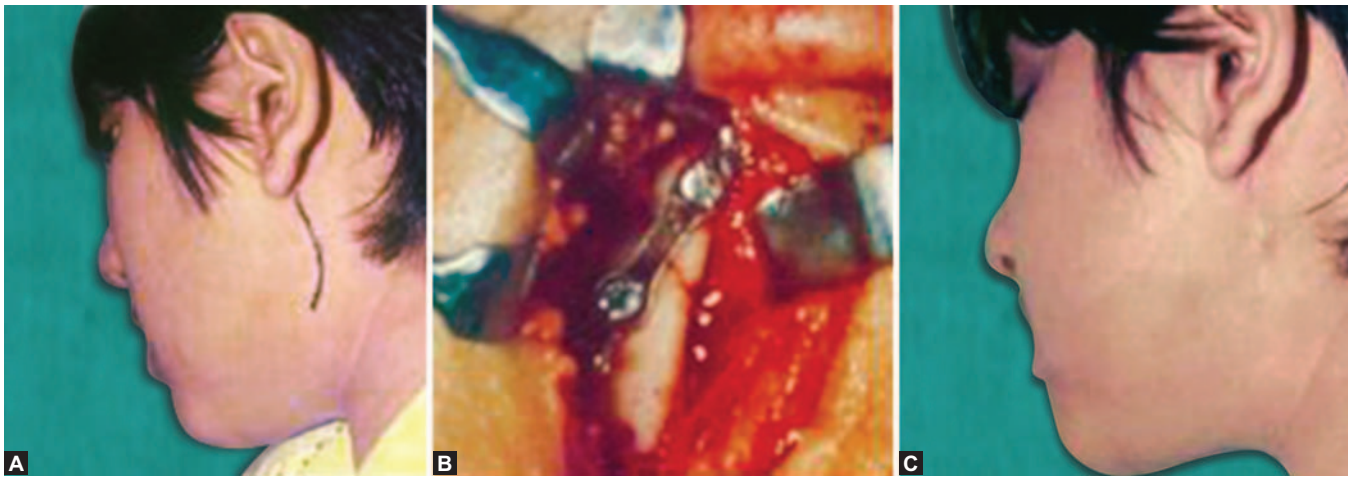


Figs 35.18A to B: A 15-year-old girl was hit by an autorickshaw. She had deranged occlusion with restricted oral opening and deviation of the chin towards right side. (A) Preoperative X-ray showing unilateral fracture of the condylar process; (B) Postoperative X-ray showing bone plating

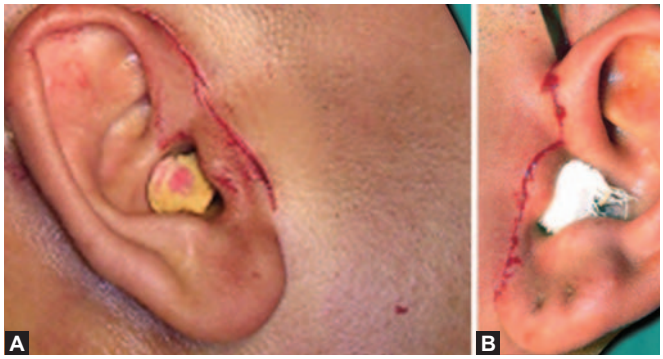
with a hemostat. This wire is pulled downwards, so that there is better access for grasping the condylar fragment as well as ramus. By using periosteal elevator and special condylar retractor, another hole is drilled in the ramal fragment. The wire, previously placed in the condylar fragment is now drawn through from the fracture surface by inserting a looped wire in the hole from the outer surface of the ramus. The fracture is then reduced under direct vision and temporary IMF is done intraorally by the assistant. After that the wire



Figs 35.19A to G: (A) Preoperative restricted opening; (B) X-ray—bilateral fracture condyles; (C) Occlusion before reduction; (D) Open reduction, fixation; (E) Postoperative oral opening; (F) Occlusion after reduction; and (G) Postoperative X-ray



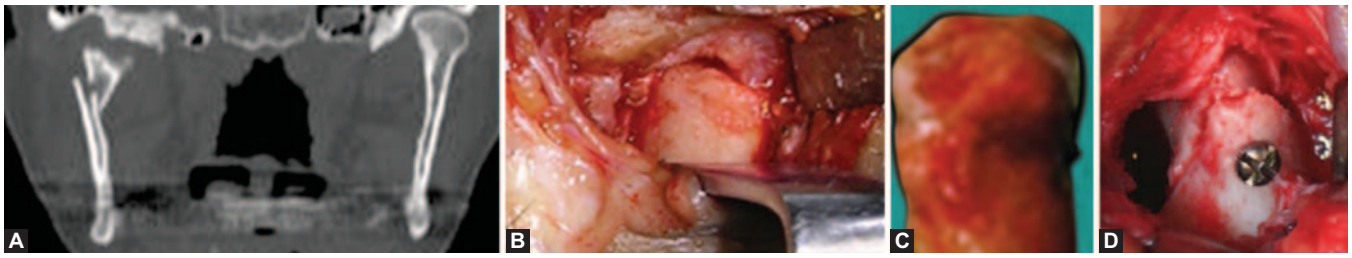
Figs 35.20A to C: (A) Marking for postramal incision, (B) Bone plating for left condylar fracture, (C) Postoperative scar



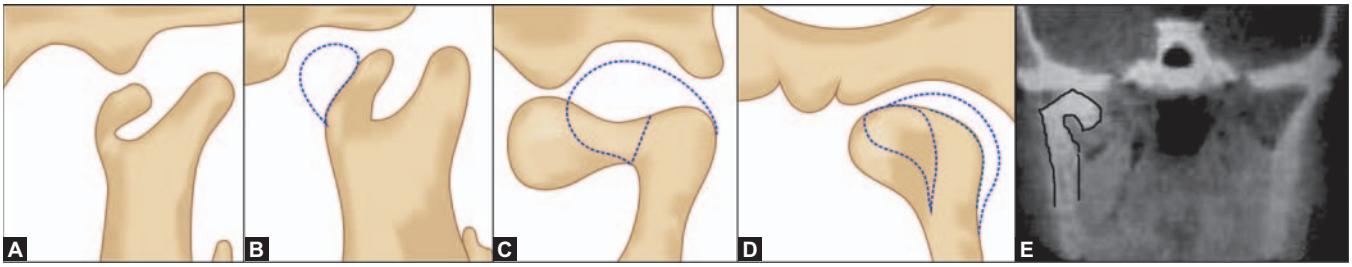
Figs 35.21A and B: Preauricular incision for exposure of high condylar fracture

ends are twisted together and cut off and the ends are bent over close to the bone. In cases, where condyles are medially displaced, the procedure is reversed. First the mandibular fragment is located by manipulation and same procedure can be repeated as described. After fixation by the wires, the wound is closed in layers and dressing is given. At the end of the operation, temporary IMF should be removed to facilitate extubation and it should be replaced next day. Immobilization is kept for 15–20 days.

Minibone plating can also be done instead of intraosseous wiring **(Figs 35.17 to 35.20)**. Here, the fracture should be reduced as described and then the small four-



Figs 35.22A to D: High condylar fracture reduction via preauricular approach. (A) CT scan showing medially dislocated condylar fractured head; (B) Medially dislocated condylar fractured head brought laterally; (C) Condylar head removed in toto, and used as a free graft for replantation, as normal fixation was not possible; and (D) Replanted head fixed in position with screw



Figs 35.23A to E: : Dysarthrosis: (A to D) Diagram of the formation of dysarthrosis; (E) Coronal CT scan showing dysarthrosis of the right TMJ after malunion of medially displaced condylar fragment

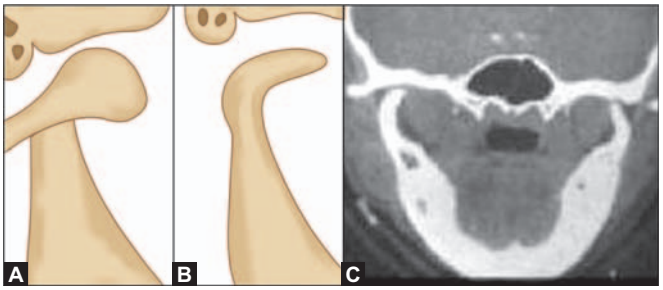
hole or two-hole bone plate should be adapted to the external cortex and fixed with monocortical selftapping screws. If the high condylar fractured fragment is displaced too anteromedially, then it should be located by depressing the ramal fragment and catching it with the hemostat. Then if it can be fixed back as a free graft to the ramal stump, the attempt should be done **(Figs 35.21 and 35.22)**. But many times condylectomy is recommended, because replantation is not possible.

Malunion (Dysarthrosis or Meta-arthrosis) and Pseudoarthrosis

Dysarthrosis: Here morphological change is seen in unreduced fracture dislocation producing nonarticulating deformed condyle. The malunion results in disturbance in anatomy as well as in function. Patient will have pain and limitation of movements of lower jaw **(Figs 35.23A to E)**.

Meta-arthrosis: It is result of healed fracture in malposition, but it produces no symptoms. These are the type of joints with altered anatomy, but functionally acceptable (anatomically altered, transformed, modified joints) **(Figs 35.24A to C)**.

Pseudoarthrosis: False joint, very painful during normal excursions. Condylectomy may be required.



Figs 35.24A to C: Meta-arthrosis of TMJ after malunion of fractured condyle: (A and B) Diagram; and (C) CT scan meta-arthrosis of both the temporomandibular joints

Points to Remember

- Classification and etiological fractures of condylar fractures
- Diagnostic findings of condylar fractures
- Treatment of condylar fractures.

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Section 8

Preprosthetic Surgery

36. Preprosthetic Surgery

CHAPTER 36 Preprosthetic Surgery

INTRODUCTION

Since the end of World War II, through the development of better materials, the improved accuracy of processing techniques and a better understanding of oral physiology, dental prosthetics has made great strides in increasing the successful use of prosthetic appliances in edentulous patients.

ORAL AND MAXILLOFACIAL PROSTHETICS

By definition oral "*prosthetics*" is the replacement of missing teeth (lost or congenitally absent) and contiguous oral and maxillofacial tissues, with artificial substitute. The principles of form and function combine to guide the clinical application of prosthodontics towards the most natural cosmetic and functional result.

Nonetheless, there remains a significant number of patients, who can never be made to use dentures effectively, because of bone atrophy, soft tissue hypertrophy or localized soft and hard tissue problems or all of them, which have progressed beyond the point of prosthetic accommodation. It is in these patients, that preprosthetic surgery offers a significant contribution. Many times in the oral cavity preexisting structures like frenal attachments, exostosis and tori have no significance and their presence do not interfere with masticatory function, when the teeth are present. But, these very nonsignificant structures definitely cause hinderance for denture stability and resultant reduced masticatory function after tooth loss.

'**Preprosthetic surgery**' is carried out to reform/redesign soft/hard tissues, by eliminating biological hinderances to receive comfortable and stable prosthesis. (Reform/redesign denture bearing area to create an oral environment to support a functional and esthetically acceptable prosthetic appliance. Surgical procedures are undertaken to modify the anatomy of the ridges to facilitate the retention of conventional dentures. Since the availability of the intraosseous oral implants, certain additional procedures are also carried out to receive the implants.)

OBJECTIVE OF THE PREPROSTHETIC SURGERY

Objective of the preprosthetic surgery is that to provide a better anatomic environment and to create proper supporting structures for denture construction. Ultimate goal should be rehabilitation of the patient, with restoration of the best possible masticatory function, combined with restoration or improvement of dental and facial esthetics. To achieve this goal, maximum preservation of hard and soft tissues of the denture base, is of utmost importance. The planning should start much before the extraction of teeth, whenever possible.

Aims of Preprosthetic Surgery

- To conserve the oral structures to provide tissue to withstand the masticatory forces and achieve functional esthetics
- To provide optimum ridge in terms of height, width and contour-adequate bone support
- To provide adequate soft tissue support-establishment of correct/optimum vestibular depth
- Elimination of pre-existing bony deformities, e.g. tori, prominent mylohyoid ridge, genial tubercle
- Correction of maxillary and mandibular ridge relationship
- Elimination of preexisting soft tissue deformities, e.g. epulis, flabby ridges, hyperplastic tissues
- Relocation of frenal/muscle attachments
- Relocation of mental nerve
- Lateralization of inferior alveolar nerve.

Denture Base Areas of Concern

Maxilla: Maxillary alveolar ridge, labial and buccal vestibular area and palatal vault. Frenal/muscle attachments, tuberosity area, level of floor of the maxillary sinus and nasal floor.
Mandible: Mandibular alveolar ridge, labial, buccal and lingual vestibules, retromolar area, mylohyoid ridge, frenal/muscle attachments, level of genial tubercles and level of mental/inferior alveolar nerve.

Pathophysiology of Edentulous Bone Loss

Complete denture retention and stability is dependent on the well adapted fit, hydrostatic pressure/peripheral seal and physical features of the alveolar process such as contour and height/width. Over the years, the progressive bone loss, which is seen in the individuals, can negatively impact prosthetic stability, retention and serviceability.
Alveolar atrophy: It is the regression of the teeth supporting crescent-shaped osseous part of the upper and lower jaw, after the loss of teeth.

Causes of Bone Loss

- Physiologic
- Environmental
- Pathologic or
- Combination of above causes.

Metabolic factors: Bone loss due to metabolic factors is detailed in **Table 36.1**.
Aging: Continuous pneumatization of the maxillary sinus, as the age of the patient progresses, in the posterior maxilla. Continuous resorption of the alveolar ridges, after teeth extractions over the years.

Table 36.1: Metabolic factors of bone loss

Osteoporosis	*Osteomalacia-calcium/ Vitamin D deficiency*
Loss of bone mass, where there is thinning of cortex, with volume loss of cancellous bone	Loss of bone volume
Ratio of organic matrix to mineral matrix is normal	Increase in the ratio of unmineralized organic matrix (osteoid) to mineralized matrix
Due to senile osteoporosis, postmenopausal osteoporosis, hyperparathyroidism, Cushing's syndrome	Due to vitamin D deficiency, renal osteodystrophy, secondary hyperparathyroidism and malnutrition

Trauma: Bone loss secondary to trauma (during extraction or otherwise) affects the dento-alveolar process and overlying tissue.
Periodontal disease: Generalized bone loss is seen due to extensive periodontal problems. The bone loss will show irregular pattern. Routinely, the alveolar process will show loss in the vertical fashion than the width (width is maintained by the presence of the roots of the teeth).
Combination problems: In case of upper full denture with natural lower dentition, the pressure resorption is seen in the upper alveolar ridge, because of the pressure exerted by the natural dentition. The bone loss is vertical, as well as horizontal especially seen in the anterior maxilla.
Disuse atrophy: It can cause alveolar bone loss. But, it is of less importance, when compared with the bone loss in denture wearers.
Long-term denture usage: It is a known fact, that tension forces result in bone opposition and compressive forces result in bone resorption. These forces interact with the edentulous jaw, until a balance is met.

Rate of Resorption of Residual Alveolar Ridges Depends On

- The size, shape, density of the alveolar ridge
- The cellular activity of the osteoblasts and osteoclasts
- The duration, frequency and direction of any previous occlusal forces to the bone
- Forces generated from the present prosthetic appliance
- The patient's resistance to these forces.

Forces applied to the denture bearing areas by the denture are compressive in nature. This results in resorption of the alveolar ridges. Ill-fitting dentures offer excessive compressive forces.

Patterns of Bone Loss

- Tallgren, in 1972, has stated that most of the bone loss occurs in the 1st year of denture wearing and it is 10 times greater than the loss seen in the following years [probably a period of gaining equilibrium between oppositional and destructive forces **(Fig. 36.1)**.
- Tallgren has estimated that the edentulous bone loss (EBL) is up to 1 mm/year, with the greatest loss occurring within 12–18 months after extractions.
- He also demonstrated 4 times more bone loss in the mandible, than in the maxilla over the years (maxilla distributes the compressive forces over a wider surface area).
- The direction of resorption in the maxilla differs from the mandibular bone resorption.



Fig. 36.1: Patterns of bone loss in maxillary and mandibular arch

- The usual resorption of the maxilla is on the buccal and inferior portion of the alveolar ridge. The pattern of EBL results in upward and inward loss of structures. In the anterior maxilla, there is less horizontal bone loss and posterior drift of the anterior crest is seen more than in the edentulous mandible. In the posterior maxilla, there is inward drift of the posterior crest. The width of the maxilla is reduced.
- Because of the progressive resorption over the years, the depth of the palatal vault decreases, and a very thin bone may be present between the floor of the maxillary sinus and the nasal cavity.
- The mandible resorbs downwards and outwards, causing rapid flattening of the ridge. Initially resorption starts on the alveolar part of the mandible. Resorption is faster in the labial and buccal parts of the alveolar ridge. Rest of the basal bone remains unchanged.
- Extractions of teeth done at different times with long-time gaps will exhibit irregular bony ridge pattern.
- Skeletal morphology has got definite role on the resorption pattern of the edentulous maxilla. People with long faces have more alveolar height than those with short faces. Short face patients have greater biting force, therefore are predisposed to greater bone loss. Preexisting skeletal deformity will also lead to disturbance in the relationship of the bony ridges.

Mercier in 1995 has described a resorptive pattern of the edentulous ridge **(Table 36.2)**.

Characteristics of Ideal Denture Base Area

The ideal edentulous ridges, both maxillary and mandibular, should exhibit following features:

- Adequate bone support—broad U-shaped alveolar ridge, with buccal and lingual/palatal cortices as parallel to each other as possible.
- Adequate firm soft tissue coverage—the ridge must have adequate coverage of keratinized firm mucosa with uniform thickness. The presence of supple firm/compressible tissue, without any irregularities is necessary for maximum peripheral seal.
- No bony or soft tissue undercuts or prominences/protruberances
- No sharp ridges
- No presence of peripheral fibrous tissue bands (scars) to prevent proper seating of a denture
- No high muscle or frenal attachments at the crest of the ridge to dislodge the denture
- No soft tissue redundancies or hypertrophies on the ridges or in the sulci
- No intraoral or extraoral pathology
- Proper alveolar maxillary to mandibular ridges relationship in all three planes-A-P, vertical and transverse.

Treatment Planning and Examination

Preprosthetic surgery is an integral part of the oral and maxillofacial surgery. It comprises of both, basic procedures and the sophisticated advanced techniques of reconstructions and rehabilitation of the oral and

Table 36.2: Resorptive pattern of the edentulous ridge (Mercier, 1995)

1.	The ridge is wide enough at its crest to accommodate the recently extracted teeth	Type I—minor ridge modeling. Adequate height/width
2.	The ridge becomes thin and pointed	Type II—sharp atrophic knife-edged residual ridge-deficient both in height/width
3.	The pointed ridge flattens to the level of the basal bone	Type III—basal bone ridge-concave form in posterior areas of mandible and sharp bony ridge form with flabby mobile soft tissue in maxilla
4.	The flattened ridge becomes concave as the basal bone resorbs	Type IV—basal bone resorption-pencil thin flat mandible/maxilla

maxillofacial region. During treatment planning, there should be coordination between the prosthodontist and the oral and maxillofacial surgeon. As the goal of the prosthetic appliance construction is to improve function and esthetics, the requirements to achieve these goals should be discussed by the team members.

The treatment planning will include a thorough medical, surgical and dental history of the patient and medical and dental clinical examination of the patient. This should be supplemented with radiological examination, plus study of the dental casts, whenever indicated. As most of these patients needing preprosthetic surgeries, are in the elderly age group, a thorough medical history should be recorded. Earlier surgical, medical and hospitalization history should be evaluated. Quick assessment of the patient's physical evaluation including vital signs, general functional capacity and psychological status is very important for the treatment planning and its successful outcome. If the patient is on certain long-term medications, then their side effects are known to interfere with the surgical plan. Modification/withdrawal (temporary) of these medications may be required prior to planned surgical procedures. Many drugs known to cause xerostomia—caries problems and periodontal problems in partially edentulous patients and may cause burning sensation in the mouth after wearing the full dentures due to loss of salivary lubrication.

Patient's psychological make up is also equally important to receive the prosthetic appliance and to maintain it. Expectations of the patient, willingness and acceptance of the patient to wear the full denture should be known to the clinician. The unwilling, uncooperative patient can be problematic to handle at times. Patient's cooperation, will power and motivation is absolutely mandatory for the success of the treatment.

For the prosthetic appliance, whether it is in the form of partial denture, crown and bridge or full denture or implant based prosthesis, patient's attitude for maintaining oral hygiene should be taken into account. If the patient is unaware, but willing to learn the basic protocols of oral hygiene maintenance, then it will be helpful for treatment planning for type of prosthetic appliance to be offered to the patient. It is also important to know the patient's parafunctional and food/eating habits.

A good clinical examination will include careful assessment of both soft and hard tissues and should include a good facial esthetic examination and radiological examination.

Facial Esthetic Examination

- Presence of unsupported upper lip
- Poor vermilion show
- Loss of nasolabial fold or decreased nasolabial fold
- Poor/obtuse nasolabial angle with poor projection
- Excessive lower lip show.

The extent or degree of the above features should be noted.

Intraoral Examination

Examination of the alveolar ridges, both maxillary and mandibular should be carried out along with the soft tissue examination of the entire oral cavity including posterior pharynx. Inspection and palpation should be carried out.

- Ridge form should be inspected for the amount and contour of the bone
- Quality and quantity of the overlying soft tissues of the denture bearing areas to be ascertained (vestibular depth and area)
- Location of frenal/muscle attachments in relation to the alveolar crest should be noted
- Presence or absence of soft tissue and bony pathology should be looked for
- Relationship of the maxillary alveolar arch to the mandibular alveolar arch in all three planes.

Systemic evaluation of the alveolar ridge and supporting tissue should be done.

- Ridge form and contour
- Height and width of the ridge
- Quality of the ridge—whether flabby, mobile tissue is present over the ridge
  - Presence of any gross irregularities in the ridge
  - Presence of any exostosis, undercuts, prominences, tori, sharp mylohyoid ridge with severe resorption of external oblique ridge.
  - Buccal and labial, as well as lingual vestibules evaluation for depth and type of soft tissue
  - Examination of palatal vault
  - Tuberosity area—undercuts, hyperplastic tissue, flabby ridge, etc. Height, width, fibrous or excess bony tuberosity can impair the arch space for fabrication of full or partial denture
  - Interarch relationship
  - Adequate post-tuberosity notching.

Supporting Soft Tissue Examination

- The amount of keratinized tissue firmly attached to the underlying bone as well as unsupported by the bone

should be distinguished from poorly keratinized or freely movable tissue.
- Inflammatory areas, scars, ulcers, hyperplastic tissues due to ill-fitting dentures should be looked for.
- Frenal attachments in relation to the alveolar crest—high maxillary labial frenal attachment will need excessive notching in the upper denture to prevent dislodgment. It can be esthetically unpleasing especially in the patients with high smile line. High mandibular lingual frena may affect the design and placement of removable partial denture.
- Both buccal and lingual vestibular depth should be checked.
- On the lingual aspect, mylohyoid muscle attachment and genioglossus muscle attachment should be checked.
- Tongue size and movement is also important for the stability of the denture. Hence needs evaluation.

Radiological evaluation: Radiological assessment should include orthopantograph or panoramic and lateral cephalometric radiographs. In difficult cases, advanced imaging techniques such as computed tomography—dental CT scan, CBCT can be used. Three-dimensional CT scan should be used, if cost permits. The radiographs should be studied to detect any presence of bony pathological lesions, presence of impacted teeth, cysts, tumors, root pieces, etc. Bony trabecular pattern, distance of the neurovascular bundle from the alveolar crest, level of mental foramen, the size and pneumatization of the maxillary sinus can be also scrutinized from the X-rays.

Diagnostic models: It should be mounted on an articulator with proper vertical dimension and studied.

PREPROSTHETIC SURGICAL PROCEDURES

Preprosthetic surgical procedures can be classified as (1) *basic procedures* and (2) *advanced surgery procedures.*

The basic procedures can be carried out under LA on a day-care basis, while advanced procedures will require hospitalization and general anesthesia.

Table 36.3: Bony and soft tissue surgeries

	Alveolar ridge correction bony surgeries		***Soft tissue surgeries***
i.	Labial alveolectomy	i.	Removal of redundant crestal flabby soft tissue
ii.	Primary alveoloplasty		
iii.	Secondary alveoloplasty	ii.	Frenectomy—labial and lingual
iv.	Excision of tori-mandibular, palatal		
v.	Reduction of genial tubercle	iii.	Excision of epulis fissuratum and palatal papillary hyperplasia, denture hyperplasia
vi.	Reduction of mylohyoid ridge		
vii.	Maxillary tuberosity reduction and exostosis removal		
viii.	Removal of undercuts in maxilla/mandible		

The procedures can be carried out for the following:
- Alveolar ridge correction
- Alveolar ridge extension
- Alveolar ridge augmentation.

ALVEOLAR RIDGE CORRECTION

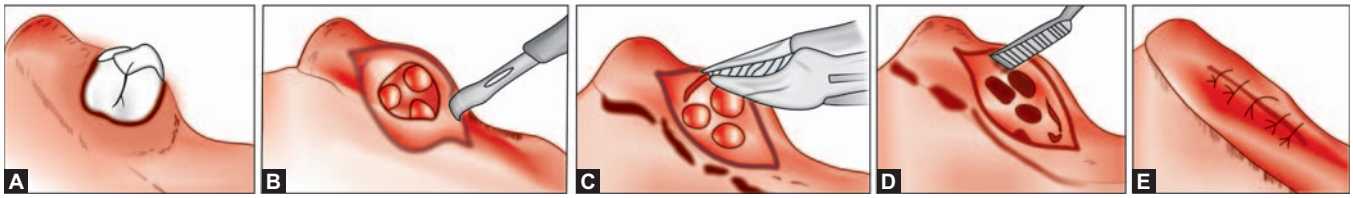
- Bony surgeries
- Soft tissue surgeries **(Table 36.3)**.

Alveolectomy (Labial)

Surgical removal or trimming of the alveolar process is termed as alveolectomy. Clinically, after extraction, whenever there is a presence of sharp margins at interdental, interseptal or labiobuccal alveolar crest, they should be trimmed with rongeur or round bur and smoothened with bone file. The trimming of the alveolar process should be carried out judiciously. Care is taken that only minimum amount of areas should be trimmed. Too much bone loss will result into poor denture base **(Figs 36.2A to E)**.

Alveoloplasty

Alveoloplasty refers to surgical recontouring of the alveolar process. This contouring is done with the purpose to take



Figs 36.2A to E: Single tooth alveolectomy and alveoloplasty

care of bony projections, sharp crestal bone or undercuts. Primary alveoloplasty is always done at the time of multiple extractions or single extraction. Conservation is the key factor in this procedure. Before construction of the prosthetic appliance, maximum efforts should be made to preserve as much of the alveolus as possible. Minimum amount of alveolar bone resorption occurs, if after simple extraction, digital compression of the alveolar cortices is done immediately. This procedure is referred as simple compression alveoloplasty **(Figs 36.3A and B)**.

The aim of alveoloplasty is to recontour the alveolar ridge for providing best possible tissue contour for denture support by maintaining as much bone and soft tissue as possible (Broad alveolar ridges for maximum distribution of masticatory load.). It should be remembered that cancellous bone resorbs faster than the compact bone.

Simple Conservative Alveoloplasty with Multiple Extractions

- If multiple adjacent teeth are to be extracted in a single sitting, the simple alveoloplasty technique is advocated, if there are no other bony irregularities present. Immediately after extractions, the buccal and lingual plates should be compressed with firm digital pressure and the gingival tissue is repositioned and the entire ridge is palpated for locating sharp bony spicules or undercuts. These should be trimmed with rongeur and the edges smoothened with bone file. In case, if there is any excess redundant tissue is present, then it should be trimmed with surgical scissors and interrupted suturing should be done.
- Elevation of a mucoperiosteal flap and buccal cortex reduction can be done for removal of undercuts with rongeurs or a rotary bur **(Figs 36.3A and B).**
- In case of severe periodontitis, alveoloplasty should be done 4–6 weeks after multiple extractions.

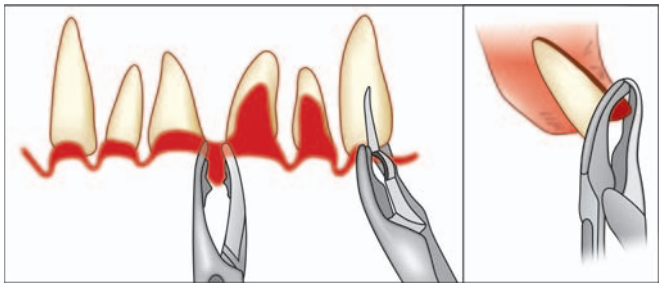


Fig. 36.3A: Simple alveoloplasty after multiple extractions

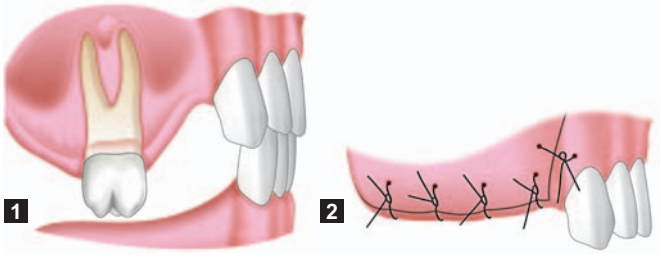


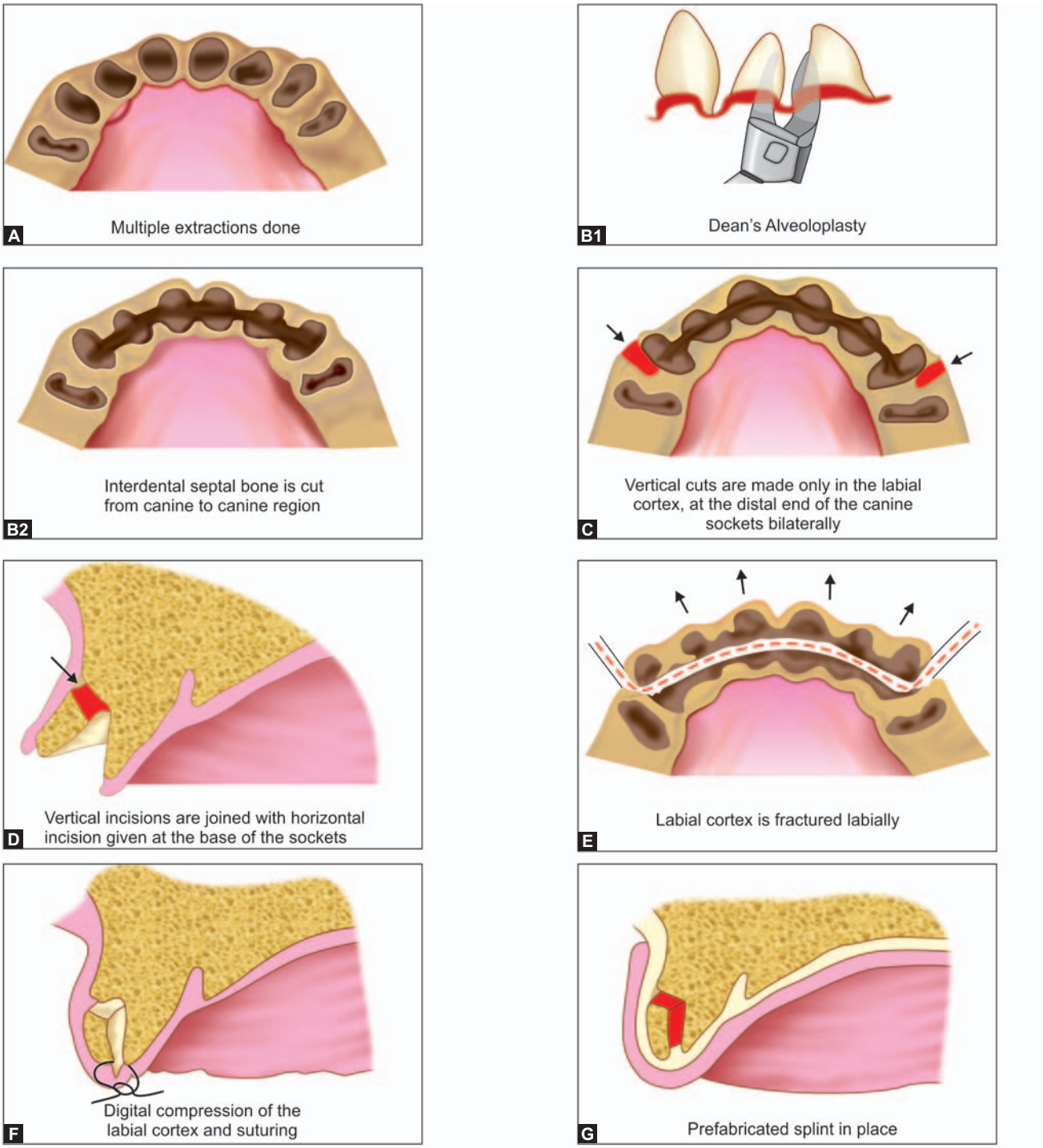
Fig. 36.3B: (1) Overerupted second maxillary molar and earlier extractions of upper premolars have resulted in difference in alveolar bone height; (2) Leveling of alveolar ridge with extraction of molar and suturing

Intraseptal Alveoloplasty—Dean's Alveoloplasty with Repositioning of Labial Cortical Bone-1936 (Figs 36.4A to G)

- Used in maxilla only (mainly in the anterior region)
- Technique is usually used to reduce gross maxillary overjet
- To reduce the volume of cancellous bone, maintaining stress bearing cortical bone intact
- Does not require raising a mucoperiosteal flap
- Carried out immediately following extractions of anterior teeth
- Maintenance of periosteal attachment to the labial plate of bone (decreases postoperative bone resorption and helps remodeling)
- It has got ability to reduce a buccal undercut or labial prominence without significantly reducing the height of the alveolar ridge
- Overall less alveolar bone resorption than with the use of buccal reduction technique. Best long-term results
- Indicated in cases, where adequate bone height exists, but an undercut is present on the buccal aspect of the maxillary ridge.
- Carried out at the time of multiple teeth extractions or early initial postextraction period
- Two steps—(1) removal of intraseptal bone followed by (2) repositioning of the labial cortical bone
- Immediate denture can be planned.

Technique

- Teeth should be extracted without much trauma (atraumatic extractions) to the labial cortex
- With straight fissure bur attached to the surgical handpiece or with rongeur, interdental septal bone is cut from canine to canine region
- With the same bur, vertical cuts are made only in the labial cortex at distal end of the canine extraction sockets bilaterally, without perforation of labial mucosa in the Dean's technique.



Figs 36.4 A to G: Dean's alveoloplasty procedure: (A) Multipe extractions done; (B1) Reduction of interdental septal bone; (B2) All the septa from canine to canine are reduced; (C) Vertical cuts made at the distal end of the canine sockets; (D) Vertical incisions are joined by horizontal cuts given at the base of the sockets; (E) Labial cortex fractured; (F) Compression of the fractured buccal plate and suturing; and (G) Prefabricated splints in place

- With periosteal elevator/osteotome placed into the base of canine sockets bilaterally, labial cortex is fractured (greenstick fracture attached to labial mucosa)
- Digital pressure is used to compress the fractured labial cortex into the palatal direction
- Labial plate and palatal plate will come into approximation with each other
- Any sharp margins at the newly created alveolar crest are filed with bone file
- Interrupted or continuous suturing is carried out.

Obwegeser's Modification for Intraseptal Alveoloplasty-1966

Repositioning of both labial and palatal cortices (Figs 36.5A to G): It is used when the maxillary overjet is gross and inward compression of only labial cortex is not sufficient to reduce the overjet.

- After cutting the intraseptal bone, an inverted cone vulcanite bur is used to widen the socket at the base
- With small disk or bur, horizontal cuts are made at the base of the extraction sockets in the labial and palatal cortices
- With a straight fissure bur, vertical cuts are then made bilaterally in both labial and palatal cortices in the area distal to canine sockets
- With digital pressure, both labial and palatal cortices are compressed together and sutures given.

If immediate denture delivery is planned, then the denture can be made in clear acrylic, so that it can be used as a template to check for any pressure points. The areas showing blanching should be judiciously trimmed, before suturing. Final fit of the immediate denture should be checked, so that rocking of the denture is not present.

Alveoloplasty after the Postextraction Healing

Many times, multiple extractions are carried out at different times, which results in an irregular ridge. The ridge may be knife-edged or multiple areas will show sharp bony spicules, which are very painful to touch. Here, crestal incision is taken and mucoperiosteal flap is reflected judiciously. Care is taken not to tear the flap, as at the sharp points, the separation becomes difficult. The sideways separation with periosteal elevator will help the smooth reflection. Sometimes releasing incisions may be needed. The sharp areas or large undercuts should be trimmed with Rongeur or round bur and suturing done.

Elimination of Unfavorable Undercuts

Due to severe atrophy of the mandible (type 3 or type 4) unfavorable prominences may hinder with the proper denture construction. These undercuts are usually seen in the mandibular lingual aspect—genial tubercle prominence, sharp mylohyoid ridge prominence can be noted. Most of the times, the patient will be wearing old dentures and due to resorption over the years, the dentures become unstable and patient may come with the complaint of severe pain on the lingual aspect, at the mylohyoid ridge. Sometimes, ulceration or inflammation at this region is also seen. Patient is asked to discontinue the use of the dentures and surgery should be planned to relieve these undercuts.

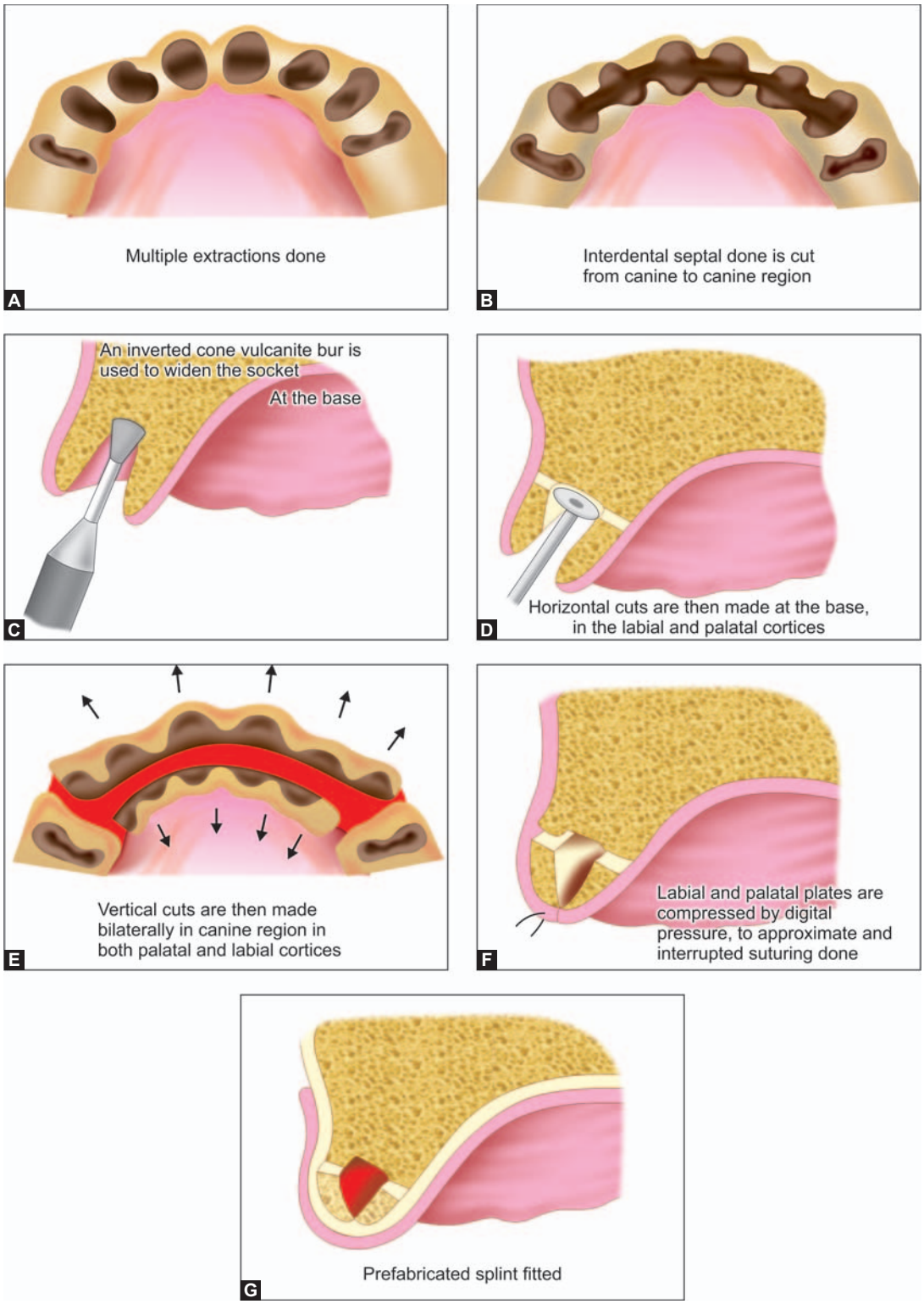
Reduction/Resection of the Genial Tubercles

The genial tubercles, the bony attachments of the genioglossus muscles can become an area of interference, due to gross resorption of the mandibular ridge. The level of the genial tubercles in these cases is seen almost at the crestal level on the lingual aspect. A shelf-like projection is seen, which will dislodge the lower denture with slightest amount of tongue movements, as the peripheral seal on the lingual aspect is not present. Frequently ulceration is also seen over the tubercle area **(Fig. 36.6).**

- A crestal incision is made from the lower canine to canine region, after infiltration of local anesthetic solution
- No reflection of the flap is done on the labial side
- A full thickness mucoperiosteal flap is reflected to expose the genial tubercle
- The muscle attachment is removed with sharp dissection
- Excision of the tubercle is done by rotary instrumentation or Rongeurs
- Smoothening can be done with a bone file
- Copious irrigation of the area prior to suturing is needed.

Reduction of mylohyoid ridge: Usually, there will be concavity present, immediately below the alveolar crest with prominence of mylohyoid ridge below. This procedure can be performed by using LA pterygomandibular block technique **(Figs 36.7A to E).**

- A crestal incision is taken in the posterior ridge region
- Oblique releasing incision is given at the distal end of the incision, going toward buccal cheek area to avoid damage to lingual nerve
- Mucoperiosteal flap reflected on the lingual side to expose the medial surface of the mandible at the mylohyoid ridge region
- The tissue from the floor of the mouth and lingual mucoperiosteum is protected by inserting flat blade of the tongue depressor in between the flap and the bone



Figs 36.5A to G: Obwegeser's modification for intraseptal alveoloplasty: Repositioning of both labial and palatal cortices

- By using osteotome or round bur, the reduction of the mylohyoid ridge is carried out, after dissecting mylohyoid muscle fibers away
- Bone is smoothened with bone file
- Soft tissue flap is returned back and the complete lingual vestibule checked with digital pressure for any sharp areas
- After complete smoothening, the sutures are given.

Excision of Tori

Torus is exostosis/overgrowth of cortical/cortico-cancellous bone, which is localized to particular area, usually benign and asymptomatic and slow growing. Origin is unknown.

In maxilla: Usually seen in midline of the palate. Incidence—20% in females and 10% in male patients. Multiple shapes and configurations can be seen. It will vary from single smooth elevation to multiloculated pedunculated bony masses (single-domed, spindle-shaped, nodular, lobular and multiple).

In mandible: Found in 8% of population, with same incidence in male and females. Usually bilateral tori in the premolar region on the lingual aspect are seen in 80% of the patients. May be single or multiple or multilobulated. When the teeth are present, tori are of no consequence and usually there are no speech problems associated with them. But after extraction, the upper denture construction or lower partial/full denture construction is not possible, unless tori are excised.

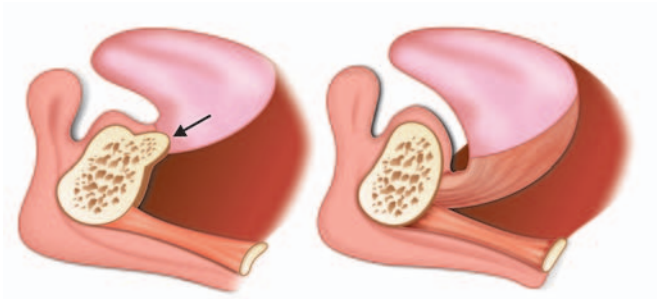


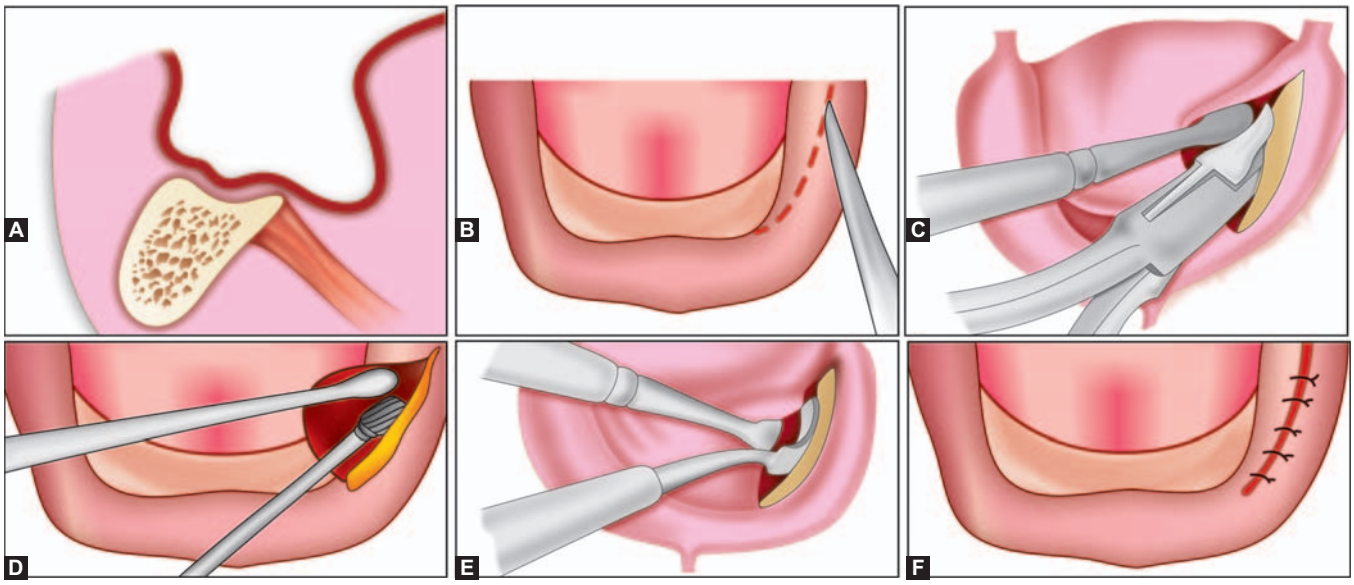
Fig. 36.6: Reduction of genial tubercles—Diagrammatic representation

Indications for Reduction/Removal/Excision of Tori

- An extremely large torus, filling the palatal vault
- A large torus that may extend beyond the postdam area.
- Ulceration/traumatization/hyperkeratinization of the overlying mucosa
- Deep bony undercuts
- Interference with the function—speech-deglutition
- Psychological consideration—malignancy/cancer phobia
- Food lodgement under the folds and projection of the tori.

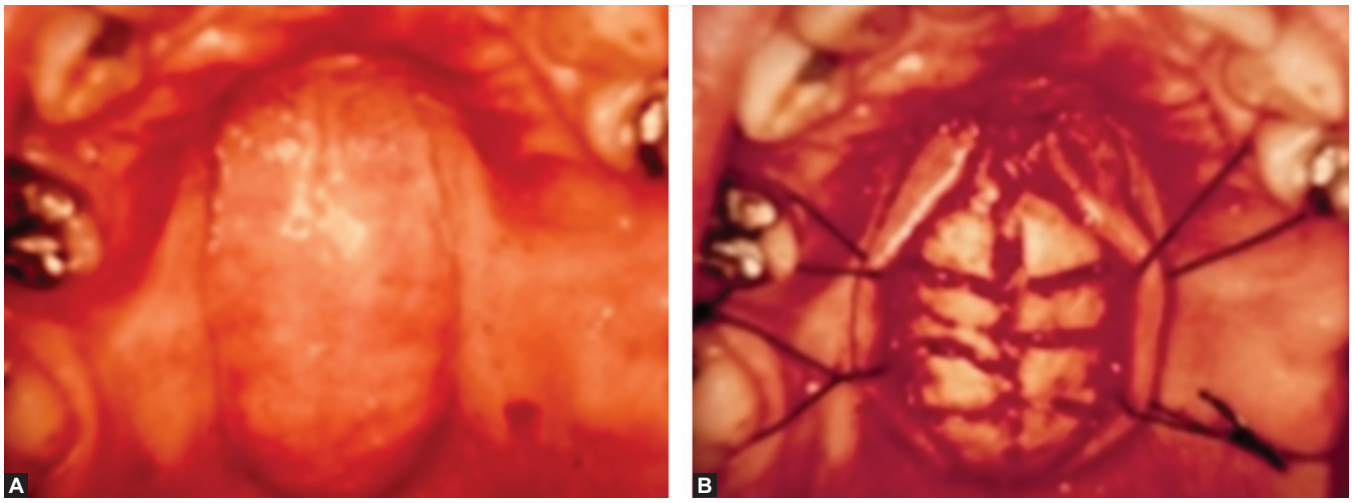
Technique for Excision of Palatal Torus

- LA—bilateral greater palatine and incisive nerve block
- Anteroposterior linear incision is made in the midline of the palate **(Figs 36.8 and 36.9)**

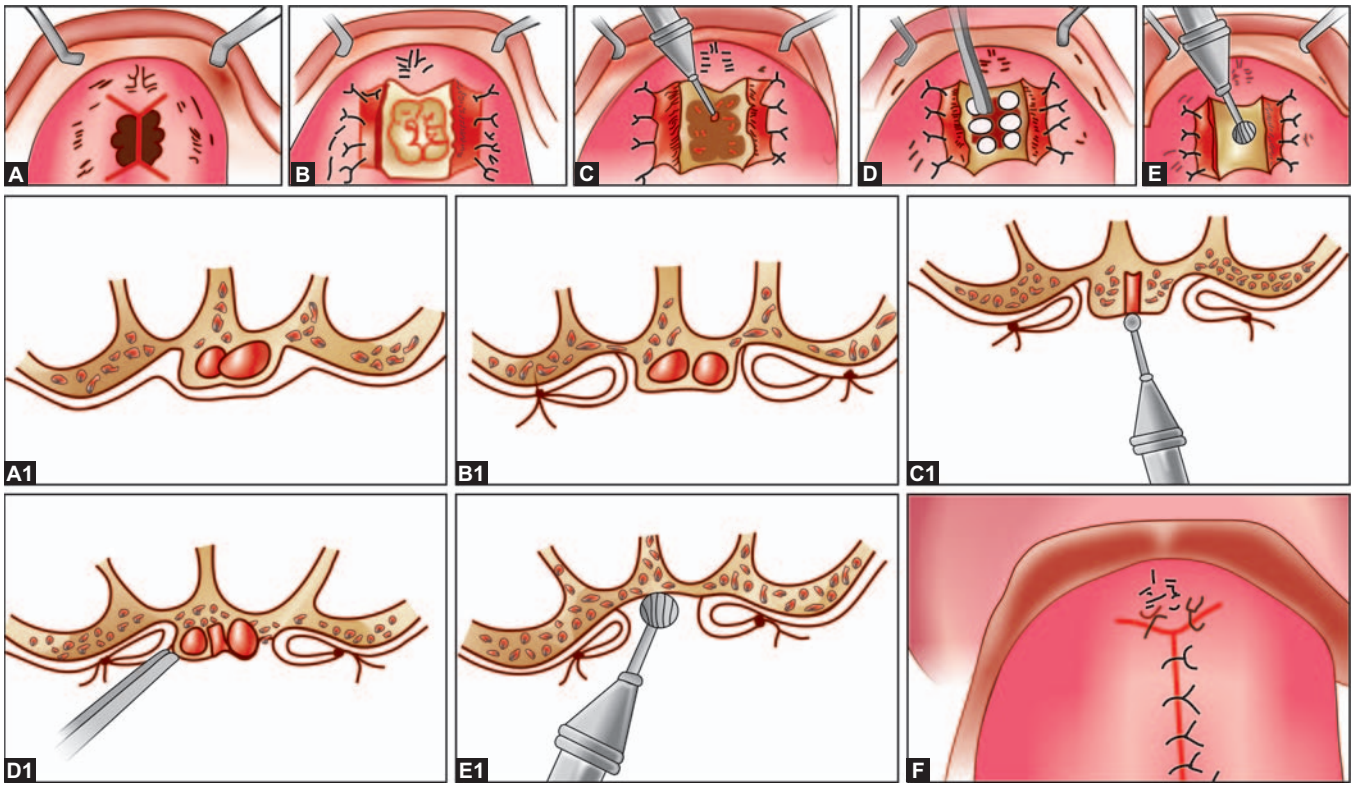


Figs 36.7A to E: Reduction of mylohyoid ridge

- Y-shaped releasing incisions at one or both the ends of incision
- Thin-lobulated mucosa should be carefully handled
- Two mucoperiosteal flaps raised with periosteal elevator, from the midline, sideways.
- Retraction sutures can be placed on both the flaps to maximize the exposure.
- The torus should never be excised en mass, because



Figs 36.8A and B: (A) Clinical intraoral picture of palatal torus; (B) Reflection of mucoperiosteal flap and retraction sutures and sectioning of torus is seen in this intraoperative picture



Figs 36.9A to F: Palatal torus and its surgical excision: (A) Palatal torus and incision; (B) Reflection of mucoperiosteal flap; (C and D) Sectioning of torus and removal of multiple small segments; (E) Complete removal of torus and smoothening of palatal vault; (F) Final suturing

of the proximity to the nasal floor (perforation into the nose—oronasal communication)
- Division of the torus into multiple segments should be done with the bur (vertical and horizontal multiple cuts)
- The small pieces removed with the chisel and mallet
- Large round bur is used judiciously to final finish
- Excess soft tissue should be trimmed
- Continuous "over and under" type suturing using fine absorbable suture material using atraumatic needle (no trauma to thin mucosa)
- Prefabricated acrylic stent/splint can be given or iodoform tie over pack can be used (to prevent hematoma).

Possible Complications

Intraoperative

- Bleeding-injury to greater palatine vessels
- Fracture of the palatal shelf
- Oronasal/oroantral perforation.

Postoperative

- Hematoma formation
- Sloughing/necrosis of the palatal mucosa
- Gaping/nonhealing wound
- Oroantral/oronasal fistula.

Mandibular Torus Removal

- LA—pterygomandibular block with local infiltration
- Incision over alveolar ridge in lower premolar region (edentulous) **(Figs 36.10A and B)**
- Lingual sulcus incision, without releasing incision in the dentulous patients (prevents damage to the lingual nerve)
- Mucoperiosteal flap is raised, only on the lingual aspect of the mandible, without perforation over the torus area.
- Make a purchase point/groove with the bur, on the medial aspect of the torus, parallel to the medial surface of the mandible from the base to the superior margin
- Cleavage is taken with the osteotome placed in the purchase groove/trough
- Gentle tapping to excise the entire torus
- Smoothening with round bur/bone file
- Irrigation and suturing.

Possible Complications

Intraoperative

- Injury to submandibular salivary gland duct
- Excessive bleeding
- Laceration of the mylohyoid muscle
- Tearing of the flap.



Fig. 36.10A: Clinical picture of mandibular tori

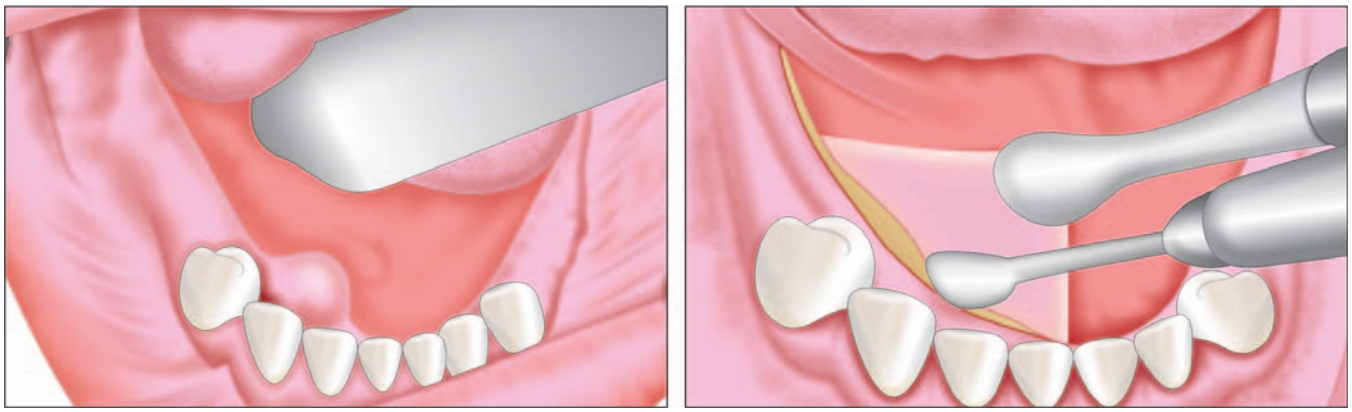
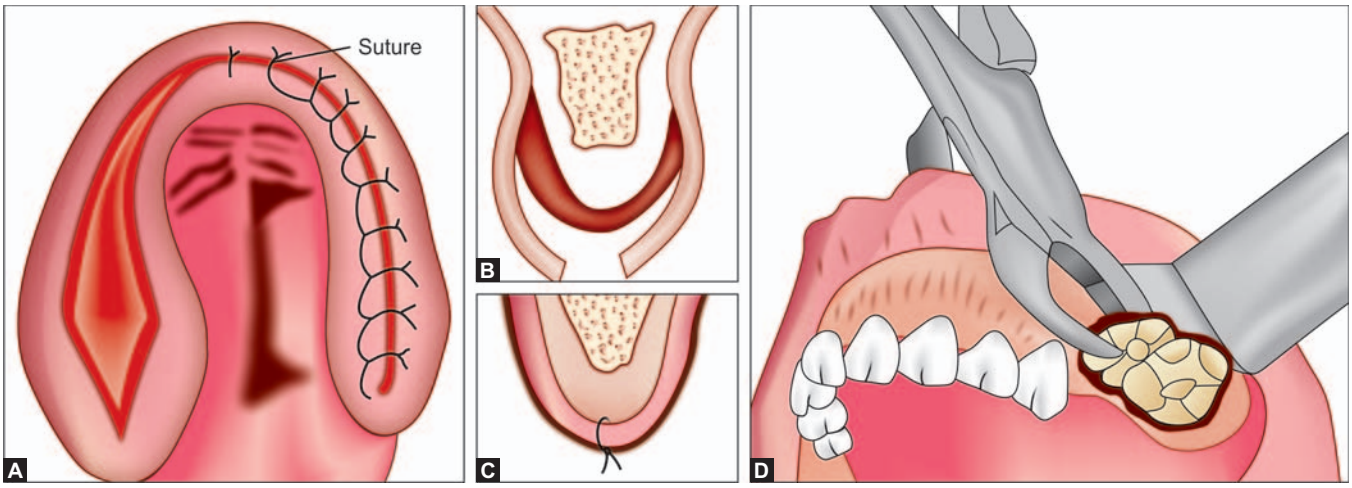
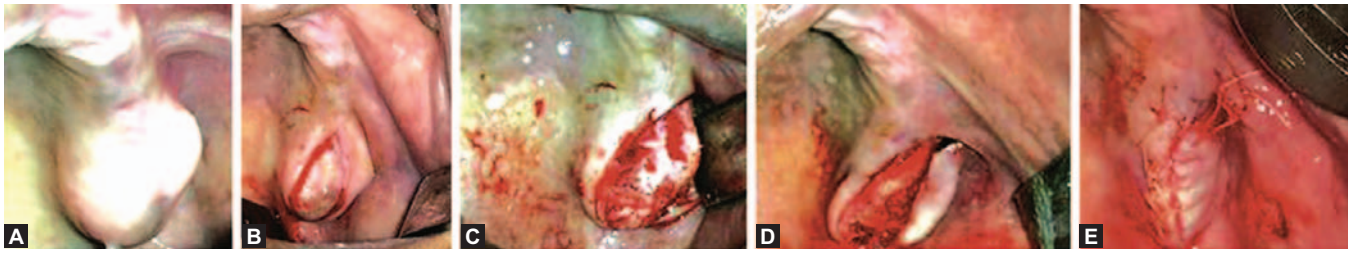


Fig. 36.10B: Diagram showing surgical removal of mandibular tori



Figs 36.11A to D: Maxillary tuberosity reduction. (A) Incision for tuberosity deformity correction and final suturing; (B) Bony reduction and contouring; (C) Suturing; (D) Elimination of buccal exostosis in posterior maxillary area



Figs 36.12A to E: Reduction of exostosis in the tuberosity region. (A) Clinical picture of bulbous tuberosity; (B) Elliptical wedge of soft tissue excised; (C) Exostosis exposed; (D) Bony exostosis reduced and contoured; (E) Final suturing

Postoperative

Life-threatening hemorrhage in the floor of the mouth infection airway obstruction.

Maxillary Tuberosity Reduction and Exostosis Removal

- Excess horizontal and vertical bony/soft tissue in the maxillary tuberosity region may interfere with denture construction
- Excessive bony undercut/mobile or redundant soft tissue/hyperplastic fibrous tissue may be present (or both)
- The excess tissue protrudes into the intermaxillary space to a degree that, there is insufficient space for lower dentures **(Figs 36.11 and 36.12).**

Radiographs are often necessary—OPG or intraoral periapical view:

- To determine the extent of the bone and soft tissue in the enlarged tuberosity region
- To locate the level of the floor of the maxillary sinus.

Aims

- To remove the bony/soft tissue irregularities
- To create adequate interarch space for the proper construction of the prosthetic appliance in the posterior area.

Technique

- LA—infiltration or posterior superior alveolar and greater palatine blocks
- A crestal elliptical incisions from tuberosity to premolar area
- The mucoperiosteum is undermined and the section of the tissue between the elliptical incisions is removed
- If the excess soft tissue is fibrous, hyperplastic, then the medial margins of the incisions on both the sides are thinned out tangentially to remove the wedge of excess fibrous tissue till the bony crest
- If the excess tissue is primarily bone, then rest of the mucoperiosteum is reflected till the vestibular depth
- Excess bone/buccal exostosis is then removed from the crest of the ridge and from the buccal plate (if excessive



Courtesy: Dr Vidya Rattan

Figs 36.13(1)A to E: (A) Clinical picture of denture hyperplasia; (B) Excision of hyperplastic tissue; (C) Excised specimen; (D) Healing in process; (E) Final denture in place

undercut exists). This can be accomplished with chisel, mallet or burs.

- After the desired contour is achieved, the excess soft tissue is trimmed along the incision edges to correct the redundancy
- The flap is sutured and a stent is placed
- In case of sinus perforation, a collagen matrix can be placed prior to suturing.

Soft Tissue Surgeries for the Correction of Alveolar Ridge

Removal of redundant crestal soft tissue: Presence of fibrous, hyperplastic tissue often gives rise to flabby and wobbly ridge form. Dense, fibromatous or the softer and redundant type of tissue results in an unstable base for dentures **(Figs 36.13-1 to 13-3)**.

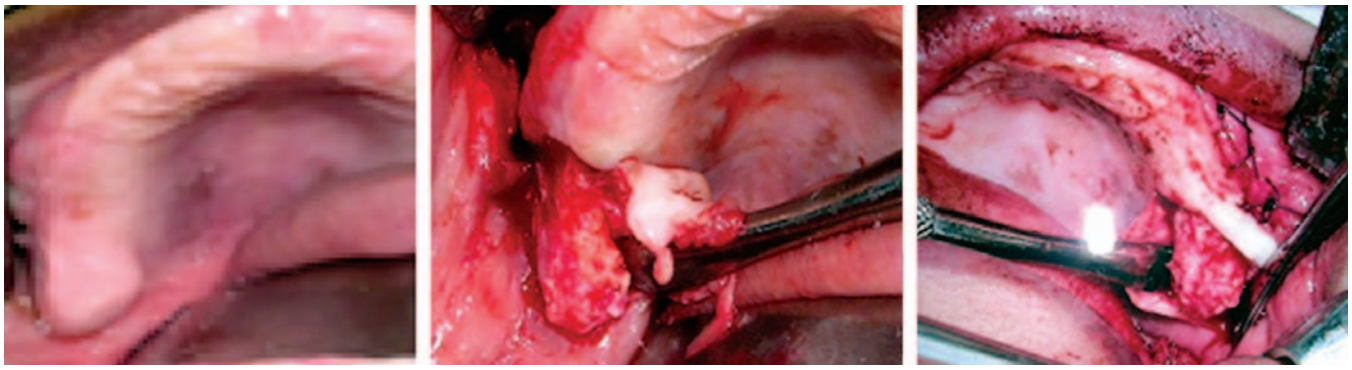
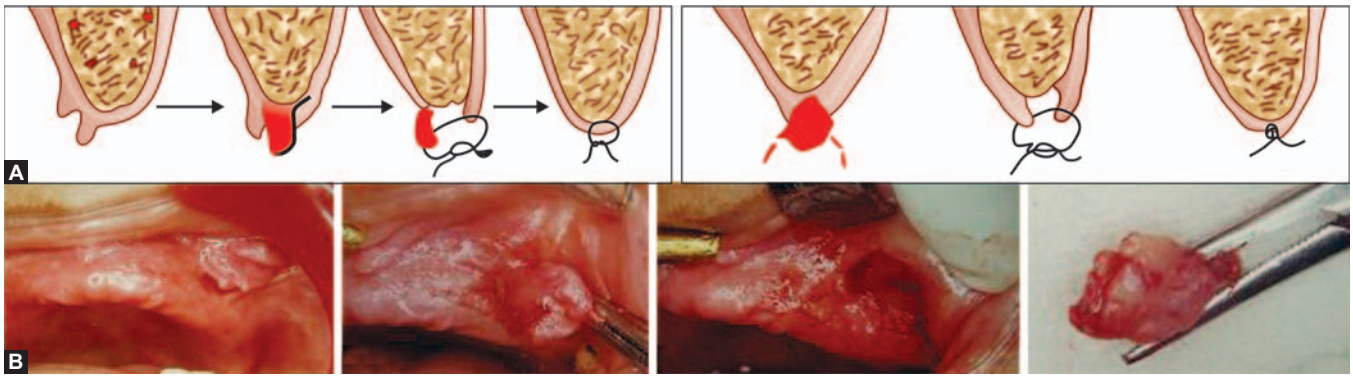


Fig. 36.13(2): Surgical excision of bony undercuts, as well as removal of excess flabby tissue in maxillary tuberosity area



Figs 36.13(3)A and B: (A) Diagram: Surgical removal of redundant crestal soft tissue; (B) Surgical picture of the same

- In maxilla—enlarged tuberosity
- In mandible—enlarged retromolar pad.

Denture granuloma or hyperplasia: It is seen in the palatal region or at the vestibular depth, obliterating the sulcus or sometimes on lingual aspect of the lower dentures. The tissue is inflamed, fibrous and hyperplastic.

Irrespective of the site, to reduce these hyperplastic tissues, elliptical incisions are taken on either side of the tissue and later on submucosal resection of the excess tissue is carried out, by doing tangential excision or two parallel incisions are taken on the buccal and lingual aspect of the tissues for excision. The patient is instructed to stop using the ill-fitting dentures.

Excision of epulis fissurata: These are the benign, pedunculated lesions present as excessive or redundant tissue of the vestibule, frequently associated with overextension of the denture border or ill-fitting dentures. Sharp excision, electrocauterization, cryosurgery or laser excision can be done.

Palatal papillary hyperplasia: It is due to chronic denture irritation, under an ill-fitting denture. There can be superimposed *Candida* infection. Denture should be relieved in this area and antifungal agents can be prescribed prior to excision of the lesion. Supraperiosteal excision with an electrocautery can be done.

Frenectomy

Frenal attachment is a thin band of fibrous tissue and a few muscle fibers covered by mucous membrane. Maxillary midline frenum is most commonly seen, lingual frenum is also found in some of the patients. Maxillary and mandibular frena are also found in premolar-molar areas.

Indications: High attachments of labial frena or fibrous bands attached near the alveolar crest in the buccal regions often displace the dentures during function. Many times ulceration can be seen at the frenal attachments due to impingement of the denture peripheries. One option is to relieve the denture borders at these frenal attachments. But for persistent problem, frenectomy should be considered.

Maxillary midline frenum or labial frenum (Figs 36.14A to C): It usually extends from the upper lip to the crest of the alveolar ridge and it can at times extend toward palate to the incisive papilla. Whenever there is a lot of tissue available, then a cross-diamond excision is used. The base



Figs 36.14A to C: Labial frenectomy and suturing procedure

of the frenum at the alveolar crest is grasped with hemostat and incision is taken below and above the hemostat. The surgical defect is created by excision of fibrous band. The closure can be done by interrupted sutures. The small defect at the alveolar crest can be left to granulate.

The Z-plasty procedure can be used, when the frenum is broad and the vestibule is short. These types of procedures can be used for eliminating the frenum, as well as for deepening the vestibule (some amount of vertical lengthening can be obtained). It also lessens the tension of the scar band.

V-Y type of incision can be used for lengthening localized area. Broad frena in premolar-molar area can be treated by taking semilunar incision at the mucogingival junction and a supraperiosteal dissection is done. The superior edge of the incision is sutured at the depth of the vestibule to the periosteum and the rest of the raw area below is allowed to heal by secondary epithelialization. Use of prefabricated stent is necessary.

Lingual Frenectomy

Lingual frenum is attached to the crest of the alveolar ridge and it connects to the tongue, below the tip of the tongue in edentulous patient. In dentulous patient, it is attached to the lingual gingiva, behind the mandibular incisors. This condition is also known as tongue tie or ankyloglossia **(Figs 36.15 and 36.16)**.

Aim of Surgery

- To correct speech
- Prior to denture construction
- To improve the tongue mobility

Technique

- LA—bilateral lingual nerve block with local infiltration

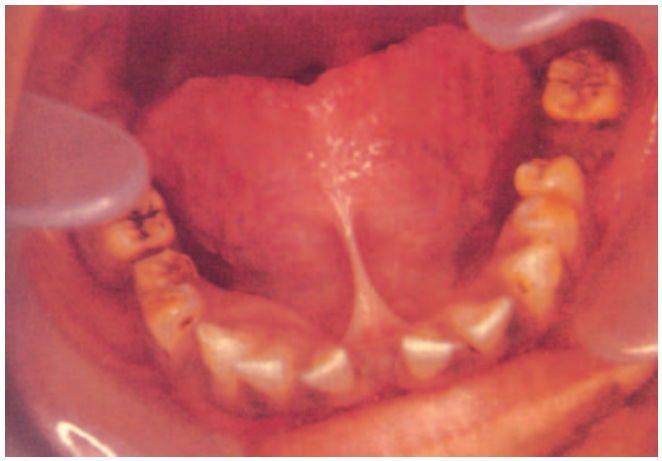
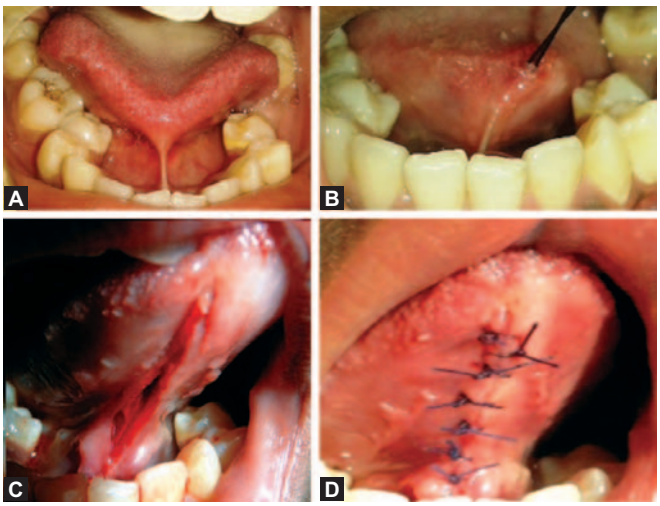


Fig. 36.15: A clinical picture of tongue tie or ankyloglossia



Courtesy: Dr Kumar Nilesh

Figs 36.16A to D: Intraoperative pictures of surgical release of lingual frenum

- Tongue traction suture is taken to improve visibility and control and stabilization of the tongue during procedure
- One hemostat can be placed at the anterior attachment of the frenum to the tongue and another hemostat be placed at the inferior attachment to the ridge
- A cross-diamond incision along the edge of both the hemostats is made.
- Submucosal dissection on either sides to undermine lingual and sublingual mucosa is carried out
- Dissection of genioglossus muscle fibers is done, if necessary
- Care is taken to avoid damage to the submandibular duct orifice
- Suturing done in vertical manner.

Intraoperative Possible Complications

- Injury to superior lingual vessels
- Injury to Wharton's duct/papilla.

Postoperative Complications

- Hematoma in the floor of the mouth
- Pain, restricted tongue movements
- Partial dysphasia.

RIDGE EXTENSION PROCEDURES

Whenever there is an inadequate vestibular depth present, (due to mandibular atrophy and high muscle and soft tissue attachments) to increase the retention and stability of the denture, deepening of the vestibule is considered. To utilize this treatment option, sufficient amount of height of the alveolar bone should be available. In extreme atrophy cases, where resorption of the basal bone has taken place, this option is out of consideration.

Deepening of the vestibule without any addition of the bone is termed as "*vestibuloplasty" or "sulcoplasty" or "sulcus deepening procedure". Vestibuloplasty is a procedure to increase the depth by uncovering the existing basal bone of the jaws surgically and by repositioning the overlying mucosa, muscle attachments to a lower position in the mandible/superior position in the maxilla".* Vestibuloplasty can be done in the maxilla or in the mandible or in both the jaws. Secondary epithelization vestibuloplasty is the procedure of choice for patients with extensive scarring and epulis, etc. Supraperiosteal dissection is carried out to raise a flap. Superior/inferior (maxilla/mandible) repositioning of this flap by suturing it to the periosteum. Exposed periosteum heals secondarily. There is about 50% relapse of the vestibular depth subsequently noted. Tissue/alloplastic graft vestibuloplasty procedure is better, as various graft materials can be used to cover the exposed periosteum and to hold the repositioned muscles in place **(Table 36.4)**.

Table 36.4: Types of vestibuloplasties

Maxilla	***Mandible***
Submucosal vestibuloplasty	Submucosal vestibuloplasty
Maxillary "pocket inlay" vestibuloplasty (obwegeser)	
Secondary epithelization procedure	Secondary epithelization procedure
• Lipswitch technique • Kazanjian's technique • Godwin's modification • Clark's technique • Obwegeser's modification • Lingual vestibuloplasty	
	A. Trauner's Technique
	B. Caldwell's Technique
	C. Obwegeser's technique (Combination of buccal and lingual vestibuloplasty)
Tissue/alloplastic grafts vestibuloplasty	Tissue/alloplastic grafts vestibuloplasty
Palatal/buccal mucosa, skin, alloplastic materials—collagen sheet, burn mesh, etc.	

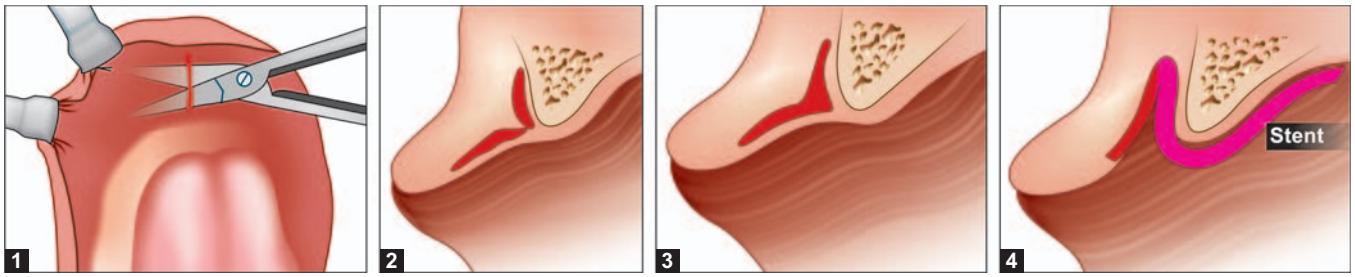
Mandibular techniques are further divided into two categories:

1. Those done on the labial side
2. Those done on the lingual side.

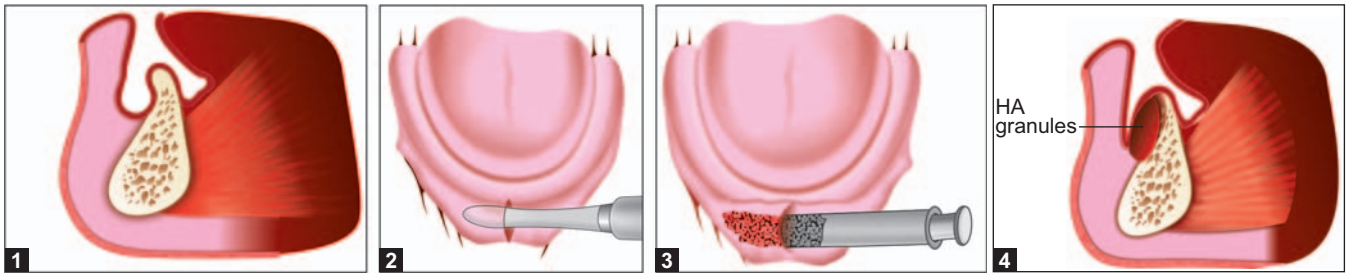
Submucosal Vestibuloplasty Technique

- Useful for maxillary and mandibular labial, buccal vestibules **(Figs 36.17A and B)**
- Was first described by MacIntosh and Obwegeser (1967)
- Indicated, when the dentures are unstable, due to shallow vestibular depth and/or high muscle attachments, but with good underlying bone height and contour available
- The mouth mirror test is used to determine the adequacy of mucosa available.

A mouth mirror is placed in the vestibule and elevated against the bone to the desired vestibular depth. If mobile tissue is present and no abnormal shortening of the lip occurs, then adequate mucosa exists to perform the submucosal vestibuloplasty.



Figs 36.17A: 1, 2, 3, 4—Maxillary submucosal vestibuloplasty procedure



Figs 36.17B: 1, 2, 3, 4—Mandibular submucosal vestibuloplasty procedure-Hydroxyapatite granules insertion in the pocket created to increase the width of the alveolus

- A vertical midline incision is made in the labial vestibule
- A supraperiosteal tunnel is made from (R) premolar to (L) premolar area
- In maxilla, further separate incisions may be given in first molar region for further advancement
- The intervening submucosal tissue is then excised or repositioned superiorly
- The new depth is maintained by placement of preformed dentures/stents, which can be fixed to the mandible with circummandibular wiring and to the maxilla by per alveolar wiring.

Maxillary "Pocket Inlay" Vestibuloplasty (Obwegeser)

The procedure involves surgically creating pockets in the maxillary buttress and the piriform aperture region and denture flange extensions into these pockets improve the total denture retention.

Preoperatively, patient's upper denture is modified with extended labial flanges.

Intraoral incision is taken just above the attached gingiva from one maxillary buttress to the other buttress. Supraperiosteal dissection is performed to create two pockets on either side of the piriform aperture. The dissection is extended superiorly to the level of the attachment of the levator angularis muscle. Dissection is also continued in the midline up to the base of the piriform aperture. Perforation of the nasal cavity should be avoided.

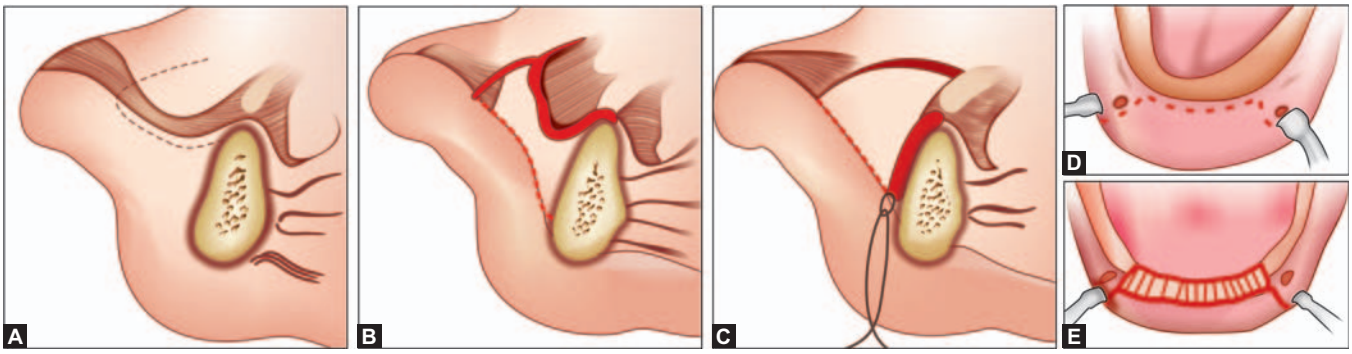
The impression of the newly created pouches is taken using impression compound. The labial flanges of the denture are then covered with the split thickness skin graft. Denture is then inserted into the place. Bilateral circumzygomatic wires and piriform margin wires are used to stabilize the denture, which remains in place for a week.

Advantages

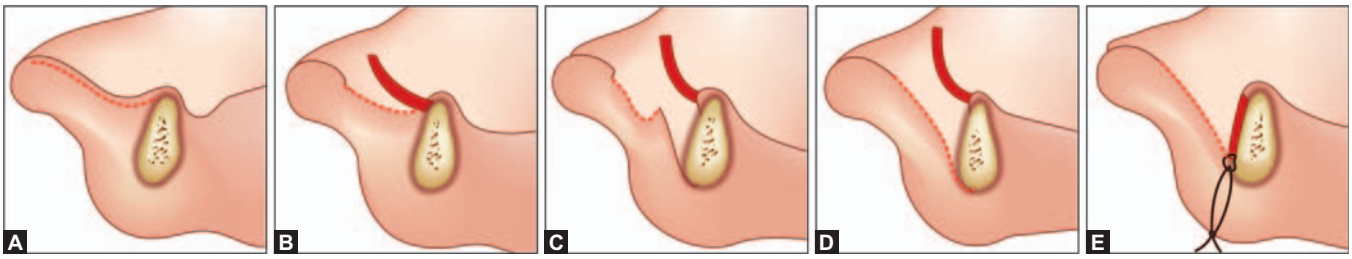
- Patients with only mandibular anterior teeth present, often have pronounced loss of the anterior maxillary alveolus, because of constant occlusal trauma. The above procedure is useful in such cases.
- Increases denture stability and retention by increasing the vestibular area and provides pocket sphincters to grip undercut denture flanges
- In severe atrophy—tuberoplasty can be combined
- Deficiency in the nasolabial fold region can be improved.

Labial Vestibular Procedures—Lip Switch Technique

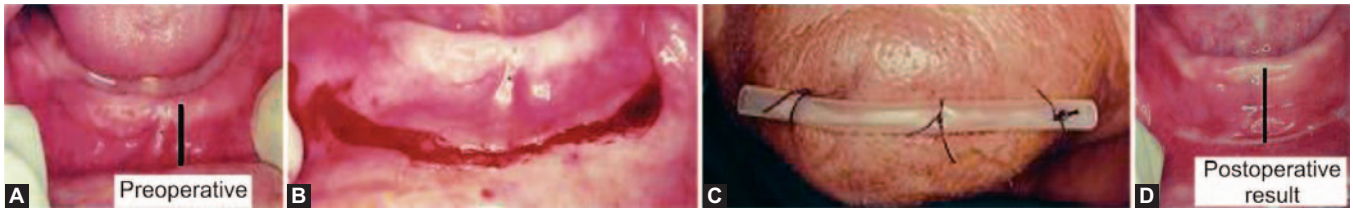
The procedure will be known as transpositional flap vestibuloplasty or lip switch procedure, when the soft tissues from the inner aspect of the lip is shifted to a



Figs 36.18A to E: Kazanjian labial vestibuloplasty procedure



Figs 36.19A to E: Modified Kazanjian technique for mandibular vestibuloplasty



Figs 36.20A to D: Kazanjian vestibuloplasty surgical procedure

favorable zone on the alveolar bone, so that the increase in the denture bearing area is achieved.

This method effectively increases the vestibular depth in the mandible, when the patient has a bone height of 15 mm or more in the anterior region. Implants or bone grafts should be considered in the patients having less than 15 mm of bone height in the anterior region. The mucosa must be healthy and must exhibit no fibrosis, scarring or hyperplasia.

Kazanjian Technique (1924): Oldest Technique

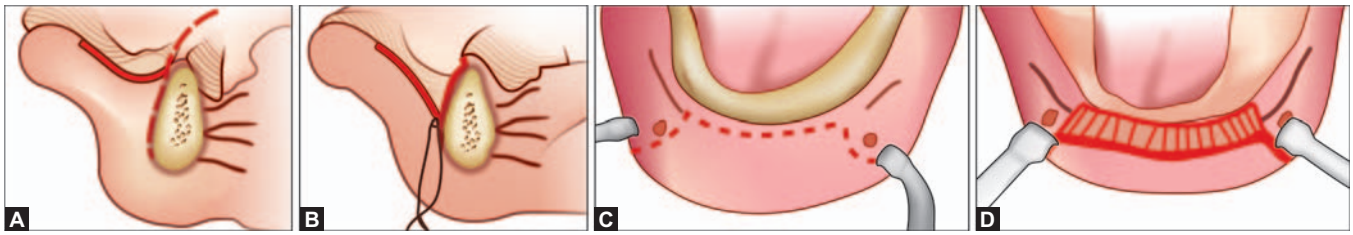
- Uses mucosal flap from the inner aspect of the lower lip to increase the depth of the anterior mandibular labial vestibule **(Figs 36.18A to E)**
- Carried out in premolar to premolar region only
- Raw area is left on the lip side to heal by secondary intention
- Periosteum on the bone is left intact.

Drawback: Severe scarring of the lip mucosa may decrease the flexibility of the lower lip (Poor long-term results).

Procedure (Figs 36.20A to D): A submucosal dissection is done from the inner aspect of the lower lip to the mucogingival junction, near the alveolar crest on the labial side. A supraperiosteal dissection is directed inferiorly to remove muscle and connective tissue attachments to the desired vestibular depth. The raised mucosal flap is adapted to the depth of the new vestibule and fixed with the sutures or a stent. The raw area on the lip is left alone.

Godwin's Modification (1947)

Mucosal incision on the inner aspect of the lip is designed longer than the proposed vestibular depth to be achieved. The mucosal flap is elevated and pedicled near the crest of the ridge. Near the superior portion of the periosteum attached on the bone, an incision is made



Figs 36.21A to D: Clark's vestibuloplasty procedure

and followed by the dissection inferiorly to the desired depth. The periosteum once again is incised at the depth of the previous dissection. The labial periosteal margin is sutured to the incised lip mucosa, then the pedicled flap is sutured to the periosteum at the depth of the vestibule. A stent can be used. Postoperatively, extraoral dressing can help the adaptation of the tissue intraorally **(Fig. 36.19).**

Clark's Technique

- Supraperiosteal flap based on the inner aspect of the lip **(Figs 36.21A to D)**
- Leaves raw surface on the bone, covering the inner lip surface, thereby reducing bleeding, postoperative pain and scarring
- An incision is started slightly labial to the crest along the alveolar ridge.
- Mucosal flap based on the inner aspect of the lip is undermined, till vermilion border, to ensure adequate mobility and overcorrection.
- Supraperiosteal dissection is done, along the labial surface of the alveolar bone till the desired vestibular depth
- Edge of the mobilized flap is pushed into the new vestibular depth area and held in position by sutures passed through the chin area extraorally and tied around cotton roll or rubber catheter placed below the chin
- As the alveolar bone is covered by periosteal layer, it heals quickly by granulation.
- Success rate is better than Kazanjian method.

Obwegeser's Modification (1959)

Similar to Clark's method, except the area of the alveolar bone with its periosteal attachment is covered with a split thickness skin graft and held in position by sutures or stent constructed preoperatively. Instead of skin, mucosal graft has also been tried.

- Covers the bone and ensures faster healing
- Reduces chances of postoperative infection
- Less bone loss and scarring.

Lingual Vestibuloplasty

Floor of the mouth extension or floor of the mouth lowering the following:

Soft tissue attachments on the lingual aspect can interfere with prosthetic rehabilitation. Posteriorly the mylohyoid muscle and genioglossus muscle anteriorly, on the lingual surface of the mandible are the two problem areas.

- Technique provides an adequate denture bearing area
- Eliminates the muscle attachments that dislodge the prosthesis
- Used in the mandible, when the mylohyoid and genioglossus attachments are close to the alveolar ridge.

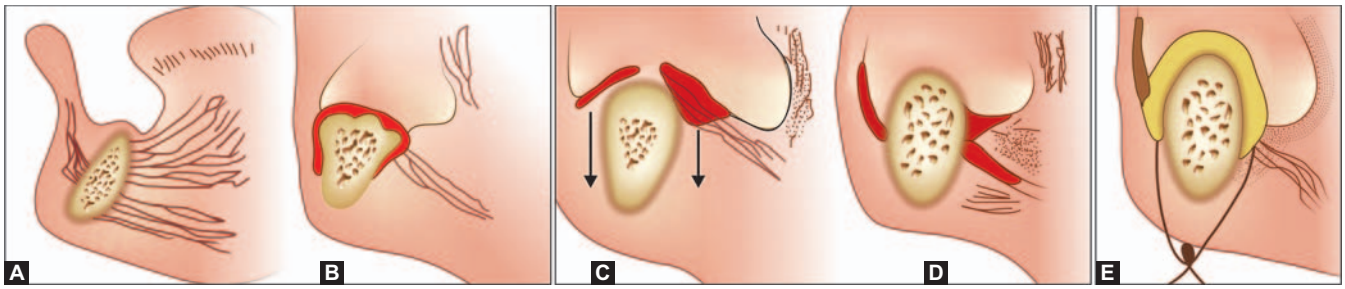
Floor of the mouth extension or floor of the mouth lowering can be done by following methods:

A. Trauner's technique

- Used for increasing the depth of the floor of the mouth in the mylohyoid region.
- Incision given over lingual side of the alveolar ridge bilaterally, in the posterior region or from second molar to second molar region.
- Supraperiosteal dissection is done to identify mylohyoid muscle.
- Instrument is passed below mylohyoid muscle and muscle separated from the bony attachment.
- Care is taken to avoid lingual nerve damage.
- Fixation of incisal edge of the mylohyoid muscle to a new desired vestibular depth on lingual side by:
  - Sutures passed extraorally over the skin at the inferior border of the mandible
  - Placement of the skin graft and preformed denture/stent.

B. Caldwell's technique

- Entire lingual mucoperiosteal flap is reflected from molar-to-molar region.
- Mylohyoid ridge is reduced/removed along with the reduction of genial tubercle.
- Mylohyoid muscle and superficial fibers of genioglossus muscles are pushed inferiorly.



Figs 36.22A to E: Obwegeser's buccal and lingual vestibuloplasty surgical procedure

- Rubber tubing placed in the lingual vestibule and the flap is held in position at the vestibular depth, by sutures passed through the skin extraorally, at the inferior border of the mandible.

C. Obwegeser's technique [combination of buccal and lingual vestibuloplasty (Figs 36.22A to E)]

- Incision is given on the alveolar ridge
- Mucosal flap raised buccally and lingually
- Mylohyoid muscle attachment and only superficial fibers of genioglossus muscle are separated on the lingual side.
- Edges of buccal and lingual flaps attached/sutured to each other, below inferior border of the mandible.
- Skin graft is placed over entire alveolar ridge.
- Preformed acrylic stent/denture placed and fixed to the mandible, with circummandibular wiring.

RIDGE AUGMENTATION PROCEDURES

When the alveolar ridge resorption is so extreme, that the alveolar bone has completely disappeared and in maxilla, the height has been reduced to the point that a nearly flat surface exists between the vestibule and palate and the piriform aperture lies just beneath the gingiva. And in the mandible, the basal bone has shown considerable amount of resorption with the mental nerve positioned almost at the crest and very thin mandibular alveolar ridge exists, which can end up in fracture easily. Vestibuloplasty is out of consideration in such cases, until the replacement of necessary supportive bone is done.

Many techniques have been described in the literature for augmenting the bony architecture of the maxilla and/or the mandible.

Two approaches/options are available: (1) augmentation of alveolar bone (2) place the implants.

Aims

- Restoration of optimum/near optimum ridge height and width, ridge form, vestibular depth and optimum denture bearing area.
- Protection of neurovascular bundle
- Establishment of proper interarch relationship
- Improvement of retention and stability of denture
- Improve the patient comfort for wearing the denture.

Limitations

- Physical condition of the patient
- Metabolism of the patient (healing capacity)
- Nutritional deficiencies
- Availability of adequate soft tissue coverage
- Compliance of the patient for major surgery.

Ridge augmentation procedures can be carried out in the maxilla or in the mandible or both **(Table 36.5)**.

Materials used for Augmentation of Alveolar Ridge

- Autogeneous bone graft—iliac crest, rib grafts
- Allogenic bone grafts—freeze dried cadaver bone
- Alloplastic material—hydroxyapatite
- Metal mesh with autogenous corticocancellous bone
- Metal mesh with hydroxyapatite.

Mandibular Ridge Augmentation

Superior border grafting/augmentation (Fig. 36.23A and B): Davis (1970) has described a technique for ridge augmentation, where ridge height is less than 10 mm. It uses two 15–16 cm. Long-autogenous rib grafts—from 5th to 9th rib. One rib is scored vertically at the cortex of inner surface of one rib (Kerfing), followed by contouring the same rib in the shape of the mandibular ridge. The rib graft is fixed to the mandible, at superior border, either with transosseous wiring or circummandibular wiring.

Table 36.5: Ridge Augmentation procedures

A.	***Mandibular ridge augmentation***
	1. Superior border augmentation a. Bone grafts—Iliac crest b. Cartilage grafts—Rib c. Alloplastic grafts—Hydroxyapatite-HA 2. Inferior border augmentation a. Bone grafts (autogenous or allogenic freeze dried cadaveric mandible) b. Cartilage grafts. 3. Interpositional or sandwich bone grafts a. Bone grafts b. Cartilage grafts c. Hydroxyapatite blocks. 4. Visor osteotomy. Vertical osteotomy 5. Onlay grafting—autogenous, alloplastic, allogenic material. 6. Pedicled augmentation-horizontal osteotomy—recent 7. Ridge split technique for implant placement—recent
B.	***Maxillary augmentation***
	1. Onlay bone grafting—autogenous/allogenic grafts 2. Onlay grafting of alloplastic material 3. Interpositional or Sandwich grafts • Sinus lift procedure • Ridge split technique for implant placement—recent
C.	***Augmentation in combination with orthognathic surgery***
	1. Mandibular osteotomy procedure 2. Maxillary osteotomy procedure.—LeForte I and Posterior segmental osteotomy 3. Combination procedure
D	***Distraction osteogenesis—Vertical, Anteroposterior vector—recent***

The other rib graft is made into corticocancellous particles and moulded around the first rib graft. The surgical flap is then closed. Iliac crest grafting to the superior border also can be used.

Disadvantages

- Donor site morbidity
- Second surgical site necessary
- Continued resorption of the grafted sites
- Soft tissue dehiscence or limitation.

Hydroxyapatite blocks can be used (precarved in a horseshoe-shaped manner blocks are available).

Inferior border grafting (Fig. 36.24): This surgical procedure is indicated, when the alveolar ridge is less than 5–8 mm in height and is at risk of pathological fracture.

First described by *Marx and Saunders* (1986), for reconstruction of the mandible following resection.

Modified by *Quinn* (1991)—used for augmentation of atrophic ridge and subsequent placement of implants.

Technique: A supraclavicular incision similar to the incision used in bilateral neck dissection is made, from mastoid to mastoid region. Subplatysmal dissection, till the inferior border of the mandible is done. Incision through the periosteum is completed from angle to angle. A freeze-dried allogenic cadaver mandible is hollowed out and multiple perforations made into it to allow for revascularization of the packed cancellous bone graft. This allogenic mandible will be used as a tray. The cancellous bone graft is harvested from the iliac crest. The cadaver mandible is then filled with autogenous cancellous graft particles and is fixed to the inferior border with 2-0 vicryl



Fig. 36.23A: Kerfing of the rib to mould it to the contour of alveolar ridge

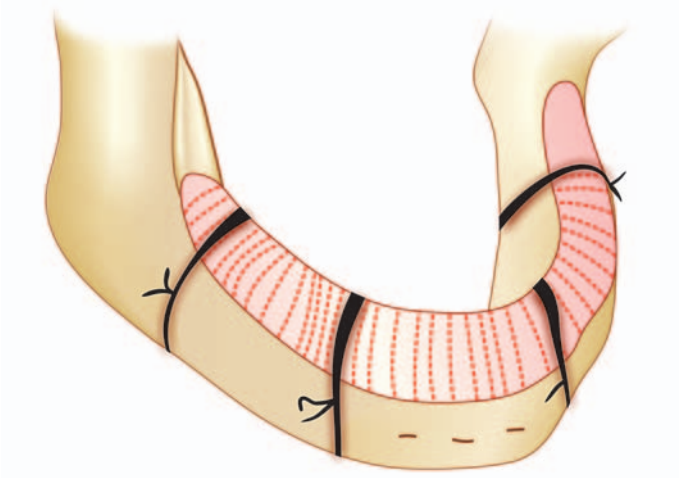


Fig. 36.23B: Superior border rib grafting fixed with circummandibular wiring

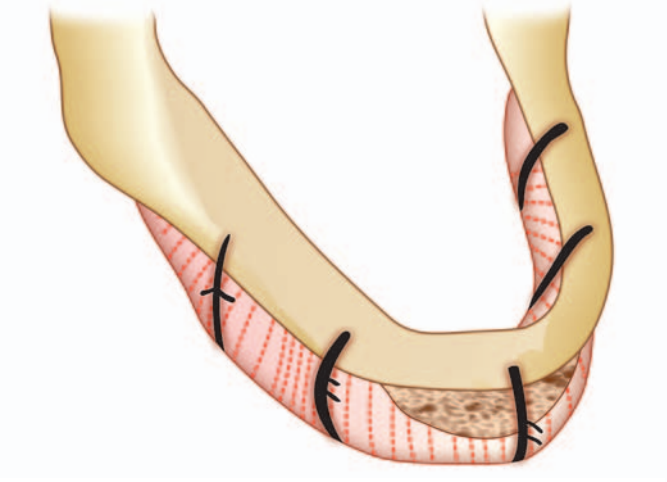


Fig. 36.24: Inferior border grafting

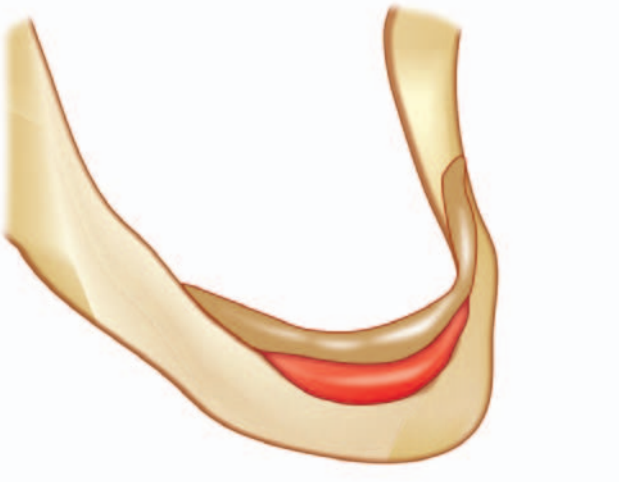


Fig. 36.25: Interpositional graft

sutures, by circummandibular fixation. The neck flap is closed in tension free manner. Osseointegrated implants can be placed approximately 4–6 months following surgery.

Advantages

- Since no surgery is done intraorally, patient's old dentures can be used as transitional dentures
- By using this technique 11–17 mm of bone augmentation can be achieved with a resorption rate of only 5% over the first several years
- Increased bone height to accommodate implant surgery
- Extraoral flap gives adequate tissue coverage
- Also lower one-third of the facial height is increased. Esthetically better results.

Interpositional Bone Grafts (Sandwich Grafting)

Danielson and Nemarich advocated this technique. During this procedure, a horizontal osteotomy is performed, splitting of the residual maxilla or mandible and bone is grafted into this osteotomy gap **(Fig. 36.25).**

In mandible, sandwich technique is mainly used for augmentation of the anterior mandible, between the mental foramina. The autogenous or allogenic bone or hydroxyapatite grafts can be used successfully. Delivery of the prosthetic appliance is delayed 3–5 months for allowing the remodeling of the bone. Secondary vestibuloplasty procedures may be necessary. For the posterior region, reasonable amount of bone should be present above mandibular canal.

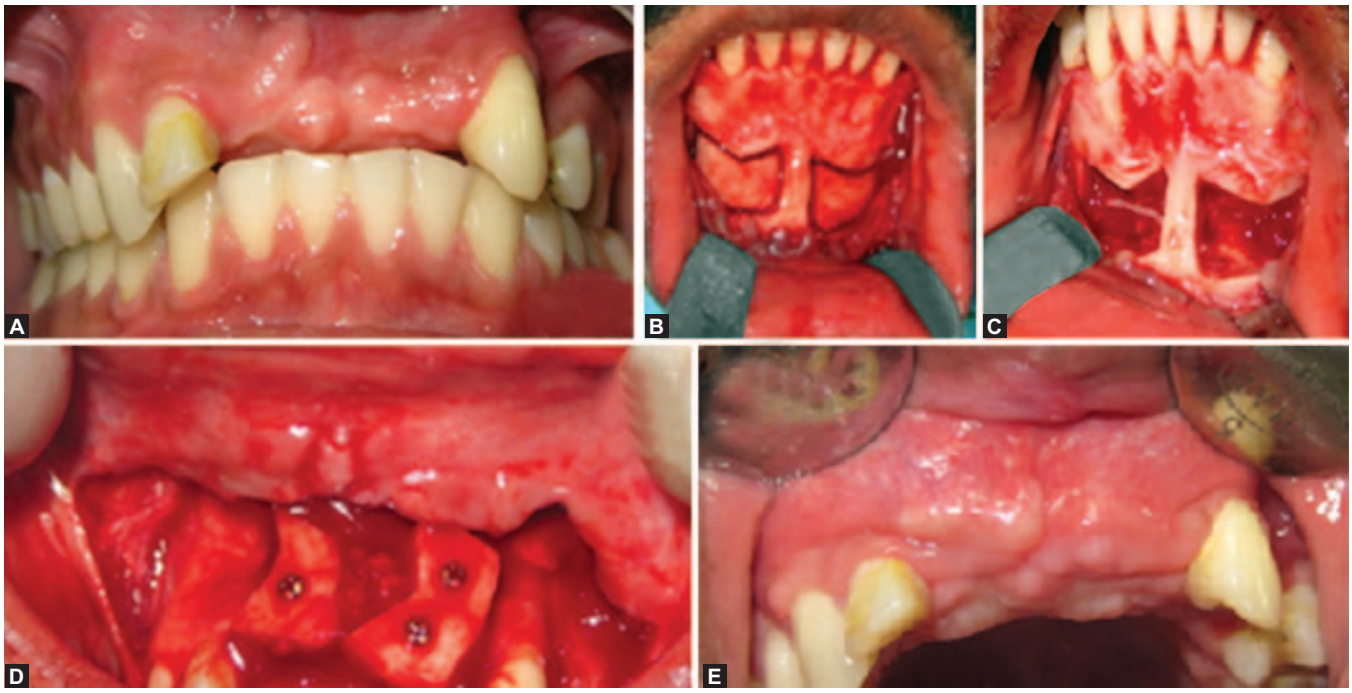
Advantages

- Less resorption rate than onlay grafting
- More predictable long-term results
- Decreased incidence of nerve paresthesia than the visor osteotomy
- Can be used in conjunction with osseointegrated implants. Implants are placed through the superior free segment of the bone and through the interpositional bone and secured inferiorly within the remaining segment of the mandible. Implant success rate is reported as high as 98% with low resorption rate.

Onlay Grafting

When adequate height is present, but width is inadequate for prosthesis in the maxilla or mandible, the option of onlay grafting (-autogenous, allografts, alloplastic materials) should be considered. Oldest technique for onlay augmentation with synthetic allograft, i.e. hydroxyapatite is advocated by Obwegeser via submucosal vestibuloplasty technique. After creating a tunnel via midline, a putty is formed of hydroxyapatite crystals, mixed with saline/blood, and is injected via syringe into the submucosal tunnel. Hydroxyapatite is the prototype of nonresorbable ceramic bone substitute. It is a calcium phosphate having physical and chemical characteristics nearly identical to tooth enamel and cortical bone. It is a simple office procedure. No donor site morbidity and material is biocompatible **(Figs 36.17B, 36.26A to E and 36.27A to F).**

Solid or porous blocks of hydroxyapatite have been used as onlay or interpositional grafts to improve the bony defect. The hydroxyapatite powder can be mixed with



Courtesy: Dr Vidya Rattan

Figs 36.26A to E: Onlay bone grafting procedure: (A) Decreased width of anterior maxillary ridge; (B) Symphysis mandible region graft harvesting; (C) Two block bone grafts from symphysis region; (D) Onlay bone grafts secured with screws in anterior maxillary region; (E) Improved width of the anterior maxilla, ready to receive implants

autogenous bone graft particles, for the bigger defects along with Titanium mesh for graft support.

Osseointegrated implants can be used in conjunction with onlay bone grafting procedure. Block bone graft from mandibular symphysis region 6 mm of bone in horizontal and vertical dimensions can be obtained easily without damaging the anterior teeth roots. Ramus buccal shelf also can be used as donor site, which can offer 2–4.5 mm cortical bone.

A split thickness rib graft/iliac crest bone graft can be used, as an onlay graft in the maxilla or mandible. Rib is more uniform and can be placed in one piece. Iliac crest is placed in blocks or pieces, not uniform.

Advantages

- Improves the height and width of the maxillary alveolar bone
- Can be used both in the anterior and posterior region.

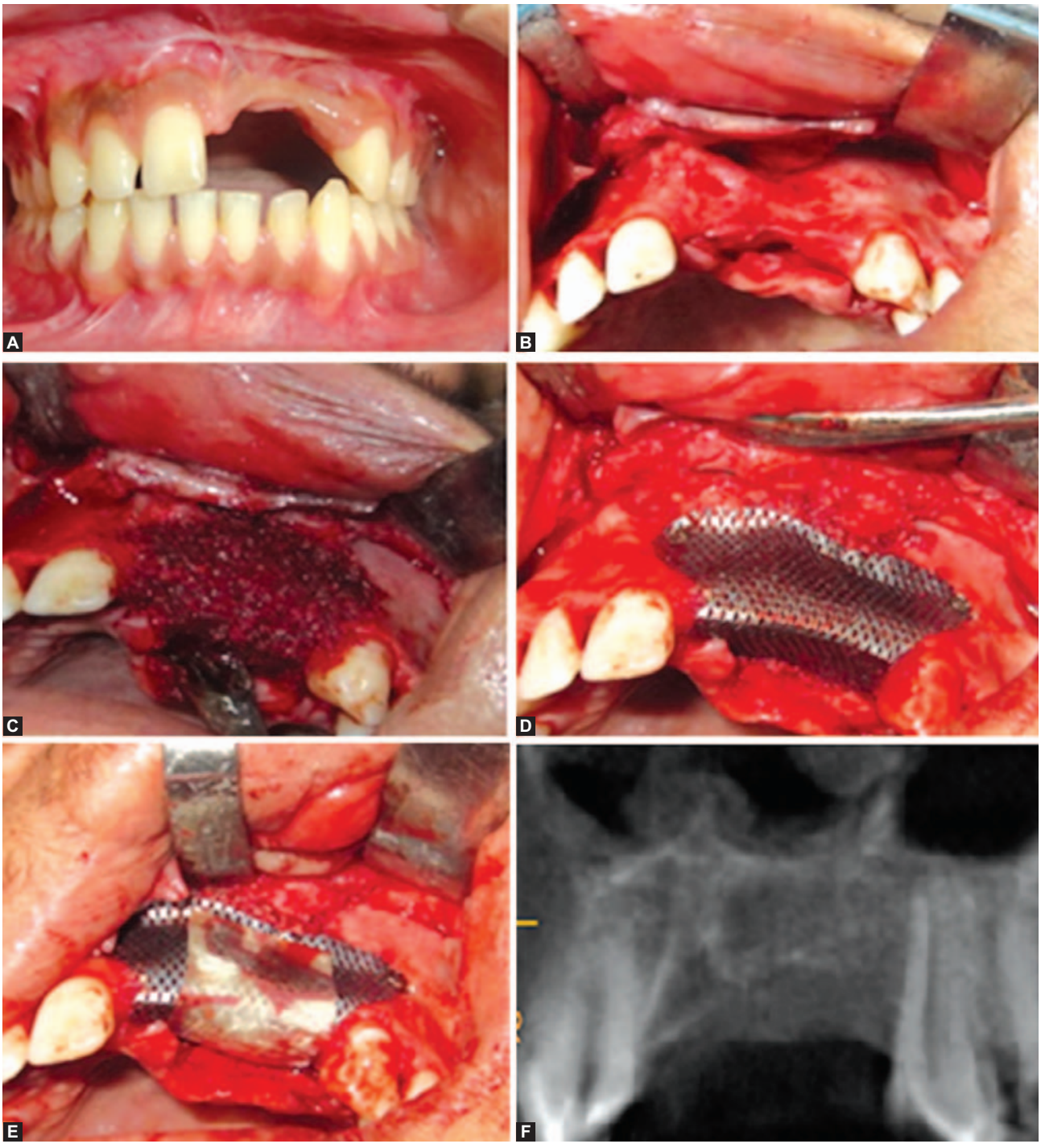
Technique: A high vestibular incision is taken to facilitate good water tight closure and to achieve good undermining of the tissues for relaxation. Mucoperiosteal flap is reflected to expose the defect. Small perforations are made in the external cortex by using small round bur to create bleeding and promotion of clot formation and neovascularization. The grafting material is placed/molded over the external cortex. Placement of barrier membrane helps in regeneration and preservation of the graft. Scoring of the periosteum is done before closure for proper mobilization of the flap.

Visor Osteotomy–Vertical Osteotomy

Harle, in 1975, proposed this technique. The goal of visor osteotomy is to increase the height of the mandibular ridge for denture support. The visor osteotomy consists of central splitting of the mandible in buccolingual dimension and the superior positioning of the lingual section of the mandible, which is wired in position. Cancellous bone graft material is placed at the outer cortex over the superior labial junction for improving the contour **(Fig. 36.28).**

Modified Visor Osteotomy—modified by Peterson and Slade in 1977

Modified visor osteotomy consists of splitting of mandible buccolingually by vertical osteotomy only in the posterior regions and a horizontal osteotomy in the anterior region. It is a combination of vertical and horizontal osteotomies. The posterior lingual segments are then pushed superiorly on both the sides and



Courtesy: Dr Vidya Rattan

Figs 36.27A to F: Onlay bone grafting procedure. (A and B) Showing the defect in the maxillary alveolar ridge, both in height as well as in width; (C to E) Cancellous bone graft from iliac crest and use of tantalum foil plus collagen membrane for guided tissue regeneration-GTR; (F) Postoperative X-ray showing the take of the graft. Note the increase in height and width.

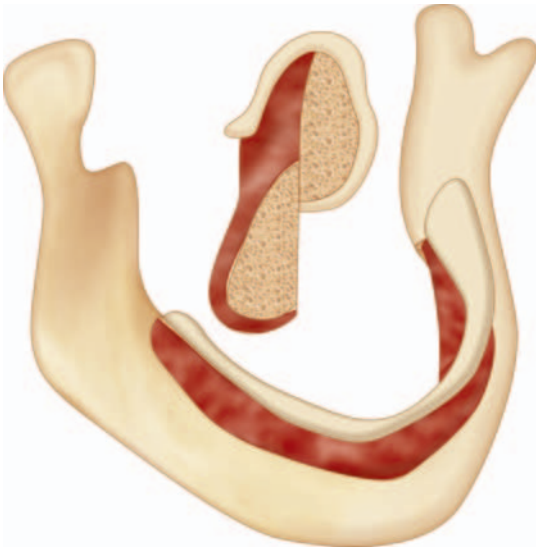


Fig. 36.28: Visor osteotomy

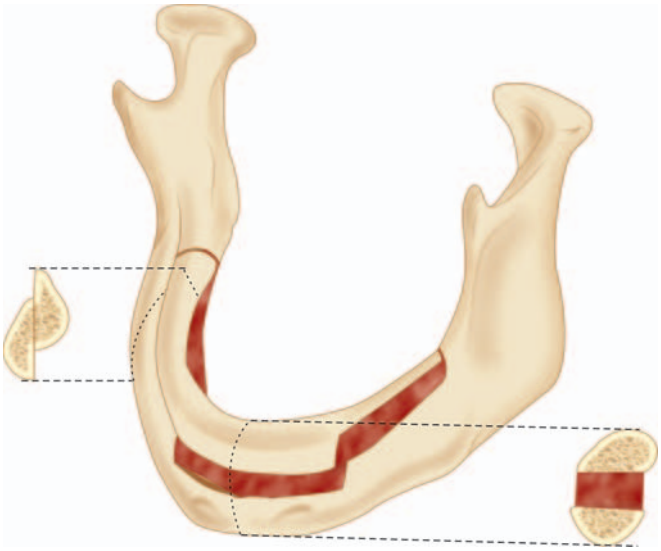


Fig. 36.29: Modified visor osteotomy

anterior fragment is also pushed superiorly and fixed with wires to the posterior newly mobilized lingual segments. Corticocancellous bone graft particles with hydroxyapatite granules is placed in the gap between the superior and inferior anterior segments. Rest of the graft material can be molded on the buccal aspect of the posterior segments **(Fig. 36.29).**

Advantage: Less risk of fracture. Better repositioning of superior and posterior segments. Correction of mild to moderate A-P descripancies. Also allows increase in the amount of augmentation in more stable fashion. 80% of the height is maintained at the end of 3–5 years.

Disadvantages

- Nerve paresthesia and dysesthesia
- Need for hospitalization
- Donor site morbidity
- Inability to wear the dentures for 3–5 months following surgery.

Pedicled Augmentation–Horizontal Pedicled Osteotomy

This is a recently developed technique. Schettler and Holteman et al., in 1977, reported a resorption pattern after this method of 0–2 mm. After 6–18 months, horizontal osteotomy is carried out pedicled on lingual tissues/muscles, for postoperative blood supply. Sandwitch grafting is done between superior and inferior segments. Bone healing with pedicled flaps occurs primarily and does not depend on replacement of nonvital bone. The attachment of genioglossus and suprahyoid muscles helps.

Sinus Lift Procedure or Sinus Grafting (Figs 36.30 (1 to 11)

It is mainly used to assist with the placement of osseointegrated implants in the posterior maxilla. Due to pneumatization of the maxillary sinus and atrophy of the ridge, the sinus floor is lowered almost to the crest of the alveolar ridge in the posterior region. In order to improve the implant support, the sinus lining at the floor is lifted up surgically and the bone graft is placed between the sinus lining and the inner aspect of the alveolar crest or floor of the maxillary sinus in the posterior maxilla.

Totum (1986) was the first surgeon to perform the sinus grafts. A variety of materials have been used with varying degree of success (autogenous bone, allogenic bone, tricalcium phosphate, hydroxyapatite, calcium phosphate, ceramics and calcium deficient carbonate apatites from bovine bone).

Technique: Intraoral incision is taken on the maxillary crest or slightly on the palatal aspect with vertical releasing incision from canine to tuberosity area. Anterolateral wall of the maxilla is exposed by reflecting the mucoperiosteal flap. A bony window is made with a trap door type osteotomy, just lateral and posterior to the canine fossa.

15–20 mm long inferior horizontal osteotomy cut is placed 3 mm above the sinus floor. The anterior vertical osteotomy cut is placed perpendicular to horizontal osteotomy and parallel to the lateral nasal wall, the

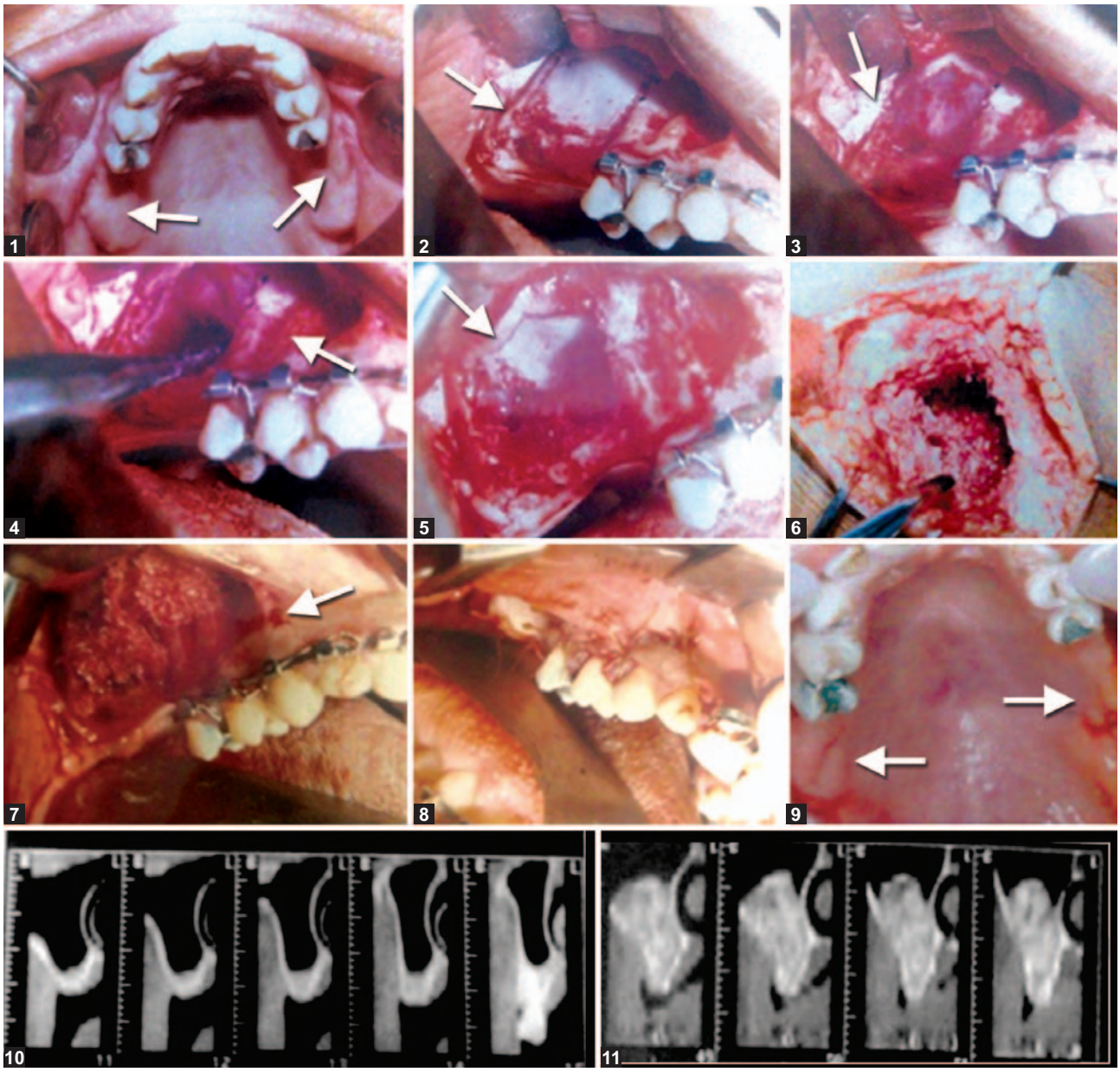
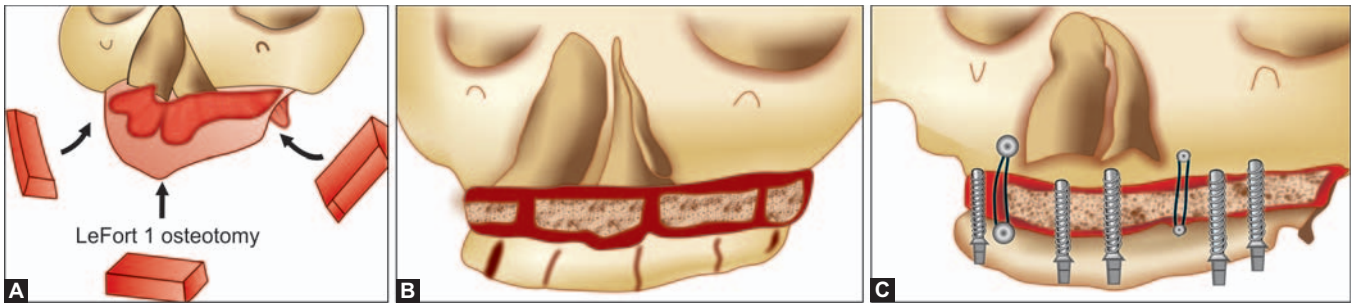
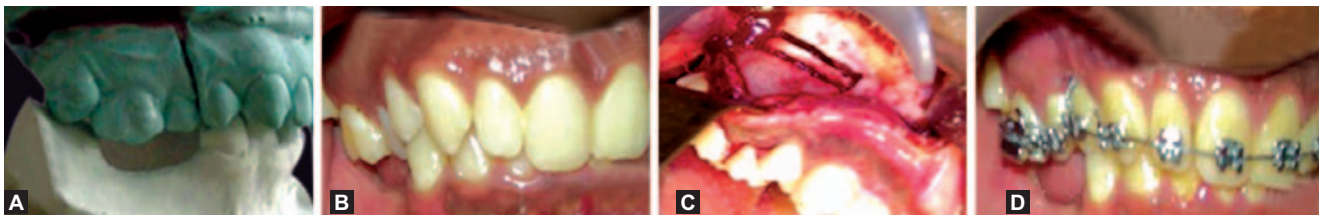


Fig. 36.30 (1 to 11): (1) Edentulous posterior ridge; (2) Reflection of mucoperiosteal flap; (3) Trap door window to expose sinus lining; (4) Gentle elevation of sinus lining; (5) Folding of trap door inwards to cover the elevated lining and to create partition to receive the graft; (6) Harvesting Tibial graft; (7) Receipient site at maxillary sinus floor with tibial graft; (8) Final suturing; (9) Postoperative healing after six months; (10) Preoperative Scans of sinus floor and alveolar crest; (11) Postoperative scan after 6 months, showing the bone graft and increase in bone height at the alveolar crest, after sinus lift and bone grafting procedure

posterior vertical cut is placed just at the maxillary buttress. The vertical cuts are joined superiorly by placing small bur holes placed at small intervals without completing the superior cut. The trap door type of bony window is then gently lifted up superiorly to expose the schneiderian membrane, which is then lifted up gently from the sinus floor and walls. The gap between the lifted sinus membrane and the floor is filled with the graft material. For one stage implant a corticocancellous iliac crest bone block can be used. Otherwise a waiting period of 6–9 months is advocated before implant placement.



Figs 36.31A to C: (A) Ridge augmentation in combination with orthognathic surgery—LeFort I osteotomy; (B) Interposition bone grafting; (C) Immediate implant fixation



Courtesy: Dr Prashant Punde

Figs 36. 32A to D: Posterior maxillary segmental osteotomy (PMSO) for improving interocclusal clearance. (A) Mock surgery for superior positioning of posterior segment; (B) supraerupted right maxillary posterior teeth; (C) Surgical picture of PMSO; (D) Postoperative result after 6 months

Augmentation in Combination with Orthognathic Surgeries

Many osteotomies have been performed for reconstruction of edentulous atrophied maxilla/mandible.

- Anterior maxillary osteotomy
- Total LeFort I osteotomy can be used along with interpositioning of the grafts **(Figs 36.31A to C)**. Total maxillary osteotomy with palatal vault osteotomy also can be used for deepening the palatal vault.

Problems Encountered with Augmentation Technique

- Inadequate soft tissue cover
- Rejection of autografts (failure of union with the host bone)
- Dehiscence of overlying mucosa
- Migration of the graft material
- Resorption of the graft

None of the grafting materials have been considered as ideal or perfect. Each investigator has his own preference and his experience with success rate. Various studies have suggested that autogenous bone grafts either from iliac crest or rib show 28% resorption at the end of 6 months, 45% at the end of 1 year, 78% at the end of 2 years, 89% at the end of 3–5 years. But the width of the graft is maintained, though there is vertical bone loss.

Posterior Segmental Osteotomy to Achieve Interocclusal Clearance (Fig. 36.32A to D)

Whenever tooth is lost/removed and not rehabilitated prosthetically for a long period of time, it will lead to supraeruption of the opposing tooth, thereby decreasing interocclusal clearance. Conventionally to achieve interocclusal clearance, the most commonly used technique was extraction of the offending supraerupted tooth or teeth. Over a period time, various options have been proposed, i.e. performing an intentional root canal therapy for the supraerupted tooth and crown shortening, orthodontic intrusion of teeth using implants, or by performing posterior maxillary segmental osteotomy (PMSO). Posterior segmental osteotomy is considered versatile and useful treatment. It is alternative for variety of dentofacial conditions, especially in case of bilateral distal extension RPD construction. Bell and Levy described that the vertical osteotomy cut should be 5 mm above the apices of the posterior teeth and they considered this distance to be safe with regards to the neurovascular regeneration of the pulp of the teeth involved.

Procedure: Vestibular incision placed extending from first premolar to second molar and full thickness mucoperiosteal flap is raised. Osteotomy cuts are placed 5 mm above the apices of teeth and at interdental bone with the help of

fine surgical burs, care is taken not to damage the roots of the teeth. Transantrally with the help of osteotomies, palatal cuts are completed. Anterior cut is made interdentally and posterior cut is limited to the socket of the third molar tooth. The segment is downfractured and sufficient amount of bone is removed superiorly and the segment is repositioned as planned preoperatively. The posterior maxillary segment is secured across the osteotomy site with the help of miniplates and screws. The case is evaluated clinically and radiographically at the end of 6 months.

Use of Distraction Osteogenesis for Preprosthetic Purpose

Distraction osteogenesis is a surgical procedure that utilizes the body's own reparative mechanisms for hard and soft tissue reconstructions. This approach has numerous clinical applications in the maxillofacial complex and has been used successfully to vertical and horizontal augmentation of the alveolar ridges. It offers a useful and acceptable alternative to conventional bone graft technique, in a selected group of patients. Optimal results can be obtained with accurate planning of the osteotomies and accurate positioning of distraction device using 3D models. Block et al. and Chin and Toth, in 1996, first used this method as more successful and stable alternative for augmentation of the ridges prior to implant placement. Success rate was 90.4%.

Distraction osteogenesis is a biological process of new bone formation along with its soft tissue, in which slow and controlled distraction of bony segments with preservation of periosteal and medullary blood supply, results in elongation of bone. The tension/traction stimulates the new bone formation, (with simultaneous expansion of the soft tissues that accompanies the bony regeneration), parallel to the vector of distraction. Development of miniaturized distraction device has made distraction osteogenesis of small segments feasible.

Distraction Osteogenesis

1. **Vertical distraction:** To generate vertical dimension of the alveolar process prior to prosthetic rehabilitation.
2. **Horizontal distraction:** To correct interarch relationship of the atrophic ridges.

Indications

The process is applied for atrophic alveolar process, resulting from periodontal disease, trauma, congenital deformity, marginal bone resection of a jaw tumor, extraction and traumatic avulsion of teeth.

Contraindications

In patients with severe osteoporosis, patients with space limitation for distraction device placement, extremely advanced age.

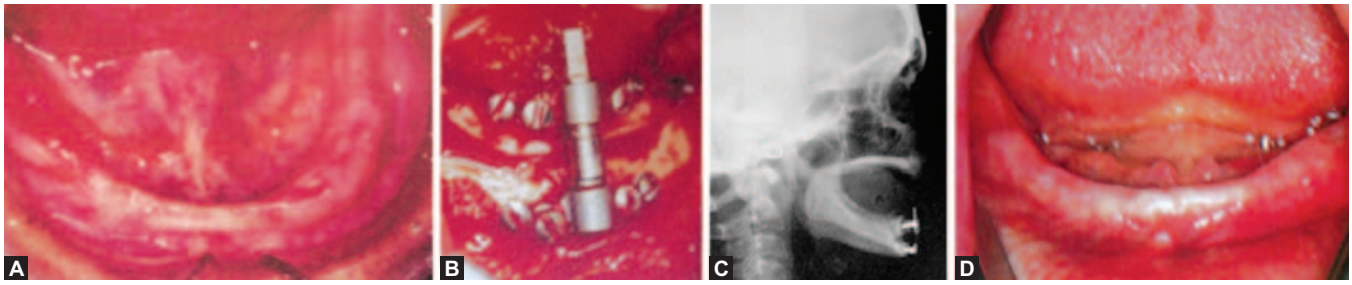
Increasing the Volume/Vertical Height of Atrophic Alveolar Ridge by Vertical Distraction Osteogenesis Procedure

Procedure

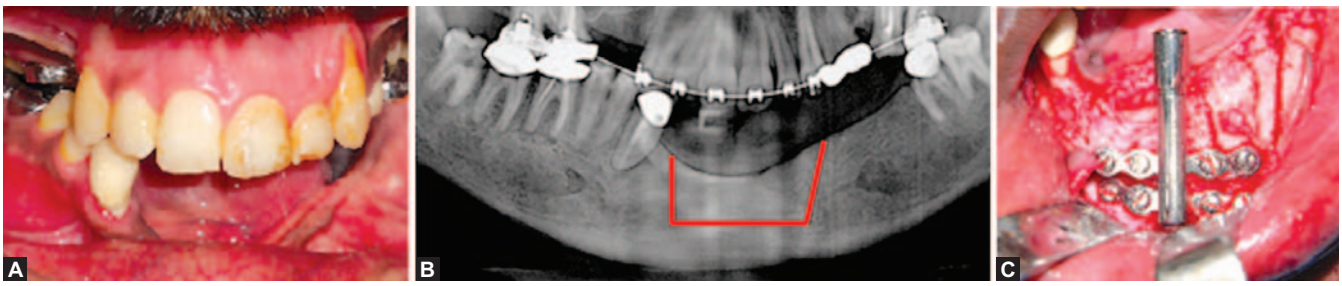
Under LA or GA a horizontal vestibular incision is taken to expose the bone at the level of the planned horizontal osteotomy. During reflection of mucoperiosteal flap, the soft tissue on crestal and lingual aspect should remain intact to maintain the viability of the osteotomy segment. A microsagittal saw is used to create a segmental osteotomy to mobilize the deficient alveolar ridge. The osteotomy consists of two vertical components, which are parallel to the roots of adjacent teeth. The horizontal osteotomy is done connecting these two vertical cuts and allowing as large a transport segment as possible,



Figs 36.33A to C: (A) Model showing vertical distraction procedure in anterior region; (B) Application of distraction device after osteotomy of posterior mandibular segment; (C) Neobone regeneration with increase in height of the posterior ridge

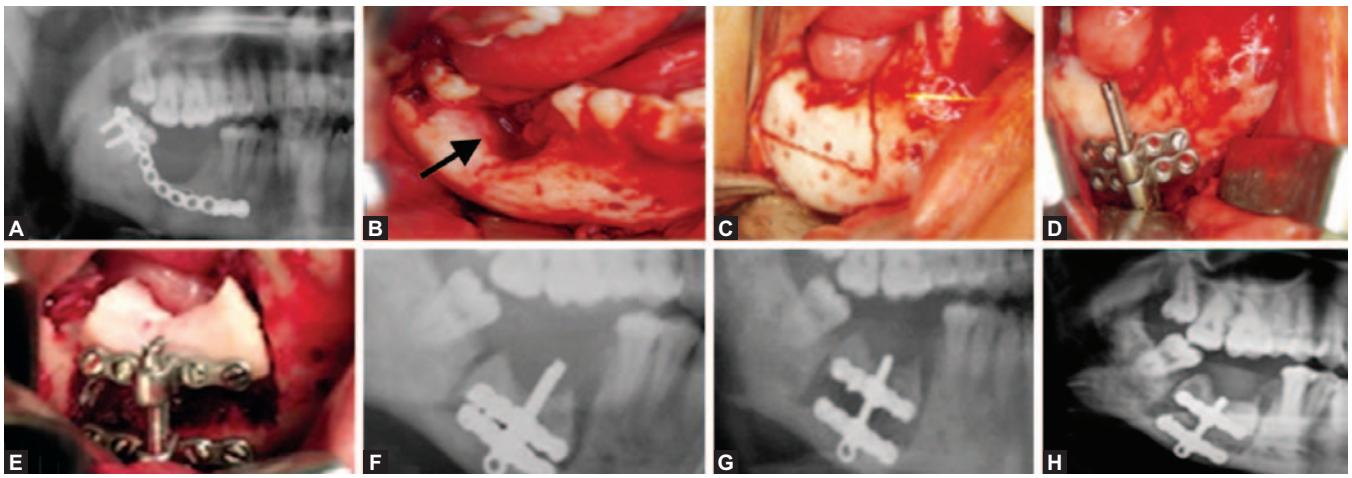


Figs 36.34A to D: Clinical picture of vertical distraction procedure. (A) Reduced vertical height of anterior alveolar ridge; (B) Application of distractor device; (C) Postoperative lateral cephalogram; (D) Increase volume of the ridge 4 months postoperatively



Courtesy: Dr Vidya Rattan

Figs 36.35A to C: (A) Clinical picture of atrophic mandibular anterior ridge; (B) OPG showing the planning of osteotomy cuts, prior to distraction; (C) Fixation of distraction device with vertical vector of augmentation



Figs 36.36A to H: Use of vertical distraction osteogenesis in the defect, postexcision of benign tumor in posterior region. (A) OPG showing pathological fracture treated with reconstruction plate; (B) Removal of reconstruction plate and vertical defect seen clinically; (C) Osteotomy prior to vertical augmentation by DO; (D) Fixation phase of DD; (E) Checking of functioning of DD; (F to H) OPGs—immediate postoperatively, at the end of 10 mm distraction and after 4 months respectively

without compromising the structural integrity of the remaining bone. The mobilization of bone segment is done with osteotome. The distractor device (DD) is placed as shown on the model diagrams. DD is activated everyday till desired/predetermined height of the alveolar segment is achieved. Latency—5–7 days. Distraction rate—1 mm/day. Consolidation period—3–4 months **(Figs 36.33 to 36.36)**.

Distraction Osteogenesis for Correcting Interarch Relationship-Horizontal Distraction

In case if Class III type of residual ridge relationship is existing, then horizontal distraction after carrying out LeFort I osteotomy of maxillary edentulous jaw can be used. Horizontal distraction of the edentulous maxilla was carried out for the first time in the World by Dr Neelima Malik



Figs 36.37A to Q: Forty-five-year-old woman with class III arch relationship, treated successfully with horizontal distraction osteogenesis with stable results. (A and B) Right and Left profile of the patient showing concave profile; (C to E) Interarch Class III relation of edentulous ridges-deficient maxillary ridge; (F) Lateral cephalogram confirming Class III relationship; (G) Scan 3D showing deficient maxillary arch; (H) Construction of individual dentures establishing vertical height; (I and J) Lefort I osteotomy and fixation of intraoral indigenous maxillary distraction devices on right and left side; (K) OPG showing DDs in place; (L) Immediate intraoperative placements of upper and lower dentures fixed with per alveolar and circummandibular wiring procedure. Distraction carried out after 5 days latency period, till the upper denture established predetermined desired position. 10 mm horizontal advancement was achieved; (M) Postoperative normal profile; (N) Postoperative Class I relationship of the arches; (O) Front view after 3 years postoperatively; (P) Profile 3 years postoperatively; (Q) Scan 3D postoperatively showing excellent result

in 2006 and the publication is already done **(Figs 36.37A to Q).**

Piezosurgical Rigde Expansion for Immediate Implant Placement-Ridge Splitting Technique

Edentulism of long-standing duration leading to severe alveolar ridge atrophy with a resultant thin ridge often poses a great challenge for rendering implant supported prosthesis in that region. Traditionally, in order to improve quantitatively compromised proposed implant site, guided bone regeneration (GBR) with or without the addition of particulate bone, with semipermeable barriers, onlay bone grafts from symphysis/ramus, interpositional osteoplasty methods have been used. The ideal treatment in such a situation will be the ridge expansion procedure for obtaining the increase in the available bone volume at the implantation site. The space thus created between the bony walls renders an ideal regenerative and implant-integrating condition. The use of a piezosurgical device for performing a

piezoelectric alveolar ridge expansion procedure permits a precise and tactile controlled osteotomy facilitating implant placement in anatomic situations previously impossible in a single stage procedure. The technique is also characterized by a valid vascular supply and a rich osteoinductive cellularity, which comes from the diversion of the medulla. Also the morbidity associated with the use of second surgical site for harvesting autogenous bone grafts or micromovements of implants formed by a particulate graft is avoided.

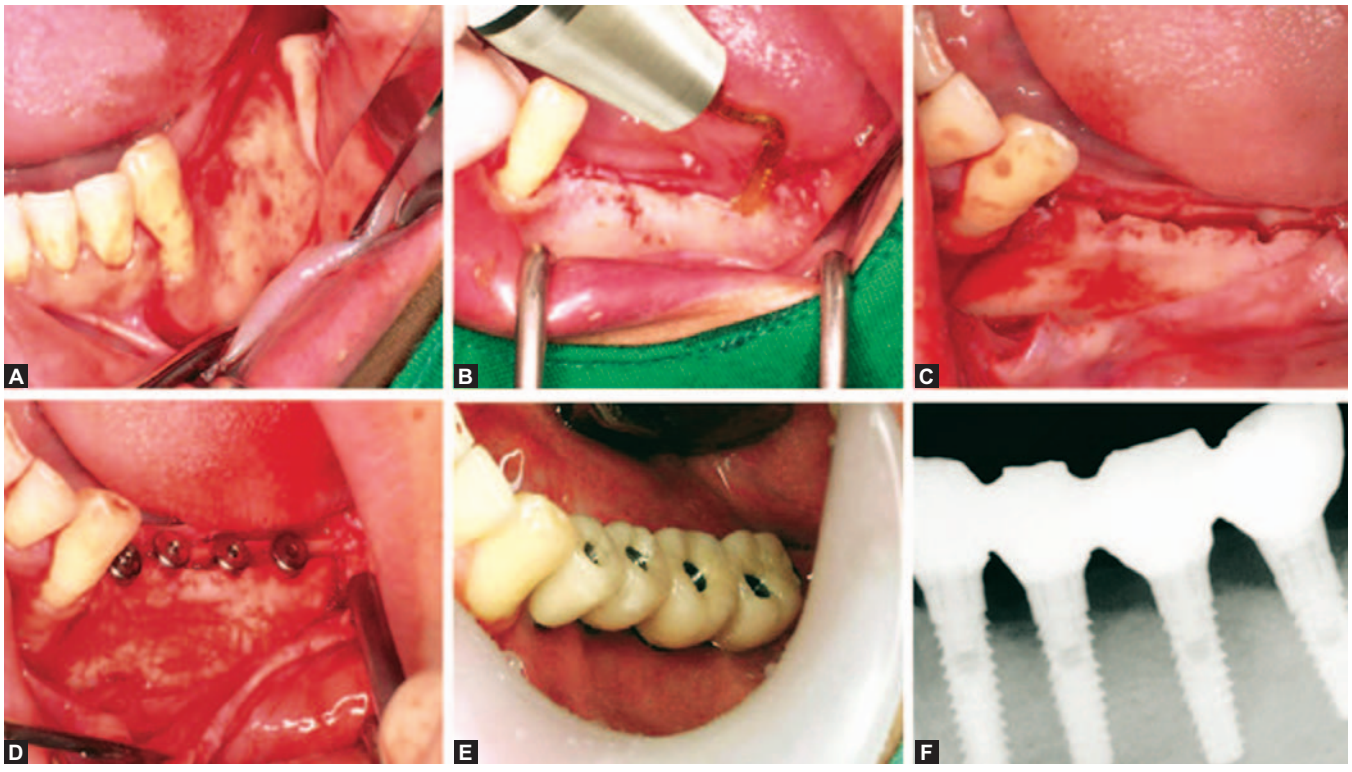
Ridge Splitting Procedure

Mucoperiosteal flap is raised at the implant placement site. A sagittal osteotomy of the edentulous ridge is initiated at the center of the ridge using piezoelectric saw form tip and sequential expansion of the ridge width is achieved by using piezosurgical scalpels of greater thickness and length until a mobile vestibular flap is obtained. Expansion of the ridge is obtained using the elastic property of the bony plates, care taken not to fracture them. The implant drilling then initiated as usual. Adequate primary stability for implants obtained by the residual host bone and intact expanded cortical walls. The space between the expanded bony plates and implants is then packed precisely with bovine hydroxyapatite synthetic graft material. Tension free flap is sutured back **(Figs 36.38A to F).**

Mental Nerve Transposition

Transpositioning of the mental nerve is a preprosthetic procedure that is useful in patients with hyperesthesia caused by the pressure effect of a dental prosthesis on the resorbed alveolar ridge. Normally mental foramen is located 1.5 cm from the alveolar crest and 3 cm from the midline of the mandibular body. Extensive atrophy in geriatric group of patients will have mental foramen situated just at the or close to the alveolar crest. Functional loading of the prosthesis in these patients will cause sharp shooting pain due to stresses of mastication.

Repositioning of the mental nerve can relieve the pain. Level of the mental foramen is ascertained with the X-rays. A crestal incision is taken with buccal releasing incisions in the region of premolars. Mucoperiosteal flap is reflected inferiorly to locate the nerve. Dissection below the foramen, till the inferior border of the mandible, should be done and the nerve is freed lightly and held with the hook upward. The terminal branches of the nerve can be fully mobilized



Figs 36.38A to F: Ridge split technique for implant insertion: (A) Exposure of an alveolar ridge; (B and C) Ridge splitting technique; (D) Implants insertion; (E) Final prosthesis; (F) X-ray after 8 months

sufficiently upwards to have access to the underlying bone. A bony groove/window is cut below the mental foramen, only in the buccal cortex. Then the nerve is repositioned inferiorly 8–10 mm and 8–10 mm distally and secured in place with gelfoam and the flap is then sutured.

Repositioning of Inferior Alveolar Nerve

Implant based rehabilitation of edentulous mandibular posterior region tends to be complicated by the presence of moderate to severe bone atrophy. In these cases, the bony height between the alveolar crest and the nerve canal is very small and sometimes limited to only a few millimeters. Implant placement in such a situation is very difficult and implies the risk of inferior nerve damage. Simultaneous lateralization or repositioning of the nerve along with implant placement is the optimum treatment for such patients. First such case was reported by Jensen and Nock in 1987, with normalization of sensory function 5 weeks postoperatively **(Figs 36.39A and B).**

Lateralization of the inferior alveolar nerve offers following advantages:

- Implants of greater length can be placed in the same sittings
- Greater primary implant stability due to the possibility of bicortical mandibular implant fixation
- Simple OPG X-ray is needed.
- Increased protection of the neurovascular bundle is achieved during implant placement.
- No bone graft is needed.

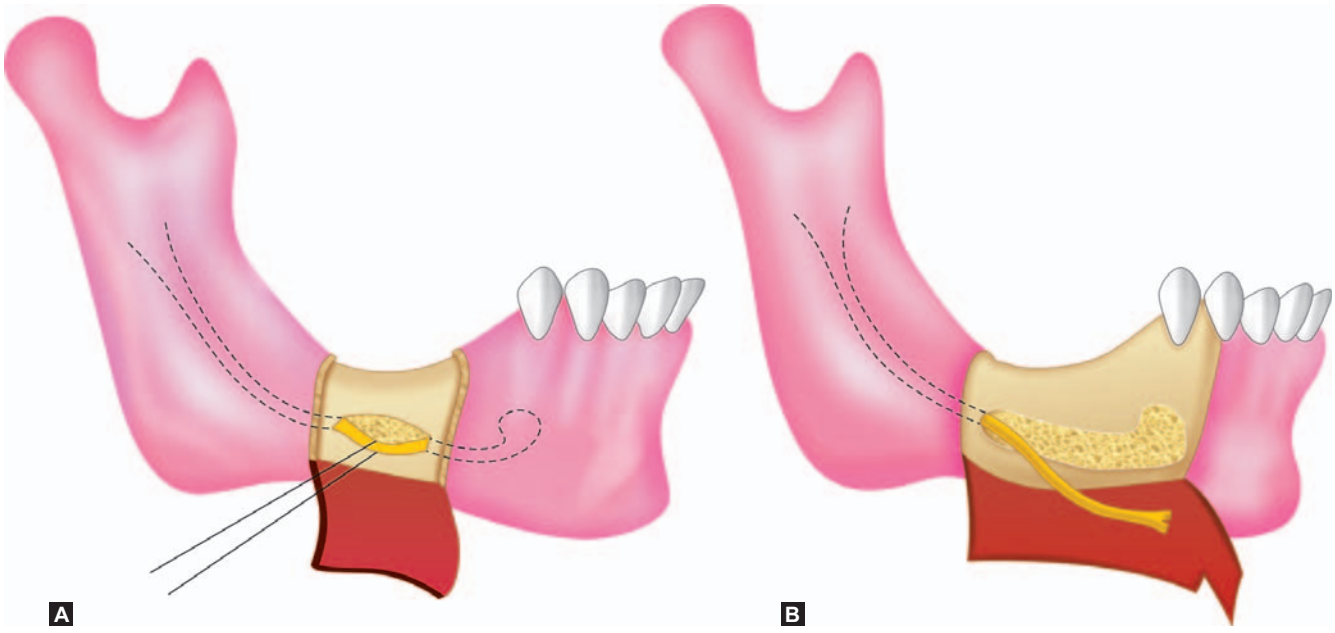
Surgical Technique

Repositioning of inferior alveolar nerve can be done by two techniques: (1) Lateralization and (2) Fenestration.

An incision is made in the vestibule below the alveolar crest, with a vestibular releasing incision anterior to mental foramen. Mucoperiosteal flap is raised.

Lateralization: An osteotomy is performed around the inferior alveolar nerve, continuing with a posterior window, until nerve is fully freed from its intrabony trajectory. Incisive branch located about 5 mm from the mental foramen and sectioned. The nerve fully lateralized and protected with periosteal elevator. The implants are placed under direct visualization. Implant primary stability achieved as a result of fixation in the mandibular basal layer. After that the cortical window plate is replaced and wound closed.

Fenestration: Cortical bone window is prepared posterior to the mental foramen. The nerve is separated using a vessel loop, applying gentle traction outwards as the implants are placed. A resorbable membrane is placed between the implants and the nerve.



Figs 36.39A and B: (A) Lateralization of inferior alveolar nerve; (B) Fenestration technique

Rosenquist et al. presented a large series of 114 patients subjected to lateralization technique with long follow up. 95% implant osseointegration was seen within 6 months. 80% of the patients experienced neurosensory changes. After 18 months, 84% had normalized, 4% had hypoesthesia, which was well tolerated. Only one patient had permanent anesthesia.

Points to Remember

- Objective of the preprosthetic surgery
- Preprosthetic surgical procedures
- Alveolar ridge correction
- Ridge extension procedure
- Ridge augmentation procedures
- Soft tissue correction surgeries
- Sinus lift/grafting procedure
- Distraction osteogenesis for preprosthetic purpose
- Ridge split procedure prior to implant placement
- Mental/inferior alveolar nerve transposition.

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Section 9

Cysts and Tumors of the Orofacial Region

37. Cysts of the Jaws and Oral/Facial Soft Tissues
38. Benign Tumors of the Jaw Bones

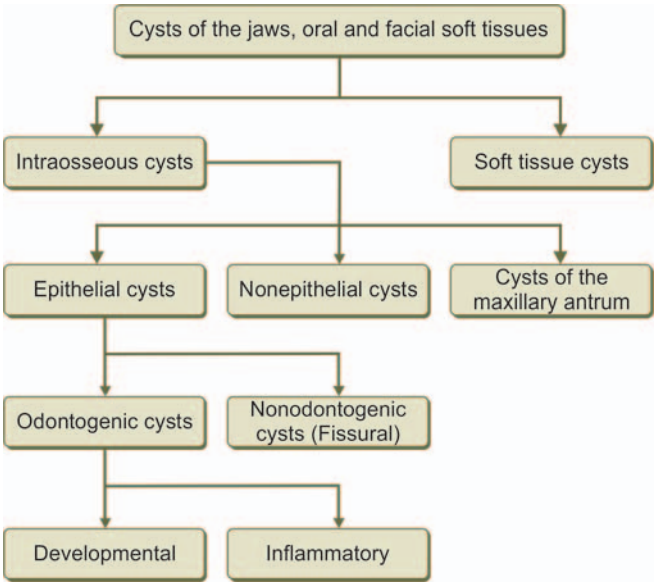
CHAPTER 37 Cysts of the Jaws and Oral/ Facial Soft Tissues

INTRODUCTION

A cyst is a pathologic cavity or sac within the hard or soft tissues that may contain fluid, semifluid/semisolid or gas and not always lined by epithelium (It may be lined by epithelium, fibrous tissue or occasionally even by neoplastic tissue.). Actually, a cyst is a space occupying lesion, with outer wall of definite fibrous connective tissue, that surrounds a central cavity, called the cyst lumen. On the inner aspect of the outer wall, a lining of the epithelium, most commonly stratified squamous epithelium, is seen. The cysts, which have epithelial lining, are called true cysts and which do not have epithelial lining are labeled as pseudocysts. The cystic fluid either is secreted by the cells lining the cavity or derived from the surrounding tissue fluid. Initially, cysts do not contain pus. It is when the cystic contents become secondarily infected and then the pus develops. Cysts may arise in any of the soft or hard tissues of the orofacial regions. Odontogenic cysts are centrally located in the jaw bone.

Originally, since the late 19th century, classifications were based upon clinical and radiologic features, but newer findings and ideas regarding origin and growth have led to some modifications. The classification presented in **Flowchart 37.1** is a slight modification of that published by Shear (1983) **(Table 37.1)**. But in 2005, the World Health Organization (WHO) reclassified the odontogenic keratocyst as the keratocystic odontogenic tumor. Therefore, we have deleted odontogenic keratocyst from the list and it will be discussed in benign tumor section. Latest classification also placed calcifying odontogenic cyst/odontogenic ghost cyst/Gorlin's cyst into tumor category and named it as calcifying cystic odontogenic tumor (CCOT) **(Table 37.2)**.

Flowchart 37.1: Classification of the cysts of jaw, oral and facial soft tissues



CYST FORMATION

Cysts occur more in the jaw bones than any other bones in body, because cysts originate from the numerous rests of odontogenic epithelium, which remain after tooth formation.

Two phases have been recognized in the pathophysiology of cystic lesions:

1. **Cyst initiation**—which results in the proliferation of the epithelial lining and the formation of a small cavity.
2. **Enlargement or expansion**—of this cystic cavity, then occurs.

Table 37.1: Intraosseous and soft tissue cysts

Intraosseous cysts	*Soft tissue cysts*
Epithelial cysts	
A. Of odontogenic epithelial origin	A. Odontogenic
1. Developmental	*Gingival cysts*
a. Primordial cyst	a. Adult
b. Dentigerous (follicular) cyst	b. Newborn
c. Lateral periodontal cyst—lateral botryoid odontogenic cyst	B. Nonodontogenic
	a. Anterior median lingual cyst
d. Calcifying odontogenic (Gorlin) cyst	b. Nasolabial cyst (or nasoalveolar cyst)
2. Inflammatory	C. Retention cysts
a. Radicular cyst (apical/lateral periodontal)	*Salivary gland cysts*
b. Residual cyst	a. Mucocele
B. Of nonodontogenic epithelial origin	b. Ranula
1. Fissural	D. Developmental/congenital cysts
a. Median mandibular	a. Dermoid and epidermoid cysts
b. Median palatal	b. Lymphoepithelial cyst (cervical/intraoral)
c. Globulomaxillary	c. Thyroglossal duct cyst
2. Incisive canal (nasopalatine duct or median anterior maxillary) cyst	d. Cystic hygroma
Nonepithelial cysts (Pseudocysts)	E. Parasitic cysts
1. Solitary bone cyst (traumatic)	a. Hydatid cysts
2. Stafne's bone cavity	b. Cysticerocis
3. Aneurysmal bone cyst	F. Heterotropic cysts
Cysts of the maxillary antrum	Oral cysts with gastric or intestinal epithelium
1. Surgical ciliated cyst of maxilla	
2. Benign mucosal cyst of the maxillary antrum	

Table 37.2: New classification of odontogenic cysts

- **Inflammatory cysts**
  - Radicular cyst—apical, periapical, lateral apical
  - Residual cyst
  - Paradental cyst
- **Developmental cysts**
  1. Dentigerous cyst
  2. Lateral periodontal cysts
     - Botryoid odontogenic cyst
     - Gingival cyst of the adult
     - Glandular odontogenic cyst
  3. Orthokeratinized odontogenic cyst
  4. Gingival cyst of newborn
- **Neoplastic cysts**
  - Keratocystic odontogenic tumor
  - Calcifying cystic odontogenic tumor

These processes have been clearly defined for epithelium lined cysts, where the initiation is different for each group of cysts, the enlargement process is most likely similar for all epithelium lined cysts, though there may be some variations in the mode of enlargement. Regarding, the bone cysts, little information is available for certain, about their origin and mode of enlargement.

Cyst Initiation

The stimulus for the phenomenon of cyst initiation is not known, other than the inflammatory odontogenic cysts, where clearly it is the infection that is considered as the precipitating factor that results in cystic initiation. In others, it is possible that there is a predisposition in some individuals to form cysts from developing odontogenic epithelium, i.e. from the following tissues, which have the potential to form a cyst **(Table 37.3)**.

- A tooth germ—enamel organ
- Dental lamina and its remnants

Table 37.3: Cells of origin of a cyst

Source	*Cyst*
1. Bud stage/cap stage odontogenic epithelium	No tooth development—primordial cyst
2. Reduced enamel epithelium	After formation of crown of a tooth—dentigerous cyst
3. Remnant of dental lamina (cell rest of Serres)	Odontogenic keratocyst
4. Hertwig's root sheath (cell rest of Malassez)	After root formation—lateral periodontal cyst

- Extensions of basal cells from the overlying oral epithelium
- Reduced enamel epithelium
- Cell rests of Malassez, etc.

Whatever may be the precipitating factor in the initiation of the cystic lesion, it is followed by cyst formation, the factors responsible for which are as follows:

Pathogenesis of cyst formation: It is proposed that during cyst formation stage, the cyst cavity gets lined by stratified squamous epithelium. The blood supply is rich at the periphery and the cells in the center lack nutrition. As a result, these cells tend to desquamate into the center of the mass. This produces a fluid with increased osmolarity in the center surrounded by an epithelial lining.

Cyst Enlargement

- Proliferation of the epithelial lining and fibrous capsule—degeneration and liquefaction in the center
- Fluid accumulation within the cyst cavity—elevated hydrostatic luminal pressure: Hydrostatic pressure is about 70 cm of water (higher than the capillary bed), which exerts osmotic pressure on the walls of the cyst
- Cyst expansion/enlargement
- Bone resorption—Osteoclastic resorption, release of prostaglandins PGE2 and PGE3.

The origin and pathogenesis related to each cystic lesion is discussed in length, later.

Cyst Enlargement

Harris in 1974 first postulated the theory of cyst expansion/enlargement. Later on many researchers modified it.

- **Mural growth theory**: Cyst epithelial division leads to increased mural pressure which leads to expansion. (1) Peripheral cell division, (2) accumulated contents of the cystic cavity.
- **Osmotic pressure theory**: Differentiation end products of epithelium are keratin. Due to accumulation of protein (intraluminally), there is increased osmotic pressure. This increased osmotic pressure leads to increased fluid inflow into cystic cavity. Hydrostatic pressure: (1) secretion, (2) transudation and exudation, (3) increased osmolarity.
- **Bone resorption theory**: Peripheral release of bone resorption factors (BRFs) from cystic lining leads to bone resorption and cyst expansion.
- **Accumulation theory**: Accumulation of contents into cystic lumen leads to expansion.

Once cyst formation has been initiated, it continues to grow and enlarge, irrespective of its type and its origin. Following mechanisms have been forwarded, regarding enlargement of cystic lesions:

- Increase in the volume of the contents
- Increase in the surface area of the sac or epithelial proliferation
- Resorption of the surrounding bone and at times
- Displacement of the surrounding soft tissues.

The periosteum is stimulated to form a layer of new bone-subperiosteal deposition.

Increase in the Volume of its Contents

It is generally considered that the volume of the contents of a cyst may increase due to the following factors or their combination, which may bring about cystic enlargement, examples are given below.

Secretions

Mucus-secreting cyst, where the lining is mucus secreting, an accumulation of mucus explains the increase in volume.

Transudation and exudation: Inflammatory cysts or the presence of infection—Inflammatory cells, which are commonly present in the capsule, release cofactors, lymphocytes release the lymphokine, osteoclast-activating factor (OAF) and monocytes release interleukin-1 which stimulates the fibroblasts to release the prostaglandins. These desquamated epithelial cells of cyst lining undergo autolysis/breakdown and produce a large number of molecules of lower molecular weight, raising the osmolarity of the fluid. Toller suggested the role of osmolarity by the cyst fluid in the enlargement of a cyst.

Increased hyperosmolarity: (1) Raises internal hydrostatic pressure, (2) Attracts external fluid into the cystic cavity, (3) Retention of fluid within the cystic cavity.

A. Increased osmolarity of the cyst fluid may play a role in its enlargement, osmotic differences between the serum and cystic fluids are related to the proteins

present within the cystic fluid, such as large molecules of globulins, albumin, fibrinogen and fibrin-degradation products, which are responsible for the increase in osmotic pressure of a cyst, which in turn results in cystic expansion.

B. Increased hydrostatic pressure further draws in the fluid, from the surrounding tissues, as the cyst wall is a semi permeable membrane. Thus, the increased hydrostatic pressure, which is much dependent on the type of cystic lining, its permeability and the cystic contents of by-products of epithelial cell autolysis, causes cystic enlargement. This increased hydrostatic pressure is transmitted to the adjacent bone. It is also believed that acute inflammation makes the capillaries in the region highly permeable. This results in exudation of protein-rich fluids into the cystic cavity.

C. Semipermeable membrane governs access into the cyst, prevents the escape of certain substances from its contents. The products of epithelial cell autolysis can affect both osmotic attraction and retention within the cavity. Toller's experiments have shown that the osmotic imbalance resulted in the inability of the large molecules in the fluid to escape, because of lack of access to the lymphatic system.

Cyst Enlargement due to Epithelial Proliferation

Mural growth in the form of epithelial proliferation is one of the essential processes by which the surface area of the sac increases, basically by peripheral cell division or by accumulation of cellular contents.

- A multicentric pattern of cyst growth brought about by the proliferation of local groups of epithelial cells as in the keratocysts, results in cystic expansion.
- **Collagenase activity** in some cysts such as the primordial and radicular cysts by way of increased collagenolysis could result in cyst expansion.
- **Unremitting growth** of certain epithelial linings due to high mitotic values as in keratocysts plays a role in cystic enlargement.
- **Presence of low-grade infection** stimulates cells such as the cell rests of Malassez to proliferate and form arcades. The number of epithelial layers is then determined by the period of viability of each cell and the rate of maturation and desquamation.

Bone Resorption

As the epithelial cells divide, the cyst is able to enlarge within the rigid bony cavity by the release of bone resorbing factors from the capsule, which stimulate *osteoclast function*, e.g. prostanoids like PGE2 and PGI2 and certain leukotrienes. Differences in the sizes of various cystic lesions could possibly be dependent upon the quantity of release of prostaglandins and other bone resorbing factors. Also increased internal pressure is transmitted to the adjacent bone, which causes bone resorption and enlargement of cyst cavity. Further enlargement of the cystic cavity produces microcracks on the thinned out cortical plates. This produces egg shell crackling during palpation of the lesion. In the later stage, as the expansion continues, thinned out cortical bone completely resorbs and cyst lining lies just below the oral mucosa, causing fluctuation. Perforations in the cortical plates and cystic lining will cause escape of cystic fluid in the oral cavity, producing salty taste in the mouth.

Cyst Regression

Any process that leads to the involution of the cyst epithelium, e.g. extraction of the necrotic tooth or conversion of the epithelial lining to oral mucosa and reduction of intracystic pressure as with marsupialization may cause the connective tissue capsule to regress and the cavity to be filled by bone or scar tissue.

INTRAOSSEOUS CYSTS

Odontogenic Epithelial Origin

Primordial Cyst

Robinson (1945), first popularized the term *primordial cyst* for cysts arising from primordial odontogenic epithelium, i.e. dental lamina or its remnants, odontogenic basal cell hamartias or enamel organ, prior to the formation of calcified structures, thus, this cyst is found in place of a tooth (from the normal series or supernumerary) instead of being associated with one **(Fig. 37.1)**.

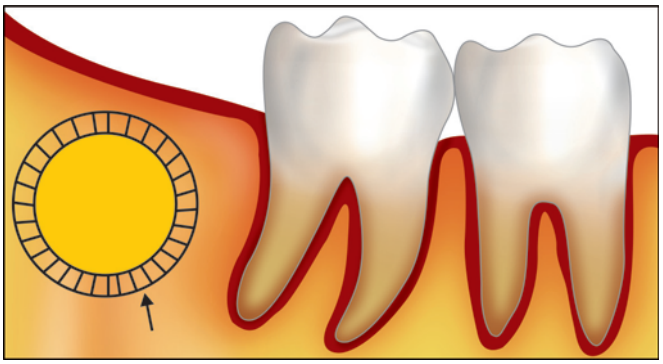


Fig. 37.1: A diagrammatic representation of primordial cyst

Incidence: Primordial cysts comprise approximately about 5–10% of odontogenic cysts of the jaws and are seen predominantly in the 2nd, 3rd and 4th decades of life, though they can occur in any age group. They have a slight predilection for the males than females.

Site: The primordial cysts have a strong predilection of occurrence in the mandible than the maxilla, about one-half of the former are seen to involve the angle of the mandible with extension for varying distances into the ascending ramus and body mandible. However, they can occur anywhere in the jaws, including the midline, though majority of the cysts are seen posterior to the first bicuspids.

Clinical features: The physical signs and symptoms of a jaw cyst will depend to a certain extent on the dimensions of the lesion. A small cyst is unlikely to be diagnosed on routine examination of the mouth, and is generally detected accidentally on a radiographic examination. In case of the primordial cyst, patients are remarkably free of symptoms until the cysts have reached a large size at times involving the entire ascending ramus. This is because the primordial cyst initially extends in the medullary cavity and clinically observable expansion of the bone occurs late.

The enlarging cyst may lead to displacement of the teeth, percussion of the teeth overlying the cyst may produce a dull or hollow sound. A single missing tooth from the normal series should invite suspicion of the existence of the primordial type cyst. The teeth adjoining the cyst will have vital pulps unless there is coincidental disease of the teeth. Buccal expansion of the bone is commonly seen, lingual and palatal expansion is rare. Large mandibular cysts invariably deflect the neurovascular bundle into an abnormal position. If acute infection sets in, with accumulation of pus within the sac, neuropraxia of the nerve results with the onset of labial paresthesia or anesthesia. When tension is relieved, with spontaneous discharge of pus via a sinus tract or surgical drainage, sensation returns to normal.

Radiological features: The primordial cyst is usually unilocular, but sometimes have scalloped outline, which gives a multilocular appearance. The borders are hyperostotic. The involved tooth is usually missing. The adjacent teeth may be displaced, diverged or deflected. Primordial cysts in maxilla are smaller than their mandibular counterparts.

When they occur in the periapical region of vital teeth, they can be mistaken for a radicular cyst. They may impede the eruption of related teeth and this results in a dentigerous cyst appearance radiologically.

Pathogenesis: Primordial cyst is generally considered to be a developmental anomaly, which arises from odontogenic epithelium, the main sources being:

- Dental lamina or its remnants
- Basal cells from the overlying oral mucosa
- Enamel organ—by degeneration of the stellate reticulum.

Cyst contents (aspirate): It reveals a thick, granular, yellowish material.

Histopathology: The primordial cysts are thin-walled and are lined by a regular keratinized stratified squamous epithelium, which is usually 5–8 cell layers thick and is devoid of rete pegs. The epithelial cells are arranged in a "picket fence" or "tombstone pattern". The enucleated lining easily separates from the underlying connective tissue. The capsule is quite thin and normally free of inflammatory cells, and may contain strands of odontogenic epithelium resembling the dental lamina, cell nests and daughter cysts.

Recurrence: Primordial cysts have a pronounced tendency to recur. This aggressive peculiarity was first reported by Pindborg and Hansen (1963). The recurrence rate may vary from 5% to 62% with most occurring in the first 5 years. Some of the possible reasons reported for this feature are as follows:

- Tendency to multiplicity
- Presence of satellite cysts
- Cystic lining is very thin and fragile, portions of which may be left behind.

Treatment: Treatment should always be based on proper clinical assessment, accurate diagnosis and appropriate tests of the cystic aspirate.

Marsupialization is incorrect in principle in the treatment of primordial cysts, owing to their high incidence and tendency to recur.

Bramley (1971, 1974) had very rationally outlined the surgical management of these cysts as follows:

- **Small single cysts with regular spherical outline** should be enucleated from an intraoral approach, provided the access is good.
- **Larger or less accessible cysts with regular spherical outline** should be enucleated from an extraoral approach, as an intraoral access would be inadequate and a blind procedure. Care should be taken to ensure that all fragments of the extremely thin lining are removed.

- **Unilocular lesions with scalloped or loculated periphery and small multilocular lesions** should be treated by marginal excision, i.e. resection of the containing block of bone, while maintaining the continuity of the posterior and inferior borders as in the ascending ramus, angle and body mandible, if there is difficulty of access, extraoral exposure is necessary. If the cystic lining is found to be adherent and in contiguity to the overlying oral mucosa or muscle then it should be excised along with marginal excision. The defect is closed primarily and can be left to heal by secondary intention or can be filled with hydroxyapatite crystals, autogenous bone graft, corticocancellous chips or allogenous bone powder, chips or block.
- **Large multilocular lesions with or without cortical perforation** may require resection of the involved bone followed by primary or secondary reconstruction with a choice of reconstruction plates of stainless steel, vitallium, titanium, use of titanium or stainless steel mesh and bone grafting procedures with iliac crest graft, costochondral graft or allogenous bone grafts.

Clearly, every cyst and every patient should be assessed individually and the treatment planned carefully for each case, whatever form of surgical approach is selected, the patient should be reviewed regularly over a long follow-up.

Dentigerous (Follicular) Cyst

A dentigerous cyst is one that results because of the enlargement of the follicular space of the whole or part of the crown of an impacted or unerupted tooth and it encloses the crown of an unerupted/impacted tooth at the cementoenamel junction.

Paget (1863) coined the term dentigerous cyst. These cysts involve teeth of the adult dentition or occasionally supernumerary teeth.

Incidence: The dentigerous cyst is seen more commonly than the primordial cyst, but less common than the apical types (second most common cyst). The dentigerous cyst is the most common type of developmental odontogenic cyst, making up about 20% of all epithelium lined cysts of the jaws.

The most common age periods for diagnosis are the 1st, 2nd and 3rd decades, subsequently there is a gradual decline in occurrence. Incidence appears to be equal in both sexes, though some reports mention a slight predilection for the males and the prevalence is higher for whites than for blacks.

Site: It occurs more frequently in the mandible than the maxilla. Late erupting teeth are the most frequently involved in descending order are the lower third molars, upper cuspids, upper third molars and the lower bicuspid teeth. Although dentigerous cysts may occur in association with any unerupted tooth, most often they involve mandibular third molars. Other relatively frequent sites include maxillary canines, maxillary third molars and mandibular second premolars. Dentigerous cysts rarely involve unerupted deciduous teeth. Occasionally, they are associated with supernumerary teeth or odontomas.

Clinical features: Dentigerous cysts have the potential to attain a large size, often it is the pronounced facial asymmetry or the problem of ill-fitting dentures that force a patient to seek treatment. Pain may be a presenting symptom, if secondary infection supervenes. Clinically, a tooth from the normal series will be found to be missing, unless the cause is a supernumerary tooth, sometimes other adjacent teeth may also fail to erupt, may be tilted or otherwise be out of alignment. The lateral expansion causes a smooth, hard, painless, prominence, later as the cyst expands the bone, covering the center of the convexity, becomes thinned and can be indented with pressure on palpation, with further expansion. This fragile outer shell of bone becomes fragmented and the sensation imparted and sound produced on palpation over the area is described aptly as egg shell crackling, which is also true for other large odontogenic cysts. Still later, the cyst lining may come to lie immediately beneath the oral mucosa and fluctuation can be elicited.

Radiological features (Figs 37.2 to 37.4): Radiographs will generally reveal a unilocular radiolucency associated

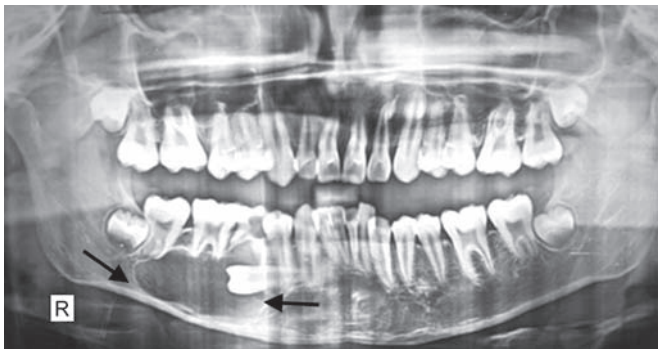


Fig. 37.2: An orthopantomogram (OPG) revealed a single, unilateral, unilocular well-defined corticated radiolucency seen around the crown of horizontally impacted lower mandibular second premolar. It also revealed: grossly carious right mandibular deciduous second molar, over retained right mandibular deciduous second molar and root resorption of right mandibular first and second molar. Circumferential type of dentigerous cyst

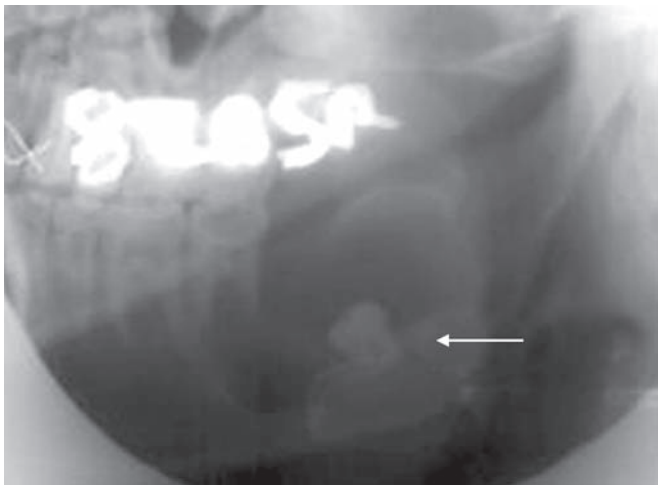


Fig. 37.3: Circumferential type of dentigerous cyst, with mild resorption of second molar

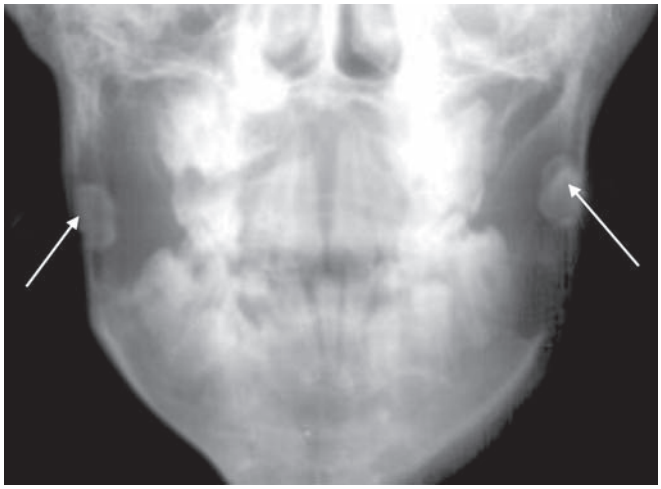
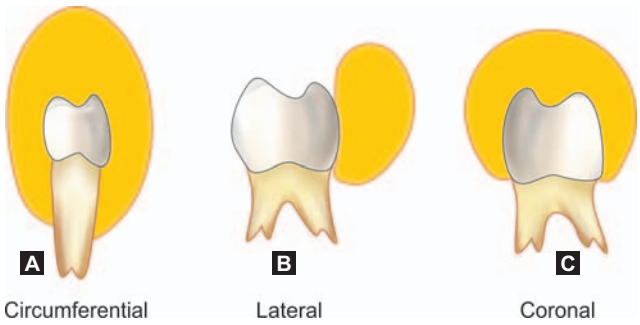


Fig. 37.4: Bilateral dentigerous cysts involving the body and ramus mandible



Figs 37.5A to C: Radiological presentation of dentigerous cysts

with crowns of unerupted impacted teeth; at times a multilocular effect can be seen, when the cyst is of irregular shape due to persistence of bony trabeculations. Cysts have a well-defined sclerotic margin, unless when they are infected, then the margins are poorly defined. With the pressure of an enlarging cyst, the unerupted tooth can be pushed away from its direction of eruption, e.g. the lower third molar may be pushed to the inferior border, or into the ascending ramus, whereas the upper cuspid or incisor may be pushed up into the maxillary sinus or floor of the nose, or till the orbital floor. As compared to the other jaw cysts, dentigerous cysts have a higher tendency to cause root resorption of adjacent teeth. Radiologically, the dental follicle may expand around the unerupted or impacted tooth in three variations, i.e. (1) circumferential, (2) lateral and (3) central or coronal **(Figs 37.5A to C)**.

Pathogenesis: Dentigerous cysts develop by accumulation of fluid between the reduced enamel epithelium or within the enamel organ itself, after complete odontogenesis of unerupted or impacted teeth. In case of a dilated follicle, a pericoronal width of more than 3–4 mm is considered as a cyst. Another possibility suggested for the development of dentigerous cysts is because of degeneration of the stellate reticulum at an early stage of development and is likely to be associated with enamel hypoplasia.

Cystic contents (aspirate): The cyst contents consist of clear yellowish fluid, in which cholesterol crystals may be present, or purulent material, if infection has occurred.

Pathology: The histopathologic features of dentigerous cysts vary, depending on whether the cyst is inflamed or not inflamed. In the noninflamed dentigerous cyst, the fibrous connective tissue wall is loosely arranged and contains considerable glycosaminoglycan ground substance. Small islands or cords of inactive appearing odontogenic epithelial rests may be present in the fibrous wall. Sometimes, macroscopic examination of the cystic lining may exhibit mural thickenings which on histological examination may exhibit ameloblastic changes. The cystic lining is of reduced enamel epithelium, consists of 2–3 cell layers of flat or nonkeratinizing cuboidal cells and is attached to the tooth at the cementoenamel junction. The epithelial lining is not keratinized, rarely a dentigerous cyst may form keratin by metaplasia. Because a thin layer of reduced enamel epithelium normally lines the dental follicle surrounding the crown of an unerupted tooth, it can be difficult to distinguish a small dentigerous cyst from simply a normal or enlarged dental follicle based on microscopic features alone. Again, this distinction often represents largely an academic exercise; the most

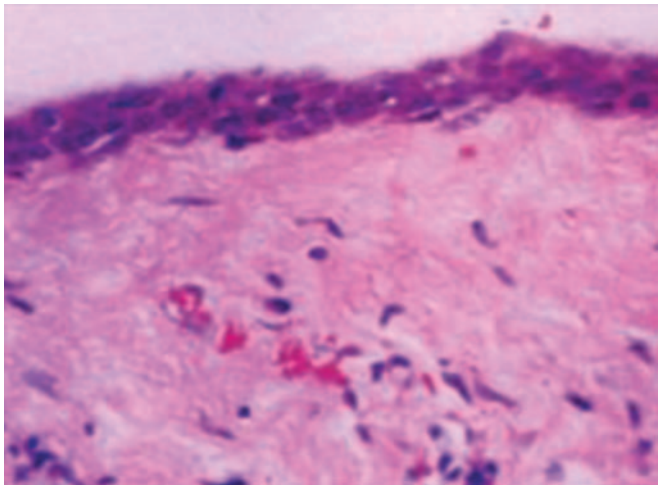


Fig. 37.6: Dentigerous cyst reveals thin, nonkeratinized stratified squamous epithelium and uninflamed fibrous tissue

important consideration is assuring that the lesion does not represent a more significant pathologic process (e.g. odontogenic keratocyst or ameloblastoma) **(Fig. 37.6)**.

Presence of sebaceous glands, mucous or ciliated cells in the epithelial lining is also considered to form as a result of metaplasia. Hyaline bodies may be seen within the epithelium, and clefts from cholesterol crystals may be found in the connective tissue capsule. Epithelial discontinuities may be present, because of intense inflammatory infiltrate in the adjacent capsule or because of partial adherence to enamel.

Treatment: Treatment via an intraoral or extraoral approach is decided by the size of the cyst, adequate access and whether it is desirable to save the involved tooth.

Marsupialization (Partsch surgery): It is indicated in children if the cyst is very large in size and the involved tooth/teeth are to be maintained. The tooth may erupt into occlusion as the defect heals with normal bone, or orthodontic forces may be used to bring the tooth into occlusion.

Enucleation: Alternatively, the cyst can be enucleated together with the involved tooth in adults, as the possibility of the tooth erupting is low.

In children, an attempt could be made to salvage the tooth, in which case, the lining is separated from the neck of the tooth with a scalpel. This procedure is worth attempting, when root formation is complete, so that the risk of tooth dislodgement is low.

Behavior and prognosis: It is widely believed that ameloblastomas frequently arise in dentigerous cysts, and some have even termed them as preameloblastic lesions. Recurrence is a possibility if some epithelium remains.

Neoplastic potential—ameloblastoma, squamous cell carcinoma, mucoepidermoid carcinoma.

Developmental Lateral Periodontal Cysts

Lateral periodontal cysts are found lateral to the roots of one or two vital teeth, and in which an inflammatory etiology or a collateral primordial cyst has been excluded on clinical and histological evidence.

Incidence: This cyst is chiefly found in adults, though it is a recognized entity, it occurs so rarely that no significant conclusions can be drawn regarding specific age or sex predilection. 0.7% of oral cysts.

Site: It occurs more often in the mandible than the maxilla. It is most often related to the mandibular cuspid, bicuspid and third molar roots, followed by the anterior region of the maxilla.

Clinical features: Majority of the cases have no clinical signs or symptoms and are discovered during routine radiological examination. The associated teeth are vital. At times a gingival swelling may occur on the buccal or lingual aspect, and this must be differentiated from a gingival cyst. The lingual type of cyst involving the mandibular third molar, seems to be more common and if infected, can cause a severe spreading infection of the submandibular space.

Radiological features: Radiographs reveal a well-defined round or ovoid radiolucency with a sclerotic margin, the lamina dura of the involved tooth is destroyed. Most of the cysts are smaller than 1 cm in size and are seen to be present between the cervical margin and apex of the root. In case of the lower third molar roots, they are seen to be present in the bifurcation, buccally or lingually or against the distal surface of the root.

Pathogenesis: Considering that the lateral periodontal cyst is a distinct entity of developmental odontogenic origin, three possibilities have been suggested regarding its origin, for example:

1. Reduced enamel epithelium
2. Remnants of dental lamina
3. Cell rests of Malassez.

Cystic contents (aspirate): It has a serous caseous content.

Pathology: The cyst is usually lined by a well formed, nonkeratinized, stratified squamous epithelial lining. Localized epithelial proliferations may be seen in the form of plaques. The connective tissue wall may show inflammatory cell infiltrate.

Treatment: Enucleation is generally the method of choice, and is easily performed because of the small size and easy access. All attempts should be made to avoid sacrificing the associated tooth. Recurrences rare, if ever.

Botryoid Odontogenic Cyst

The botryoid odontogenic cyst was recognized by Weathers and Waldron (1973), which is thought to arise from odontogenic epithelial rests. It is probable that the botryoid cyst is a *variant of the lateral periodontal cyst.* The gross appearance of the largest lesion was described as resembling a *bunch of grapes*, hence the term *botryoid*. They have been reported to occur within the mandible in the cuspid-premolar region, they give the appearance of a polycystic lesion on the radiograph.

Microscopically, the cysts are divided into multiple compartments, with very thin fibrous connective tissue septae, each cavity is lined by thin, 1–2 cells wide, nonkeratinizing squamous epithelium, which exhibits "buds" or "plaque-like" thickenings of clear cells similar to the lateral periodontal cyst. These thickening could be the source of microcysts in the fibrous wall, giving rise to a polycystic or a multilocular lesion.

Behavior: The lateral periodontal cyst does not have a tendency to recur.

Glandular Odontogenic Cyst

There is a controversy regarding this lesion. All the experts do not agree that this is a variant of the lateral periodontal cyst, especially because of its significantly more aggressive biological behavior.

Little is known about this cyst, because so few cases have been reported.

Clinical features: Middle-aged and older people, equal occurrence in both the sexes, predilection for mandible, anterior region and sometimes maxillary anteriors. The cyst may reach an impressive size.

Radiological features: Multilocular, radiolucent, well circumscribed, usually larger than 1 cm.

Histology: Epithelium—nonkeratinizing of varying thickness. Focal thickenings. Cuboidal cells with cilia superficially. Mucous cells and clear cells. All these forms characteristic intraepithelial duct-like or gland-like structures. Hence, its name is derived from the observation of histopathological picture. Connective tissue exhibits collagen and fibroblasts.

Treatment: Enucleation. Recurrence: 30%. Some recommend en bloc resection. Transformation into central mucoepidermoid carcinoma has been reported.

Calcifying Epithelial Odontogenic Cyst: Gorlin's Cyst

The WHO in 2005, reclassified this cyst as a cystic neoplasm—the ghost cell tumor **(Figs 37.7A to F)**.

Classification of Odontogenic Ghost Lesions

Group I: Simple cysts—calcifying epithelial odontogenic cyst (CEOC).

Group II: Cysts associated with odontogenic hamartomas or benign neoplasms—CCOT.

Group III: Solid benign odontogenic neoplasms with similar cell morphology to that in the CEOC and with dentinoid formation.

Group IV: Malignant odontogenic neoplasms with the features similar to those of the dentinogenic ghost cell tumor, ghost cell odontogenic carcinoma.

The calcifying odontogenic cyst is a lesion of developmental odontogenic epithelial origin, which is relatively uncommon and bears resemblance to the calcifying epithelioma of Malherbe. It was first described by Gorlin and associates (1962, 1964). and it should not be confused with the cyst that occurs in Gorlin's syndrome—the keratocyst.

Incidence: Very few cases have been reported, this cyst has no sex predilection. It occurs over a wide age range, but is said to be more common in children and young adults, peak in 2nd decade.

Site: They have been described in either jaw, but probably the most common site of occurrence is in the anterior part of the mandible. Usually central in bone, but also peripheral lesions seen on gingiva.

Clinical features (Figs 37.7A and B): A large number of cases are symptomless, and are discovered accidently on radiographic examination. Swelling is the most frequent complaint, rarely there is pain. A peripheral or intraosseous lesion may be seen, the latter produce a hard bony expansion and may be fairly extensive. Lingual and palatal expansion may be noted. Some cysts arise close to the periosteum and produce a saucer-shaped depression in the bone, in a few cases displacement of the teeth may be seen.

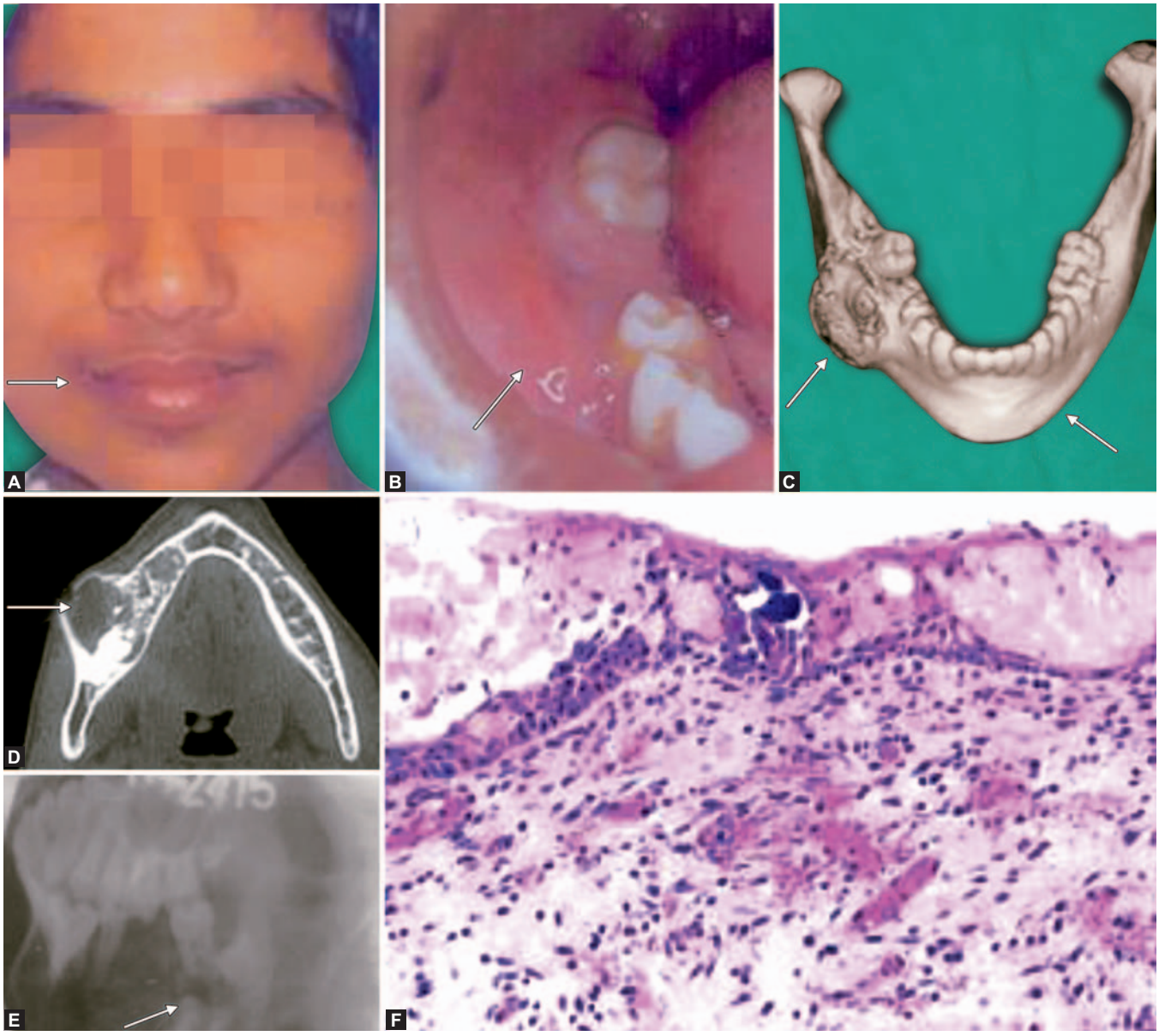
Radiological features (Figs 37.7C to E): *This is the only cyst that may produce calcifications, so that it may have a mixed radiolucent/radiopaque appearance radiographically*. When small, the cyst will be seen between the roots of the teeth. The periphery may be well demarcated or irregular, some lesions are unilocular, whereas others exhibit a multilocular pattern.

Cortical perforation may be evident. Calcifications, as irregular radiopaque specks may be seen within the bone cavity, sometimes the calcification can be substantial and occupies a large area of the lesion. The cyst may be associated with a complex odontoma or an unerupted tooth. Resorption of the roots of the adjacent teeth may be seen.

Pathogenesis: There is strong evidence that the cyst has an odontogenic origin, the probable sources being:

- Remnants of dental lamina
- Stellate reticulum
- Reduced enamel epithelium.

The epithelial lining appears to have the ability to induce the formation of dental tissues in the adjacent



Figs 37.7A to F: Gorlin's cyst: (A) Swelling seen involving right body mandible; (B) Intraoral view showing extensive right buccal expansion due to Gorlin's cyst; (C) 3D CT shows expansion and perforation of buccal cortex due to Gorlin's cyst; (D) Axial CT scan shows radiolucency with speckled calcification and an unerupted, displaced tooth; (E) Radiograph of patient with Gorlin's cyst, (F) Calcifying odontogenic cyst (histopathology), epithelial lining with ghost cells, foci of calcification and mild inflammation in the cystic wall

connective wall; therefore, it is quite possible that an odontoma, dentinoid alone, or even tumors such as ameloblastoma, odontoameloblastoma, ameloblastic fibroma or ameloblastic fibro-odontoma may be found in the cyst wall, induced by the lining epithelium.

Histopathology (Fig. 37.7F): The histologic characteristics are unique and pathognomonic. The odontogenic type lining of stratified squamous epithelium is 6–8 cells thick and has columnar or cuboidal basal layer of cells, occasionally with nuclei at the ends of the cells, opposite the basement membrane, i.e. they undergo a reversal of polarity reminiscent of the ameloblast. In some areas, the lining is thin, in patches, the epithelium proliferates, the cells become swollen and eosinophilic, due to a form of keratinization. The nucleus disappears leaving a clear hole formerly occupied by the nucleus. These are called "*ghost cells*". At first the outline of the cells and their nuclei can still be distinguished, later the outline is lost, the cells fuse and tend to calcify. It is this calcification, which forms the opacities that is seen in the radiographs. The ghost cells are widely separated by intercellular edema. They are enlarged, ballooned, ovoid or elongated, a few contain nuclear remnants, but they are in various stages of degeneration leaving only a faint outline of the nucleus. Irregular amounts of dentin or osteodentin also may be found throughout the lesion. Melanin deposits sometimes may be present in the epithelial linings. The ghost cells can evoke a foreign body reaction with the formation of multinucleate giant cells in the connective tissue wall of the cyst. In the fibrous wall, strands and islands of odontogenic epithelium may be seen. This cyst sometimes assumes a noncystic, solid form and is referred to as a ghost cell tumor.

Treatment: Simple enucleation is never followed by recurrence. If, however, the cyst is associated with another odontogenic tumor such as an ameloblastic fibroma, then a wider excision will be required. When associated with a complex odontoma, a conservative removal is adequate.

Comment: A noncystic, solid variant is well known—the odontogenic/dentinogenic ghost cell tumor and a rare malignant variant has been reported—odontogenic ghost cell carcinoma.

Inflammatory (Periodontal) Radicular Cysts

The radicular cyst is an inflammatory cyst which results due to infection extending from the pulp into surrounding periapical tissues **(Fig. 37.8)**. It may develop apically, when it is termed as a periapical (periodontal) radicular cyst, or it may develop on the side of the root of a pulpless tooth, when it is termed as a lateral (periodontal) radicular cyst, this cyst should be differentiated from a developmental lateral periodontal cyst which is associated with a vital tooth.

Incidence: As compared to all other jaw cysts, this is the most common of all cysts of odontogenic origin, 75% of all the cysts of the jaws. Males are affected more commonly than females. Very few cases are seen in the 1st decade, peak incidence is in the 3rd and 4th decades.

Site: The incidence is highest in the anterior maxilla than the mandible, as the maxillary incisors are most prone to caries, trauma, pulpal death due to development defects and irritating effects of synthetic restorative materials. Frequency in maxilla is 3 times more than mandible—60–70%. In the mandible, cysts more commonly involve the mandibular posterior teeth, there may be separate small cysts arising from each apex of a multirooted tooth.

Clinical features: The cyst itself is frequently symptomless and may be discovered, when periapical radiographs are taken of teeth with nonvital pulps. Slowly enlarging swellings are often complained of. Radicular cysts at times attain a large size. Pain may be a significant chief complaint, in the presence of suppuration. Initially, the enlargement is bony hard, as the cyst increases in size, the covering bone becomes thin and exhibits springiness due to fluctuation. In the maxilla, buccal and palatal or only palatal expansion due to the lateral incisor or a palatal root will be noted. In the mandible, lingual expansion is very rare. The mucosa overlying the cystic expansion, as with the other cysts, is at first of normal color; then it may become conspicuous, because of the presence of dilated

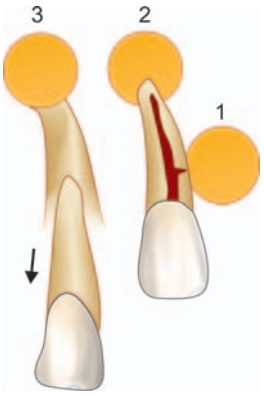


Fig. 37.8: Periodontal cysts: (1) Lateral—20%; (2) Apical—70%; (3) Residual—10%

blood vessels and finally it will take on a profound dark bluish tinge, in case of large cysts. An intraoral sinus tract may be identified with discharging pus or brownish fluid, when the cyst is infected. The involved tooth/teeth will be found to be nonvital, discolored, fractured or with heavy restorations or a failed root canal treatment. They may be sensitive to percussion or hypermobile, or displaced. It may involve deciduous or the permanent dentition. Temporary paresthesia or anesthesia of the regional nerve distribution may be evident as with other cysts when infection is present. Pathologic fracture may be the form of presentation in the mandible, as with other large cysts.

Radiological features: The common description of radicular cysts is a round, pear or ovoid-shaped radiolucency, generally outlined by a narrow radiopaque margin that extends from the lamina dura of the involved tooth/teeth. In case of very large cysts or infected cysts, this peripheral white line is occasionally absent. Root resorption is rare, but may be seen. A lateral radicular cyst may be seen in association with an accessory root canal or lateral perforation during root canal therapy.

Pathogenesis: The epithelial lining is derived from epithelial cell rests of Malassez in the periodontal ligament, the development of the cyst then occurs in three phases. The exact mechanisms involved in all the phases are debatable.

- **The phase of initiation:** Chronic low-grade invasion from the pulp/pulpal necrosis leads to the formation of the periapical granuloma. This leads to the activation and proliferation of epithelial rests in the periodontal ligament in the form of strands, arcades or rings.
- **The phase of cyst formation:** A cystic cavity forms, lined by stratified squamous epithelium due to various possible mechanisms, for example:
  - Death of the central cells occurs due to increase in the size and reduction of nutrients and oxygen to maintain them
  - Central epithelial cells desquamate, others orient towards the periphery, adjacent to the source of nutrition from the connective tissue, or
  - Epithelial cells orient towards the periphery to isolate the central necrotic zone.
- **The phase of enlargement:** Once initiation of cyst has occurred, the continuation of enlargement may occur due to various different mechanisms, which is true for any cyst, for example:
  - Mural growth
  - Accumulation of fluid
  - Retention of fluid
  - Production of a raised intrastatic pressure
  - Bone resorption with increase in cystic size (as has been explained in length earlier in the chapter).

Cystic contents (aspirate): The uninfected cystic fluid is straw colored or brownish and has cholesterol clefts; a small quantity of keratin flakes may be identified.

In case of a long-standing infection, a dirty-white caseous material may be expressed or frank pus may be present.

Pathology: The cyst is lined by stratified squamous epithelium, the lining may be thin or thick up to 5 mm in size. An inflammatory infiltrate of polymorphonuclear leukocytes will be seen in the lining. Epithelial linings may show the presence of Ruston's hyaline bodies, mucous cells or ciliated cells.

The fibrous capsule is composed of collagen and loose connective tissue. Acute and chronic inflammatory cell infiltrate may be found in the fibrous capsule.

Treatment: Nonvital teeth that are associated with the cyst, can either be extracted (depending on conditions of sufficient bone support and restorative possibilities) or they can be retained, by endodontic treatment and apicoectomy. External sinus tracts should always be excised to prevent epithelial ingrowth. The commonly employed surgical procedure for radicular cysts is enucleation, with primary closure. Very small cysts can be removed through the tooth socket. Large periodontal cysts that encroach upon the maxillary antrum or inferior alveolar neurovascular bundle or the nose may be treated by marsupialization.

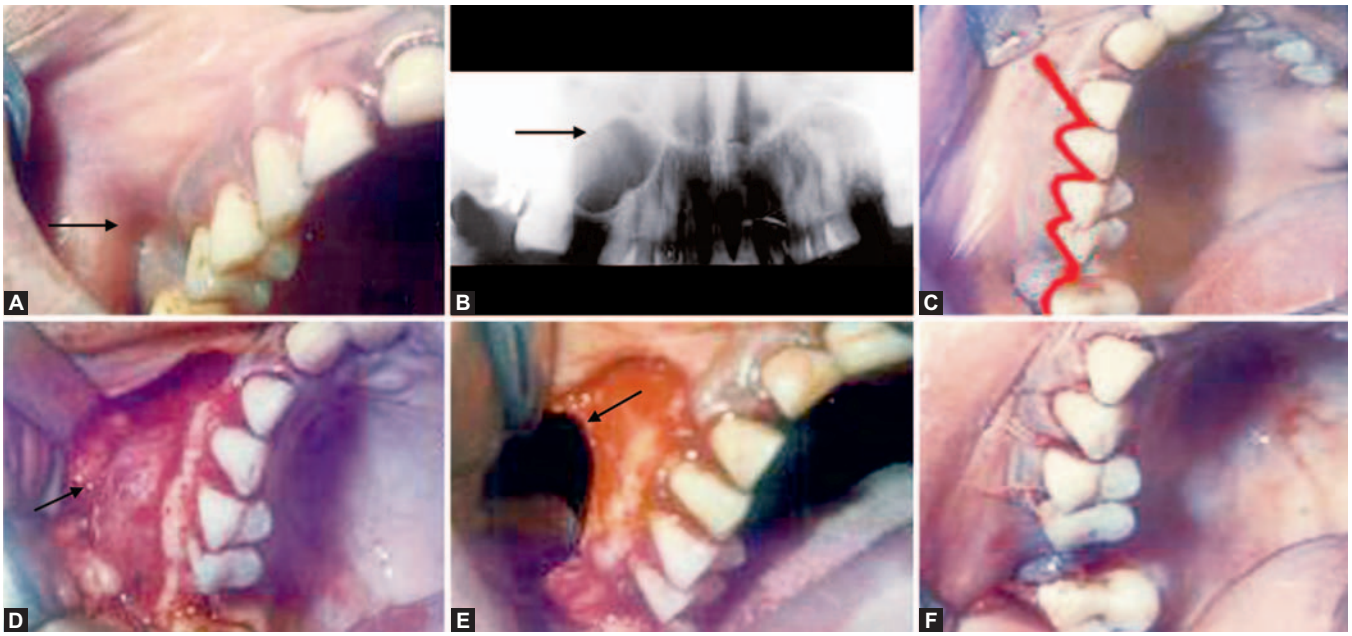
Behavior and prognosis: Some well-documented reports have been published, which contend that squamous cell carcinoma may arise from the epithelial lining of radicular cysts. Browne and other (1972) reported that epithelial dysplasia and keratin metaplasia may precede carcinomatous transformation.

Residual Cyst

A residual cyst is one that is overlooked after the causative root or tooth is extracted **(Figs 37.9A to F)**.

Causes: The possible causes are as follows:

- An incompletely removed periapical granuloma or cyst that potentially enlarges
- An impacted tooth associated with a lateral dentigerous cyst is removed, but the cystic lesion is unrecognized and is left *in situ*, this residual cyst persists and will enlarge
- A cystic lesion develops on either a deciduous tooth or a retained tooth, which either exfoliates or is extracted without knowledge of the underlying pathologic process.



Figs 37.9A to F: Residual cyst: (A) Buccal expansion and missing upper, R-First molar (extracted earlier); (B) OPG—a residual cystic lesion in 16 regions; (C) Incision, (D) Exposure of cystic lesion; (E) Defect after enucleation; (F) Wound closure

Incidence: It is less commonly seen than in the radicular cysts. It is identified mainly in middle-aged and elderly patients. There is no sex predilection.

Site: The incidence is greater in the maxilla than in the mandible. It is typically seen in edentulous sites **(Figs 37.9A and B)**.

Clinical features: Majority of the cases are asymptomatic and are discovered on radiographic examination **(Fig. 37.9B)**. Occasionally in case of large residual cysts, a patho-logic fracture or signs of encroachment on associated structures may be the presenting symptoms.

Histopathology: It is similar to the underlying process that was initially present.

Treatment (Figs 37.9C to F): It is similar to that which is employed for a radicular cyst, care should be taken to maintain and preserve the contour of the edentulous ridge.

Paradental Cyst

Distal to third molar, or mandibular infected buccal cyst, which develops on the buccal aspect of a first molar tooth, which has an enamel extension into the furcation zone (buccal bifurcation cyst or inflammatory collateral cyst).

Pathogenesis: Pericoronitis/inflammation stimulates cell rests of Malassez or reduced enamel epithelium.

Clinical features: 2nd or 3rd decade, equally seen in both the sexes, distal to third molar/besides a molar tooth.

Radiological features: Well-circumscribed radiolucency with sclerotic margin.

Histology: Like radicular cyst.

Treatment: Extraction of molar/third molar, enucleation of the cyst.

Multiple Cystic Lesions of the Jaws

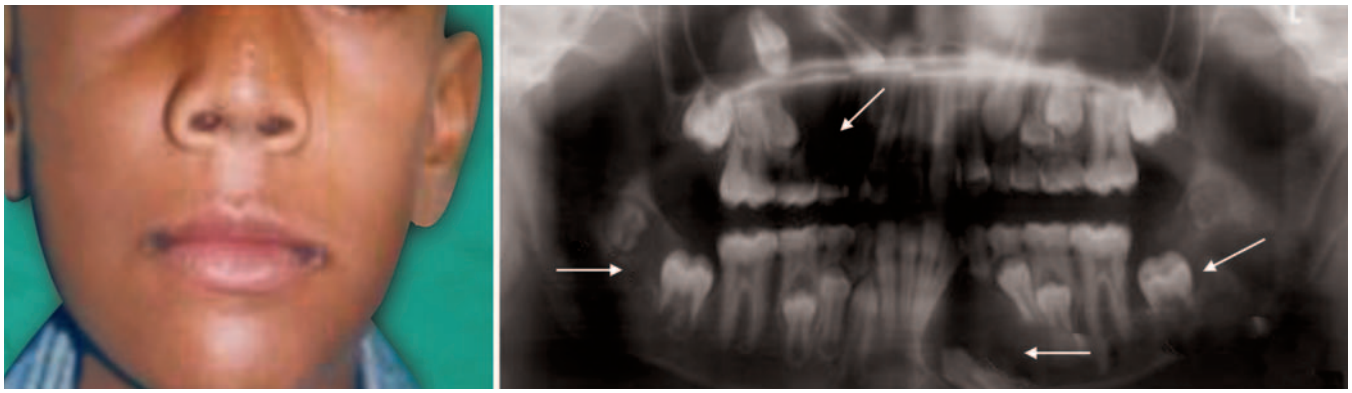
Majority of the cases that have been reported of multiple occurrence in the jaw bones, have been of either, primary dentigerous cysts or keratocystic odontogenic tumor or radicular cysts.

Multiple radicular cysts will be associated with several, carious nonvital teeth, generally the maxillary incisors or mandibular posterior teeth. Multiple dentigerous cysts may be present symmetrically in both the upper and lower jaws, involved with unerupted teeth or may be scattered in different quadrants **(Figs 37.10A and B)**.

Intraosseous Cyst of Nonodontogenic Epithelial Origin

Developmental Fissural Cysts

Fissural cysts are nonodontogenic cysts that arise owning to epithelial inclusions or entrapments in the lines of closure of the developing facial processes during the embryonic period of life. Each cyst is correlated, with its actual anatomic location **(Fig. 37.11)**.



Figs 37.10A and B: Multiple dentigerous cysts: (A) Extraoral view of a 10-year-old child, who had multiple dentigerous cyst; (B) Multiple dentigerous cysts and displaced unerupted permanent teeth (OPG)

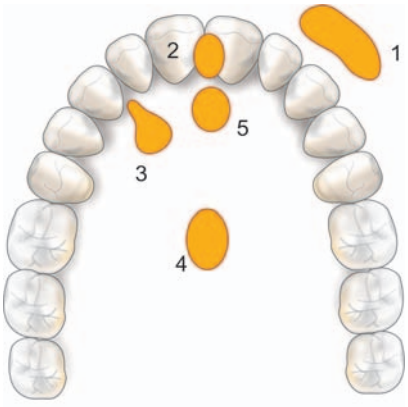


Fig. 37.11: Developmental and soft tissue cysts: (1) Nasolabial; (2) Median alveolar (median mandibular); (3) Globulomaxillary; (4) Median palatal; (5) Nasopalatine

Median Mandibular Cyst

The mandibular mesenchyme migrates medially from each side and fuses beneath the epithelium to form the mandibular arch, so that median mandibular fissural cysts should not exist. There is no clear cut explanation for these cysts developing in the midline of the mandible, they probably arise from epithelial inclusions in the area of the symphysis.

Incidence: This cyst is less commonly seen than the other fissural cysts. There is no sex predilection.

Site: It is found symmetrically in the midline of the mandible.

Clinical features: The cyst remains relatively small in size approximately 1–3 cm in size. The associated teeth are vital. A labial swelling may be palpable. The teeth may be divergent.

Radiologic features: The cysts are small, generally well-defined, circular or ovoid in shape. The lamina dura of the involved teeth is intact.

Histopathology: The cystic lining is of stratified squamous epithelium, the fibrous connective tissue wall may reveal an inflammatory infiltrate.

Treatment: The cyst should be differentiated from primordial cysts or residual radicular cysts. The cyst should be carefully enucleated, without the involvement or damage to the apices of the incisors.

Median Palatal Cyst

Controversy exists on whether the median palatal cyst is a true fissural cyst that arises because of epithelial inclusion during the fusion of the palatal processes of the maxilla or whether it represents a posterior extension of an incisive canal cyst in case of a *median palatine cyst* and due to an anterior extension in case of *the median alveolar cyst*.

Incidence: It is a rare cyst. There is no sex predilection. It is seen mainly in adults.

Site: It may be seen in the maxillary alveolus, when it is termed as the median alveolar cyst, or in the hard palate, between the incisive fossa and the posterior border of the hard palate, when it is termed as the median palatal cyst.

Clinical features: No signs and symptoms exist, unless the cyst becomes large, with expansion of bone and a palpable ovoid swelling in the mid-palatal region or mid-alveolar region.

Radiological features: A maxillary occlusal view will help to identify the ovoid, or irregular radiolucency in the mid-palatal region, often it becomes difficult to distinguish the cyst from an extensive incisive canal cyst.

Histopathology: The cysts may be lined by stratified squamous epithelium, pseudostratified ciliated columnar or cuboidal epithelium. Chronic inflammatory infiltration may be evidently seen in the subepithelial connective tissue.

Treatment: The cyst should be differentiated from a primordial cyst that may arise from the dental lamina in the midline of the maxilla. Careful enucleation is the line of treatment with primary closure.

Globulomaxillary Cyst

The traditionally described globulomaxillary cyst is also termed as a *lateral fissural cyst*. For years together since Thoma (1937) gave its first description, it has been believed that it arises from nonodontogenic epithelium inclusions at the site of fusion of the globular process of the medial (frontonasal) process and the maxillary process. The globular process is now referred to as the premaxillary process in embryologic terminology.

A critical study of this cyst has led to a lot of controversy, with reports stating that it is improbable for a fissural cyst to develop in this region. It is further reported that, if examined carefully, there were many plausible possibilities of the cyst in this region arising as primordial cysts from supernumerary teeth, developmental periodontal cyst, residual cysts from the primary dentition, lateral periodontal cyst, etc.

Incidence: It is fairly uncommon. It is seen in adults, in either sex.

Site: It is seen between the maxillary lateral incisor and cuspid teeth.

Clinical features: The lateral and maxillary cuspid teeth will be found to be tilted coronally with root divergence. Vitality test will be normal for both the teeth.

Radiological features: If the cyst is small, it is spherical in shape, as it enlarges a typical pear-shaped radiolucency is seen between the maxillary lateral incisor and cuspid with the apex pointing towards the alveolar crest. The lamina dura of both the teeth is preserved. The roots reveal divergence.

Histopathology: The epithelial lining is of pseudostratified columnar ciliated epithelium, often derived from the nasal mucosa. The wall which is thick may have concentrations of plasma cells and lymphocytes.

Treatment: Careful enucleation without damage to the adjoining roots of the teeth, followed by primary closure is the definitive line of treatment for true globulomaxillary cysts.

Nasopalatine Duct Cyst/Incisive Canal Cyst

The nasopalatine cyst is a true, nonodontogenic cyst, also referred to as the incisive canal cyst, which occurs because of embryonic epithelial remnants within the nasopalatine canal that connects the oral and nasal cavities in the embryonic stage. Mayer (1914) first described the nasopalatine duct cyst, as a "supernumerary nasal sinus". It is also known as "incisive canal duct cyst", occurring in 1% of population.

Incidence: This is the most common type of maxillary developmental, nonodontogenic cyst. It has a slight predilection for the male sex. Majority of the cases are seen in adulthood in the 4th, 5th and 6th decades.

Site: The cyst may arise at any point along the incisive canal, but is seen more commonly in the lower portion of the maxilla, between the apices of the central incisor. Another variant is the cyst of the palatine papilla, which is located solely within the soft tissues in the region of the incisive papilla, at the opening of the canal.

Clinical features: Majority of the cysts remain asymptomatic, as they do not attain a very large size, beyond 1.5–2 cm. The notable common symptom is a recurrent swelling, in the anterior region of the midline of the palate, or on the labial aspect between the central incisors, at times the cyst may extend labiopalatally and fluctuation will be positive. Displacement of the teeth is common. The patients most commonly may complain of swelling, pain and discharge. The discharge, often described as a "salty taste" is seen to originate from a sinus tract at or near the incisive papilla.

At times a burning sensations or numbness is experienced, which is due to pressure exerted by the cyst on the nasopalatine nerves. The central incisors are vital and normal in color, unless they are affected adversely, by trauma or caries.

Radiological features: The nasopalatine duct cyst is seen as a well-defined cystic outline, between or above the roots of the maxillary central incisor teeth. It can be round or ovoid, some may appear as heart-shaped, because during expansion, they may become notched by the nasal septum or the nasal spine may be superimposed on the radiolucent area or there may be bilateral cysts developing in both Stenson canals. Kay (1972) reported that any radiograph of the fossa, which showed a shadow less than 6 mm wide may be considered within normal limits as an incisive canal fossa in the absence of specific symptoms **(Figs 37.12 and 37.13)**.

The roots of the central incisors may show divergence and an intact lamina dura around the tooth apices.

Histopathology: The type of epithelium found may vary at different levels. It may be stratified squamous at a lower level, more superiorly it may be pseudostratified columnar, cuboidal as well as ciliated. Presence of mucous glands, goblet cells and cilia is highly indicative of their origin within the incisive canal as is the presence of nerves and blood vessels in the fibrous capsule. Hyaline cartilage may be identified in the wall of the cyst.

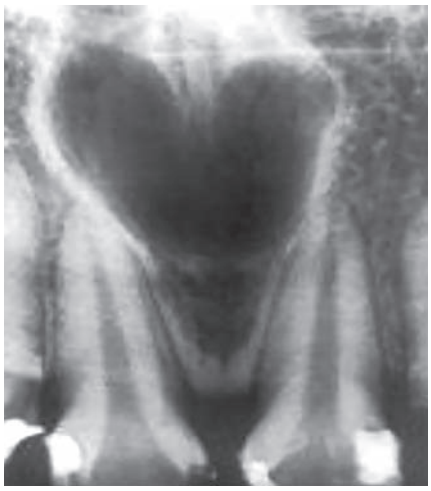


Fig. 37.12: Nasopalatine cyst is typically heart-shaped, between two vital maxillary central incisors

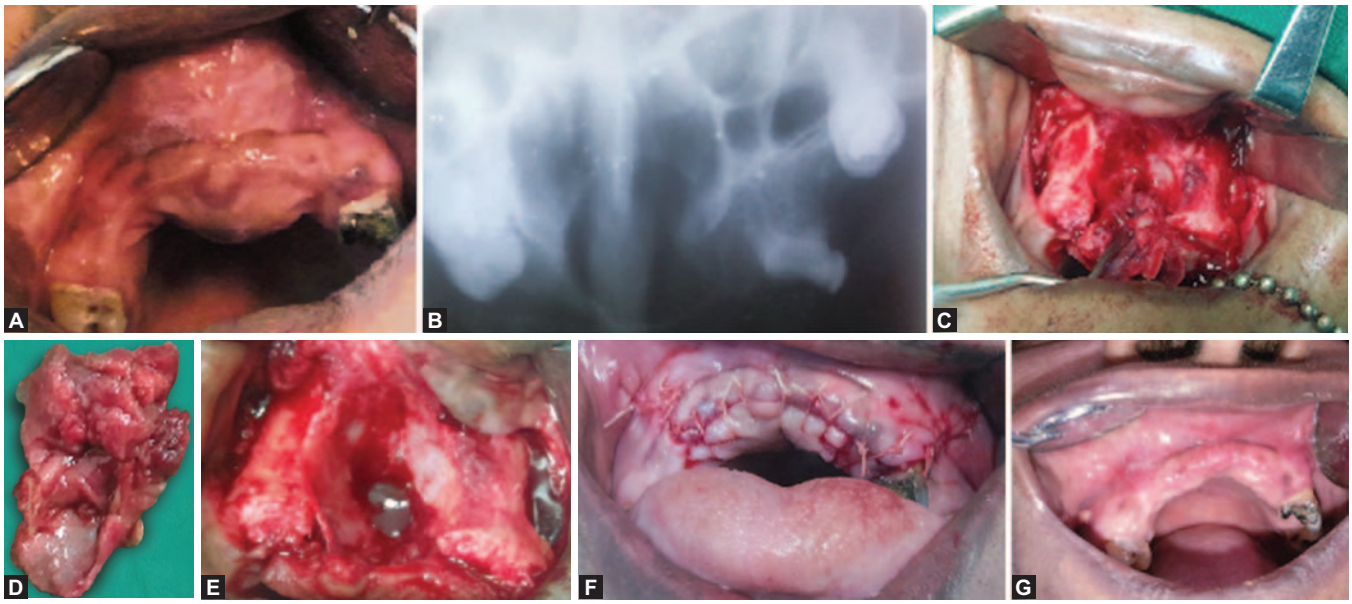
Cystic contents (aspirate): Aspiration is an important diagnostic aid to rule out a normal incisive canal fossa radiolucency. The viscous fluid content may be mucoid material or even pus if the cyst has been infected.

Treatment: Careful surgical enucleation is the line of treatment of nasopalatine duct cysts, by raising a palatal flap after taking an incision along the gingival margins of the teeth, or along the crest of the ridge in the edentulous patient, from canine to canine. The neurovascular bundle is salvaged, the cyst is carefully dissected free, from its bony bed. The flap is returned to its original position and closed by interrupted sutures through the interproximal spaces. Occasionally, an acrylic palatal stent helps in preventing swelling and hematoma formation.

Nonodontogenic Nonepithelial Bone Cysts (Cyst-like Conditions)

Solitary Bone Cyst/Traumatic or Hemorrhagic Extravasation Bone Cyst

The term cyst in relation to this lesion is controversial and probably a misnomer, also termed as *traumatic or hemorrhagic bone cyst*. It is not confined to the jaws, as similar lesions are seen elsewhere in the skeleton, commonly at the proximal ends of the humerus and upper



Courtesy: Dr M Parkar

Figs 37.13A to G: (A) Clinical picture of nasopalatine cystic lesion; (B) Heart-shaped radiolucency; (C) Surgical exposure of a lesion; (D) Excised nasopalatine cyst specimen; (E) Surgical defect; (F) Final suturing; (G) Healing after 3 months

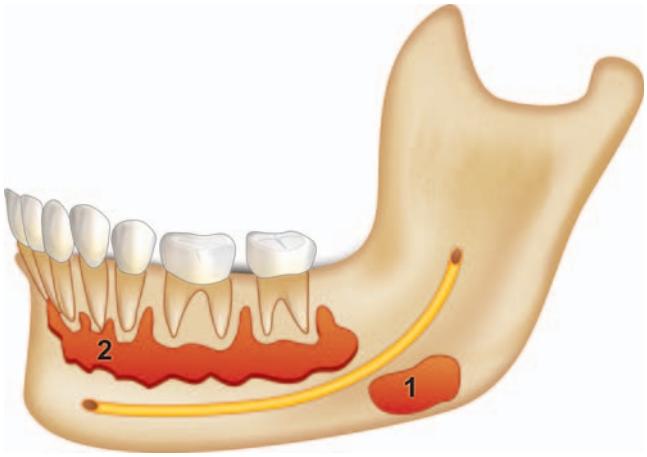


Fig. 37.14: (1) Stafne's idiopathic cavity is always located below the mandibular canal, near the angle of the mandible; (2) Solitary bone cyst is located above the mandibular canal and has a typical scalloped appearance as it often extends between the roots of the teeth

and lower portions of the femoral and tibial shafts, where it is known as *unicameral bone cyst* **(Fig. 37.14)**.

Etiology: A number of theories have been forwarded, these include:

- Trauma and intramedullary hemorrhage with failure of organization, the clot subsequently liquefies and cyst is formed
- Spontaneous atrophy of the tissue in a central benign giant cell lesion
- Abnormal calcium metabolism
- Chronic low-grade infection
- Necrosis of fatty marrow secondary to ischemia
- Aberration in the development and growth of the local osseous tissue.

Recent theory: Osteogenic cells fail to differentiate locally and thus instead of bone, the undifferentiated cells form synovial tissue.

Incidence: The simple bone cyst is not a common lesion, and is seen in the first 2 decades of life. Lesions occur particularly in children and adolescents between 10 years and 20 years of age. Males are affected more often than females, because of the increased exposure of the former to trauma. The relatively infrequent solitary bone cysts in the older age groups might support the theory that the cavities eventually tend to undergo a natural cure.

Site: It is rarely seen in the maxilla. Majority are seen in the subapical region, above the inferior dental canal, in the cuspid and molar region. Occasionally, a lesion may develop in the incisor region **[Fig. 37.14(2)]**.

Clinical features: The size ranges from 1 cm to those that are so large that they hollow out much of the jaw. Usually symptomless and is detected as an incidental finding during a radiographic examination. The cortex is usually thinned, but expansion occurs later on and may first involve the lingual aspect below the mylohyoid ridge, where it may be overlooked. The associated teeth are vital, unless involved otherwise. Unerupted teeth usually molars may be prevented from eruption.

Radiological features: The cyst appears as a unilocular cavity, which when it enlarges and pushes up into the interdental bone between the teeth to produce a characteristically scalloped dome-shaped outline to the upper border around the roots of the teeth.

In the anterior region, the outline is usually regular and general shape is round or oval, with no indentations. The roots of related teeth may be displaced, lamina dura is intact; resorption is not seen. Distension of the outer or inner cortical plates is uncommon.

Histopathology: When the cyst cavities are opened at operation, they are frequently found to be empty. No visible lining is generally seen, in some cases, a thin membrane, granulation tissue or blood clots may be evident. Loose vascular fibrous tissue membrane with hemosiderin pigment may be seen with small multinucleate cells. The adjacent bone, when included shows osteoclastic resorption on its inner surface.

Cystic contents (aspirate): Aspiration should be done carefully, a deep yellow colored fluid may be obtained. This contains plasma proteins and will clot, if left to stand. From small cysts, a heavily blood stained fluid or fresh blood may be obtained. Some cysts may be reported empty. It is suggested that they may contain gas such as "nitrogen", "oxygen" and "carbon dioxide".

Treatment: Surgical exploration is required for diagnosis and usually constitutes the treatment. Gentle curettage stimulates hemorrhage which results in rapid obliteration of the defect and eventual healing by new bone formation.

Stafne's Idiopathic Bone Cavity (Mandibular Salivary Gland Depression)

Although, Stafne's bone cavity is not a cyst, it is included because of their clinical similarity to cysts of the jaw bones and the frequent difficulty in differential diagnosis. It is also known as a *latent bone cyst or static bone cavity*.

Etiology: Various theories have been postulated that include:

- Stafne believed that such cavities are due to failure of the normal deposition of bone during development of the jaws, in an area formerly occupied by cartilage or because of failure of subperiosteal apposition at the lower border
- Developmental defects that are occupied by a lobe of normal submandibular salivary gland
- Close proximity of a lobe of submandibular salivary gland that produces a localized pressure atrophy of the lingual surface of the mandible
- Constricted remains of a solitary bone cyst
- Area of localized necrosis caused by repetitive minor pressure.

Incidence: Relatively uncommon, the largest series have been reported by Stafne (1942). Few defects have been reported in children, though majority have been reported in males over 40 years of age.

Site: They have been reported below the inferior alveolar canal, approximately in line with the position of the third molar tooth towards the inferior border of the mandible, generally unilateral, bilateral defects have been reported **[Fig. 37.14(l)].**

Clinical features: These are symptomless lesions discovered during routine radiological examination, the lesions are nonprogressive.

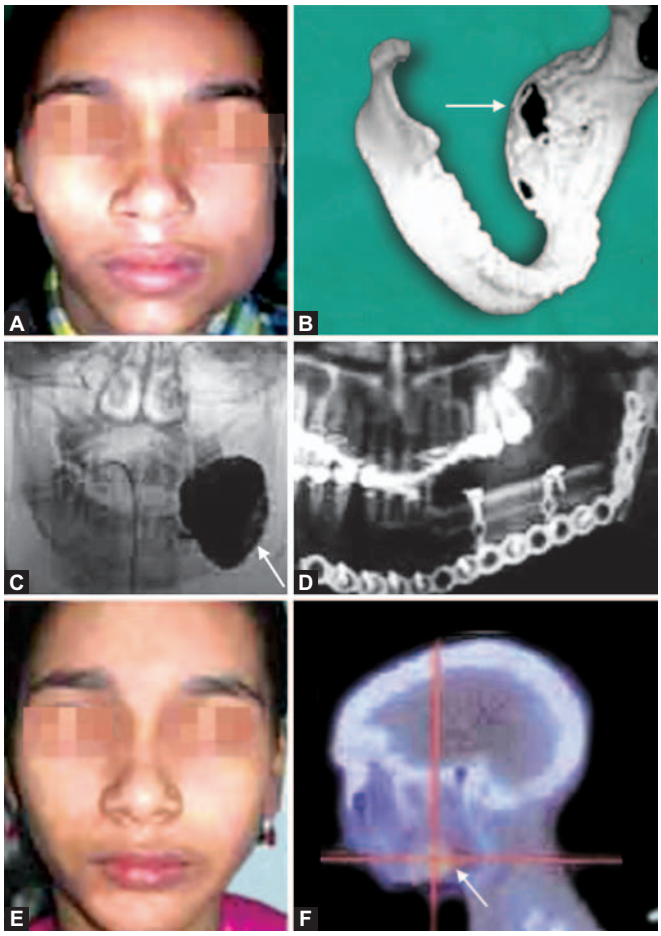
Radiological features: The depression is rounded or oval, 1–3 cm in size and appears as a round or oval defect, below the inferior alveolar canal, posterior to the first mandibular molar. The area of rarefaction is well demarcated by a dense radiopaque line. At times, if the lesion has extended up to the inferior border then cortical bone perforation may be seen.

Histopathology: These are idiopathic bone cavities and no diagnostic tissue can be mentioned. These cavities, in fact, are empty. Contrary, they may contain normal salivary gland tissue, lymph node tissue or abnormal glandular tissue.

Treatment: These idiopathic cavities are of no particular concern and once diagnosed as Stafne's cavity, no surgical intervention is warranted. Regular radiological follow-up is advised, as they constitute an area of weakness and pathologic fracture can occur.

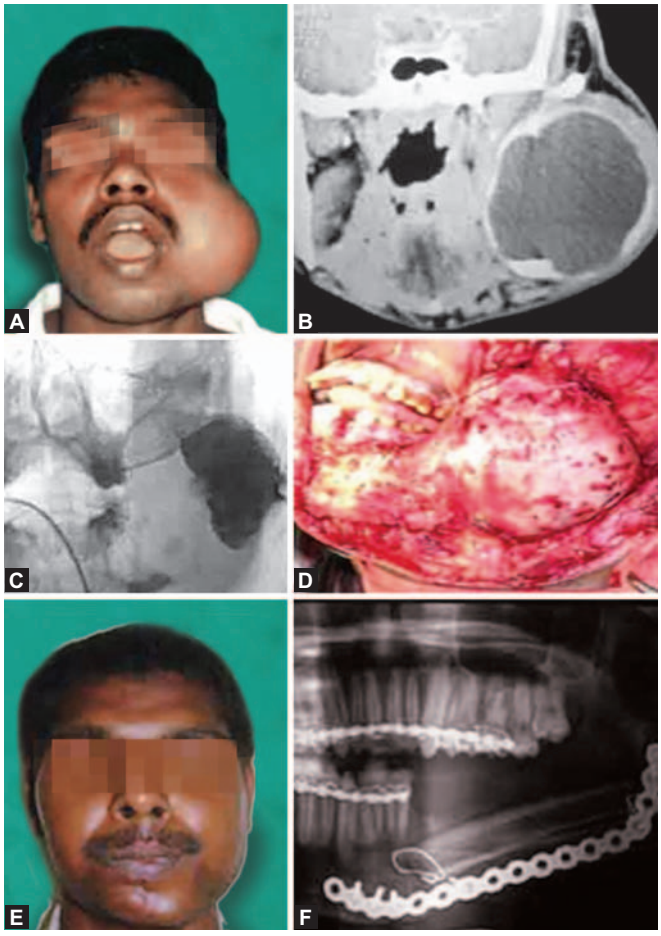
Aneurysmal Bone Cyst

The aneurysmal bone cyst (ABC) was first described by Jaffe and Lichtenstein (1942). It is an uncommon hemorrhagic lesion of the bone. *The name is misleading, as it does not contain vascular aneurysm and it is not a true bone cyst.* Though often seen in the long bones and spine, it is rarely seen in the jaws **(Figs 37.15 to 37.17)**. Previously, it has been described as an atypical giant cell tumor, hemorrhagic osteomyelitis, ossifying hematoma or benign bone cyst.



Figs 37.15A to F: Patient with aneurysmal bone cyst: (A) Preoperative frontal photograph; (B) 3D CT scan showing multiple perforations of buccal and lingual cortices; (C) Final glue cast showing glue occupying the lesion; (D) Panoramic radiograph showing fibula flap reconstruction of the mandible; (E) Postoperative frontal photograph; (F) SPECT scan suggesting increased radiotracer uptake at the reconstruction site

Jaffe and Lichtenstein described this entity with the word "aneurysmal" to emphasize the "blown out", distended contour of the affected bone, and the words "bone cyst" to underscore that when the lesion is entered through a thin shell of bone, it appears largely as a blood filled cavity. It is rapidly growing tumor-like swelling that may seem to "balloon" out of the jaw.

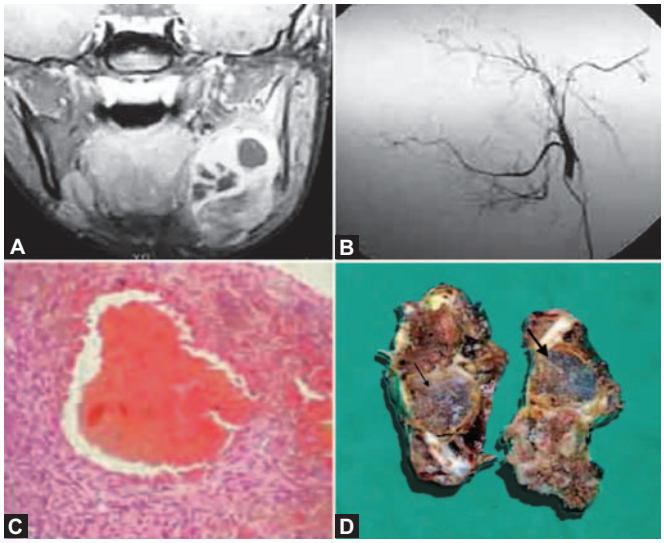


Figs 37.16A to F: Patient no. 2 with aneurysmal bone cyst: (A) Preoperative frontal photograph; (B) CT scan coronal section showing extension of the lesion, ballooning of the condylar and coronoid process; (C) Final glue cast showing glue occupying the lesion; (D) Surgical approach for the resection of the lesion; (E) Postoperative frontal photograph; (F) Panoramic radiograph showing fibula flap reconstruction of the mandible

Etiology: Various theories have been postulated, which include the following:

- History of trauma
- Possible relationship with the giant cell lesion
- Variation in the hemodynamics of the area
- Sudden venous occlusion.

Incidence: It is rare, and reports of lesion in the jaws are limited, occurring most commonly in long bones (50%), the pelvis and vertebrae (20%). In the jaw bones, they account for about 1.9% of all ABCs of the skeleton, and about 1.5% of all nonodontogenic cysts of the jaws. There is no specific sex predilection. It is seen mainly in children, adolescents or young adults.



Figs 37.17A to D: Aneurysmal bone cyst: (A) T1-weighted MRI showing hypodense cystic areas separated by septae; (B) External carotid angiography revealing stretching of the facial artery with no vascularity of the lesion; (C) Histopathology showing cavernous spaces separated by septae. Aneurysmal bone cyst; (D) Photograph of the resected specimen showing glue (arrows) in the lesion

Site: It is more commonly seen in the mandible than the maxilla, more commonly in the posterior region than the anterior.

Clinical features: The lesions produce firm swellings, the patients may give a history of rapid enlargement, the teeth may show displacement, though they remain vital. Egg shell crackling may be exhibited. Bruits are not heard and the lesion is not pulsatile.

Radiological features: The lesions are usually unilocular, they may be oval or spherical in shape, causing considerable ballooning of the cortex. They generally show a subperiosteal layer of new bone. At times internal ridges or incomplete septae may give a multilocular appearance, also described as honeycomb or soap-bubble appearance. Teeth may be displaced and root resorption has been described. The outer cortical plate may be destroyed.

Cystic contents (aspirate): Dark venous blood can be aspirated.

Histopathology: The ABCs are benign, non-neoplastic, expansile, vascular, locally destructive lesions. The *WHO classifies ABC as a tumor-like lesion and defines it as an expanding osteolytic lesion consisting of blood filled spaces of variable sizes separated by connective tissue septa*

containing trabeculae of osteoid tissue and osteoclast giant cells. Other solid areas may have the appearance of fibrous dysplasia, ossifying fibroma or may contain large numbers of multinucleate giant cells, fibroblasts, hemorrhage and hemosiderin.

Treatment: Various treatment modalities have been reported for ABCs including observation and long-term follow-up, which may lead to spontaneous regression.

Surgery is generally hampered by persistent bleeding, but ceases after all the vascular tissue has been removed. Curettage is the choice of treatment, though incomplete removal in large lesions is liable to result in recurrence in 26–53% of the cases.

Local excision with bone grafting has been suggested in very large lesions. Radiotherapy is contraindicated as it may result in the occurrence of postradiation sarcoma.

The other methods include (1) curettage along with cryotherapy, (2) percutaneous intralesional calcitonin injections in combination with methylprednisolone, (3) intralesional injection of a fibrosing agent—Ethibloc-Ethicon, (4) arterial embolization followed by en bloc resection.

1. During curettage, massive hemorrage may be encountered, which might require ligation of the external carotid artery as a precautionary measure. Cryosurgery can be supplemented with curettage to decrease the recurrence rate.
2. Intralesional calcitonin injections in combination with methylprednisolone have been used, but this therapy needs long-term repeated multiple injections and the response is unpredictable. The injections are thought to combine the inhibitory antistatic and fibroblastic effects of methylprednisolone with the osteoclastic inhibitory effect and trabecular bone-stimulating properties of calcitonin.
3. Intralesional injections of fibrosing agent may show complete involution or it can be used as an adjunct treatment, wherein the injections may help to limit the blood loss during surgery.
4. Transosseous intralesional embolization followed by en bloc resection. This modality was suggested by Malik and Vinay Kumar (2007) for handling large recurrent lesions to prevent recurrence and to reduce intraoperative massive bleeding. Here, adjunctive intralesional embolization is used preoperatively to decrease the vascularity of the lesion. Initial angiography via transfemoral approach was carried out to assess the feeder vessels and vascularity of the lesion. Percutaneous intralesional embolotherapy under constant fluoroscopic guidance was carried out with diluted n-butyl-cyanoacrylate glue (20 cc). Later on resection of the lesion was done and primary reconstruction using free fibula graft.

It has been reported that embolization occludes vascularity of the lesion, without interfering with the vascularity of the surrounding tissues, which may lead to involution of the soft tissue component. It also brings about sclerosis and ossification. This mineralization becomes apparent 2–3 months after embolization.

Cysts Associated with the Maxillary Antrum

Surgical Ciliated Cyst of the Maxilla

These cysts are highly uncommon. They may be labeled as iatrogenic cysts, as the patient will always give a previous history of some surgical procedure that was carried out in the maxilla where in the maxillary sinuses were opened surgically.

Etiology: The cysts develop from the epithelial lining of the maxillary sinus, which was trapped in the surgical incision during closure following a maxillary surgical procedure that involved the sinus lining, e.g. maxillary osteotomies, Caldwell-Luc, or maxillary fractures that had involved the antrum.

Site: The cystic lesion is present in close proximity to the maxillary sinus, but there is no communication between them, as has been proved with radio-opaque dyes.

Clinical features: Patients may complain, of a dull, localized pain in the maxilla; the cystic lesion is otherwise not associated with any tooth.

Radiological features: Radiographs will reveal a well-defined radiolucent expansion of the maxilla, with a radiopaque margin, that is closely related to the maxillary sinus. The cyst may appear to encroach upon the sinus, but in reality, is a separate entity.

Pathology: The cysts are lined by pseudostratified ciliated columnar epithelium.

Treatment: The cysts are best treated by surgical enucleation.

Benign Mucosal Cyst of the Maxillary Antrum/ Pseudocyst of Maxillary Antrum

The other terms used for this cystic lesion are "*mucocele*" or "*retention cyst*" of the maxillary antrum.

Etiology: Most of these cysts have been reported to occur due to infection and inflammation of the ducts of the mucous glands.

Incidence: It has been reported commonly, in routine radiographs of the maxilla, with a higher incidence in the 3rd decade.

Site: More commonly seen in the floor of the maxillary sinus, though the other walls also may be involved. Generally unilateral, though bilateral and sometimes multiple cysts may occur.

Clinical features: Majority of the cases are discovered accidentally on radiographs. Though some patients may complain of a dull pain over the antral region, while others may report a sense of fullness or numbness in the maxillary region.

If the lateral wall is involved or the cyst is large in size, then the patient may complain of a nasal obstruction. Others may report, yellowish discharge from the nose or complain of a postnasal drip. Large cysts may produce an obvious swelling in the maxillary region. The cyst is not associated with any teeth.

Radiological features: The cystic lesion is seen as spherical, ovoid, radiopacities within the maxillary antrum that has a smooth uniform outline. When suspected on an intraoral radiograph, an orthopantomograph must be taken to confirm its existence.

Pathology: The cysts may or may not be lined by epithelium. The secretory type cysts are lined by pseudostratified, ciliated, columnar epithelium and contain mucin. Within the capsule and lumen, a large number of chronic inflammatory cells may be seen.

Treatment: In the symptomatic patient, it is advisable, to remove the cystic lesion via a Caldwell-Luc approach, and enhance drainage via cannulation through intranasal antrostomy, whereas in the asymptomatic patient, it would be best to follow-up with periodic radiographs, as most cystic lesions remain static or undergo spontaneous regression with conservative medical treatment with antibiotics, decongestants and antral lavage.

SOFT TISSUE CYSTS OF THE ORAL CAVITY

Odontogenic (Developmental) Cysts

Gingival Cysts

The only specific criterion for these lesions is its location in the gingival tissues. There are two types of gingival cysts: (1) gingival cyst of the adult, (2) gingival cyst of infants/newborn.

Gingival Cyst of the Adult

Etiology: The cysts possibly arise from:

- Remnants of the dental lamina or cell rests of Serres
- As traumatic implantation cysts
- From enamel organ or epithelial islands of the surface epithelium
- As cystic degeneration of deep projections of surface epithelium, or
- Derived from glandular elements.

Incidence: It is relatively rare—0.5% of oral cysts, and has no sex predilection. It is known to occur in adults in the 5th or 6th decade.

Site: They occur more frequently in the mandible than in the maxilla. They appear particularly in the canine and premolar region of the mandible, rarely they may be seen in the anterior part of the jaw.

Clinical features: The cysts are seen in the attached gingiva or the interdental papilla on the labial aspect. The lesions are painless, slow growing swellings that have a smooth surface, may be of normal color or bluish. They are soft and fluctuant and the adjacent teeth are vital. Occasionally, pressure from larger lesions may cause superficial cortical erosion.

Histopathology: The cysts are lined by stratified squamous epithelium and usually contain fluid. Same as lateral periodontal cyst, except that it is in the gingival and not in the bone.

Treatment: Surgical excision is curative and there is no tendency for recurrence.

Gingival Cyst of Infants/Newborn

Gingival cysts of infants are frequently referred to as *Bohn's nodules or Epstein's pearls*.

Etiology: The cysts arise from epithelial remnants of the dental lamina.

Incidence: Frequency of gingival cysts of neonates is high in newborn infants, but they are rarely seen after 3 months of age.

Site: Bohn's nodules are found on the buccal or lingual aspects of the dental ridges, whereas Epstein's pearls are seen along the midpalatine raphe and are considered to be of nonodontogenic origin.

Clinical features: They appear as discrete white swellings. They may be single or multiple and clinically resemble a mucocele.

Histopathology: They have a thin lining of stratified squamous epithelium which may reveal parakeratinization and contain desquamated keratin.

Treatment: No treatment is required as they rupture spontaneously on eruption of the underlying teeth.

Nonodontogenic Fissural Cysts

Anterior Median Lingual Cyst

Incidence: It is a rare lesion, few cases have been reported. It is almost always present since birth.

Site: It is seen to involve the anterior two-thirds of the tongue.

Clinical features: At birth, a fluctuant swelling may be seen involving the anterior two-thirds of the dorsal surface of the tongue.

Pathogenesis: The anterior two-thirds of the tongue develops from paired processes, which develop on the back of the mandibular arch, it is reported that this cyst develops from epithelium entrapped between the lateral tubercles of the developing tongue.

Histopathology: The epithelial lining is variable, it may be stratified squamous epithelium, pseudostratified ciliated columnar epithelium or cuboidal epithelium. It may show parakeratinization.

Treatment: Incision and drainage is followed by recurrence. The cyst should be enucleated.

Nasolabial Cyst

Strictly speaking the nasolabial cyst is a true soft tissue fissural cyst, that does not occur within bone; therefore, the term nasoalveolar is a misnomer, other designations suggested are nasoextra-alveolar cyst, nasal vestibule cyst, nasal wing cyst and mucoid cyst of the nose.

Incidence: Nasolabial cysts are uncommon lesions with a wide age distribution. They are seen to occur in the 3rd, 4th and 5th decades of life. They have been seen predominantly in the female sex.

Site: They are seen above the buccal sulcus under the ala of the nose, at the junction of the globular, the lateral nasal and the maxillary processes. They may be unilateral, but bilateral cases have been reported.

Clinical features: Majority of the cases are unilateral though bilateral lesions have been reported. A swelling is seen involving the lip that lifts up the nasolabial fold and obliterates the labial sulcus. When it bulges into the inferior meatus, it may result in difficult breathing. The cysts are fluctuant and painless unless infected secondarily. Infected cysts may discharge into the nose or mouth.

Pathogenesis: Various hypotheses proposed are as follows:

First theory is that a fissural cyst arising from epithelial remnants entrapped along the line of fusion of maxillary, median nasal and lateral nasal process.

Second theory is that the cyst develops from misplaced epithelium of nasolacrimal duct.

- Remnants of the nasolacrimal duct
- Lower anterior portion of the mature nasolacrimal duct
- Mucous cysts arising from epithelium lining of the floor of the nose
- Mucous cysts within the mucous glands in the labial sulcus
- Sequestered epithelium from the depths of the groove between the maxillary and lateral nasal process.

Histopathology: The epithelium is usually pseudostratified columnar, cuboidal or ciliated. It may be stratified squamous. Goblet cells are present.

Cystic contents (aspirate): The cyst contains straw colored or whitish mucinous fluid.

Treatment: The cyst should be removed surgically by an intraoral approach. Care should be taken while separating the cystic lining from the nasal mucosa.

Retention (Salivary Glands) Cysts

A. Mucocele

Two types of distinct entities described are the *true retention cyst*, which is lined by epithelium and the other is the *mucus extravasation cyst*, which occurs because of the pooling of mucus. It does not have any epithelial lining and is surrounded by compressed connective tissue cells, in some cases only granulation tissue is present.

Etiology: Various reasons that have been forwarded are as follows:

- Obstruction of a salivary duct
- Trauma to a salivary duct which is either pinched or severed
- Trauma to the secretory acini
- Congenital atresia of submandibular duct orifices
- Cystic type of papillary cystadenoma.

Incidence: It is commonly seen in connection with the minor salivary glands. There is no predilection for age or sex. However, it has been reported that retention cysts occurred more frequently in older patients, whereas the extravasation cysts occur more commonly in the younger age group.

Site: Majority of mucoceles are seen to affect the lower lip. With the exception of the anterior half of the hard palate which is devoid of salivary glands. They can occur anywhere in the oral cavity, i.e. cheeks, ventral surface of the tongue, floor of the mouth, retromolar area.

Clinical features: Diagnosis of these cysts is not difficult, generally small in size, they appear as painless, superficial, well circumscribed, swellings on the mucosa. Often approximately, 1–2 mm in size. Dilemma in diagnosis may arise when they are deep seated. Fluctuation is positive. Color is variable, it may be translucent or bluish. The mucocele may rupture spontaneously, with the liberation of a viscous fluid. However, in a few days to weeks, additional fluid accumulates and the lesion reappears. This cycle of rupture, collapse and refilling may continue for months.

Pathology: The mucus extravasation cysts do not have any epithelial lining, and are simply, poorly defined pools containing eosinophilic mucinous material and vacuolated macrophages, granulation tissue and condensed fibrous tissue, may be seen containing lymphocytes, polymorphonuclear leukocytes and eosinophils.

The retention cysts will be partly or completely lined by epithelium which may be of stratified squamous epithelium or of cuboidal cells or pseudostratified columnar epithelium, macrophages may be associated with the epithelium lining.

Treatment: Enucleation of mucoceles is frequently followed by recurrences. They are best treated by surgical excision together with the associated minor salivary gland tissue and surrounding connective tissue. The mucosal margins are then undermined and sutured in apposition.

B. Ranula

Ranula is a mucocele that is present on the floor of the mouth, beneath the tongue. Owing to its resemblance to a frog's belly, it has been termed "ranula".

Two types have been identified, i.e. *superficial ranula and plunging ranula*.

Etiology: It has been reported that the majority of ranulas occur because of extravasation of mucus due to trauma to the excretory ducts of the sublingual salivary gland.

- *In the plunging type*, this extravasated mucus passes through the mylohyoid muscle and collects in the submandibular region.
- Dilated submandibular ducts could be a causative factor because of *atresia of submandibular duct orifices* is another theory.

Clinical features: A dome-shaped bluish swelling of a superficial ranula may be seen located laterally in the floor of the mouth beneath the tongue. The tongue may be raised or displaced as it enlarges. The swelling may cross the midline. At times, if the swelling is punctured or traumatized, a mucus secretion may be evident. In the "plunging" type a fluctuant extraoral, submandibular swelling will be seen.

Treatment: Marsupialization results in recurrence. It is advisable to surgically remove the sublingual gland from an intraoral approach for both the superficial or plunging variety. This removes the secreting source and thereby avoids any recurrence.

Nonodontogenic (Developmental) Cysts of the Soft Tissues

Dermoid and Epidermoid Cysts

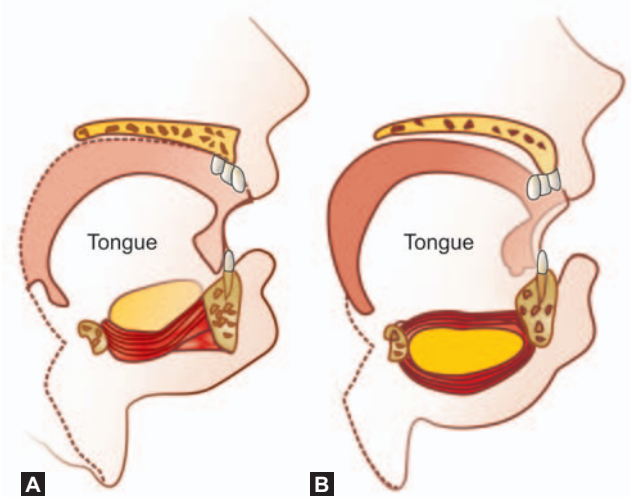
The *dermoid cyst* is a form of *cystic teratoma*, which is lined by epithelium and in addition reveals the presence of skin appendages, e.g. hair, sebaceous glands or teeth. The *epidermoid* cyst is also lined by epithelium but does not contain any skin appendages.

Incidence: It is uncommonly seen. Age of occurrence is in young adolescents; however, there is no sex predilection.

Pathogenesis: These are nonodontogenic developmental cysts that are thought to arise from epithelial rests persisting in the midline after fusion of the mandible and hyoid branchial arches, it is comprised of a combination of ectoderm, mesoderm and endodermal elements. In 5% of the cases, one of the tissue elements can become malignant.

Site: Lateral dermoids are rarely seen, median dermoids are seen in the midline in the floor of the mouth above the geniohyoid muscle or inferior to the geniohyoid muscle, which may be present, superior or inferior to the mylohyoid muscle.

Clinical features: Swellings may be seen as midline swellings or rarely as lateral swellings, in the floor of the mouth and neck. Those above the geniohyoid muscle,



Figs 37.18A and B: Location of dermoid and epidermoid cysts of the oral cavity: (A) Dermoid cyst is visible, in the floor of the mouth, as it elevates the tongue and is present above the mylohyoid muscle; (B) Epidermoid cyst is seen as a submental swelling, as it is located below the mylohyoid muscle

elevate the tongue, causing difficulty with mastication and speech. Those present inferior to the geniohyoid muscle, cause a submental swelling, that has been aptly described as a double chin. They are small in infancy but enlarge over the years to several centimeters in diameter. On palpation, a dough-like feel is appreciated **(Figs 37.18A and B)**.

Histopathology: Both the epidermoid and dermoid cysts are lined by keratinizing stratified squamous epithelium and contain keratin scales. The dermoid cysts are characterized by the presence of one or more dermal appendages in the wall, such as sebaceous glands, sweat glands, hair follicles, etc.

Treatment: Surgical excision is the best line of treatment. For cysts present in the floor of the mouth, an intraoral approach is advisable. For very large cysts present inferior to the mylohyoid muscle, an extraoral approach via a horizontal submandibular incision in the midline may be required for better access.

Lymphoepithelial Cysts

Branchial Cleft Cyst (Cervical/Intraoral)

Branchial arch remnants can give rise to cervical cysts, which are more common than intraoral branchial cysts (Bhaskar, 1966).

Incidence: Overall this is not a common cystic lesion. They may occur at all ages, though they are frequently seen in the young adults between 20 years and 40 years of age. There is no sex predilection. They are uncommon in children.

Site: The most common location is at the angle of the mandible anterior to the sternocleidomastoid muscle or the parotid region, less commonly they are seen in the floor of the mouth and the ventral surface of the tongue. Other sites of location are the soft palate, anterior palatine pillar and buccal vestibule.

Clinical features: The lesions vary in size. The neck lesions may reach a size of 10 cm. They are seen as a soft, fluctuant mass at or above cervical sites. Some may develop a fistulous tract and drain externally.

The *intraoral lesions* range in size from 1 mm to 10 mm. They are submucosal and freely mobile, often they may be confused as mucoceles, lipomas or irritation fibromas, at times they may drain intraorally via a fistulous tract.

Pathogenesis: It has been postulated that these cysts develop from, either:

- Epithelial remnants of the branchial clefts and pouches
- Residual cervical sinus epithelium
- Salivary gland inclusions in parotid lymph nodes which undergo cystic changes
- Cystic changes within cervical lymph nodes of epithelial inclusions, hence the term benign lymphoepithelial cyst.

Pathology: The cervical cysts are lined by ciliated or nonciliated, pseudostratified columnar epithelium that may contain goblet cells, beneath the epithelium lymphoid tissue may be seen as typical germinal centers or a diffuse, dense infiltrate of lymphocytes. Lumen will contain mucus and desquamated parakeratotic cells.

Intraoral cysts are usually lined by stratified squamous epithelium and lumen will contain a watery fluid. Lymphoid tissue envelops the cystic lining.

Treatment: Aspiration or drainage of these cysts is followed by recurrence. They are best treated by complete surgical excision by a cervical or intraoral approach.

Thyroglossal Duct Cyst

Incidence: Being a relatively rare cystic lesion, there is no significant data regarding age or sex predilection. Although reports reveal highest incidence in infancy and in the 2nd decade.

Site: It can occur anywhere in the midline along the course of the embryonic thyroglossal duct, which extends from the foramen cecum of the tongue into the deep fascia near the thyroid isthmus. Common sites of occurrence are floor of the mouth, area around the hyoid bone and thyroid cartilage region.

Pathogenesis: It is an uncommon developmental cyst. The thyroid gland rudiment develops around the fourth embryonic week, between the derivatives of the first and second branchial arches at the base of the tongue which is recognized later as the foramen cecum. A hollow stalk known as the thyroglossal duct extends from this foramen cecum through the neck to the thyroid gland. By about the tenth week this duct breaks up and disappears, but cysts may form from residues of this duct at any point along its course.

Clinical features: Classically swellings are seen in the midline, slight lateral positional variations may be seen. On palpation the swellings are soft, tender and movable. Pathognomonic is the movement of the cyst during swallowing and protrusion of the tongue. At times they may cause dysphagia, dysphoria or dyspnea. The size may vary from 1 cm to 5 cm in diameter.

In 25% of cases an associated sinus tract may develop, due to infection. Disfigurement and recurrent infection are common complaints.

Pathology: The epithelial lining is variable, cysts present above the level of the hyoid bone are lined by stratified squamous epithelium while those present below the hyoid bone are lined by ciliated respiratory type or columnar epithelium. However, a single cyst may show different epithelium from one area to another. In the fibrous wall, lymphoid tissue, thyroid tissue or mucous glands may be seen.

Treatment: Complete radical surgical excision of the cyst along with its tract is essential to prevent recurrence. Owing to its proximity to the hyoid bone, a central part of the hyoid bone, approximately 1–2 cm may require to be removed during surgery.

Cystic Hygroma

The cystic hygroma is a type of a lymphangioma, it is a developmental abnormality, in which cavernous lymphatic spaces communicate and form large thin-walled cysts that may grow to an impressive size.

Incidence: Typically they appear in the first few months of life, some may be diagnosed at birth or before the age of 2 years.

Site: Hygromas arise in the sites of primitive lymphatic lakes—on the floor of the mouth, under the jaw, in the neck and in the axillae—but can occur virtually anywhere in the body.

Clinical features: Hygromas that involve the facial tissues and neck produce a swelling that is painless and compressible, the swelling may increase in size over several months to a year, they may remain static or may even regress. The overlying skin may be bluish and transillumination will be positive. Hygromas may suddenly enlarge when there is an upper respiratory infection presumably because of communication with the lymphatic system. This may cause acute respiratory obstruction and may require an emergency tracheostomy or surgical extirpation.

Pathology: Cystic hygroma consists of dilated cystic spaces lined by endothelial cells.

Treatment: Early excision is recommended, even in the newborn, because although they are not malignant, they tend to infiltrate into the local tissues in and amongst muscle fibers and nerves making them difficult and hazardous to remove at a later date.

There is no satisfactory nonsurgical treatment—a wide variety of sclerosing agents have been tried, unsuccessfully. Surgical extirpation is difficult and tedious. Every effort must be made to remove the cyst wall as completely as possible to avoid a recurrence.

Parasitic Cysts

Rarely parasitic cysts may be seen involving the oral tissues, e.g. hydatid cyst, which occurs in hydatid disease or echinococcosis and is caused by the larvae of *E. granulosus,* i.e. the dog tapeworm.

Cysticercosis of the oral tissues can develop because of the pork tapeworm, *Taenia solium*.

The spread to the oral tissues occurs when the larvae penetrate the intestinal mucosa and then are distributed through the blood vessels and lymphatics when they may get localized in the orofacial tissues.

Heterotopic Cysts

Oral Cysts with Gastric or Intestinal Epithelium

The occurrence of cysts in the oral cavity that may contain gastric or intestinal epithelium is extremely rare, owing to the paucity of reported cases, an analysis is lacking.

Incidence: Most of the cases have been in infants and young children.

Site: Sublingual region, apex and dorsum of the tongue are the occasional sites of involvement.

Pathogenesis: The origin of these cysts is not defined, it has been hypothesized by Gorlin and Jirásek, that during intrauterine growth, in the 3–4 mm embryo the undifferentiated primitive stomach lies in the mid-neck region not far from the anlage of the tongue, it is quite possible that the ectodermal and endodermal epithelia fuse and mix which explains the cystic lesions in the oral cavity.

Pathology: The cysts are lined partly by stratified squamous epithelium and partly by gastric mucosa. Gastric glands, goblets cells may be seen, occasionally muscularis mucosa may be seen.

Treatment: Surgical excision is the best line of treatment.

GENERAL PRINCIPLES OF TREATMENT OF CYSTS OF THE ORAL CAVITY

Reasons for Treatment of Benign Cysts of the Oral Cavity

- Cysts tend to increase in size and produce facial disfigurement.
- Cysts tend to get infected.
- Cysts weaken the jaw and can cause pathological fractures.
- Some cysts can undergo changes and it is not possible to be certain about a cystic lesion unless the tissue is examined histologically.
- Cysts can prevent eruption of teeth—cause disturbance of dentition.

Clinical Presentation (Summary of Signs/ Symptoms)

- Before expansion of the jaw is noticeable, most cysts are discovered accidentally on radiographs.
- In case of a smooth, rounded expansion of the jaw bones, a cyst should be suspected until proved otherwise.
- A change in the fitting of dentures in the presence of a swelling should give rise to the suspicion of a cyst/ tumor.
- Absence of a tooth from its place in the arch suggests the presence of a dentigerous cyst, particularly in the young.
- Presence of a carious, discolored, fractured or heavily filled tooth related to the swelling is suggestive of an apical periodontal cyst.
- Tilting of the crowns of the teeth suggests that their roots have been displaced by the expansion of a cyst/ tumor.
- On extraction of a tooth with a sizeable radicular cyst, cystic fluid may escape from the socket.
- Infected cysts may present as painful, tender swellings and may already have discharging sinuses.
- Percussion of the teeth overlying a solitary bone cyst produces a dull or hollow sound.
- Fissural cysts are generally small in size.
- Periodontal cysts occur anywhere in the dental arch.
- Dentigerous cysts are mainly associated with impacted third molars, canines and premolars.
- Solitary bone cyst is virtually assigned to the mandible.
- Static bone cavity is located beneath the inferior dental canal.
- Large cysts usually deflect the neurovascular bundle, paresthesia and anesthesia are rare.
- Infected cysts may cause some degree of neuropraxia of the nerve.
- As a cyst enlarges a smooth, hard, painless prominence generally on the labial side is seen.
- Expansion of the lingual aspect alone can occur with an odontogenic cyst in the ramus or third molar region.
- Expansion of both cortical plates is generally indicative of a lesion, other than a cyst.
- *Egg shell crackling* is a term used to describe the fragile outer shell of bone that has thinned out due to the expansion and the sensation and sound produced is like egg shell crackling.
- *Fluctuation* is elicited when the cystic lining lies immediately beneath the mucosa.

Vitality of Teeth

It is essential to perform preoperative and postoperative vitality tests on all teeth related to the cyst regardless of the method of treatment:

- Teeth adjoining primordial cyst, fissural cyst, solitary bone cyst and other nonodontogenic cysts will have vital pulps, unless there is coincidental disease of these teeth
- Apical periodontal cysts are associated with nonvital tooth/teeth
- Lateral periodontal cyst is involved with a vital tooth
- In infected cysts, there may be a temporary absence of a vital response in adjacent teeth, because of pressure interference with sensory transmission from the pulp.

Radiographic Examination

- Periapical radiographs provide a clear and accurate image of small cystic lesions.
- Occlusal films of the maxilla will disclose the amount of palatal bone destruction by a cystic process.
- An occlusal view of the mandible will reveal the expansion of the inner or outer cortical plates.
- Extraoral radiographs provide the full extent of the cystic lesion and help in assessing the damage caused to the adjacent structures, e.g. oblique lateral views, orthopantomographs. PA mandible view helps to reveal both lateral and medial expansion of the ramus. It is also helpful for disclosing a posterior antral cyst.
- Anterior cysts of the antrum are best visualized in the Water's projection.
- CT scans may be helpful in the assessment of large cystic lesions and multicystic lesions.
- In multilocular lesions, differential diagnosis with other multicystic formation such as giant cell lesions, myxomas, hemangiomas and ameloblastomas should be considered.

Radiopaque Dyes

When the size and relations of a cyst are in doubt, its contents may be aspirated and radiopaque dye, e.g. lipiodol, triosil, can be injected prior to further radiography. Injections of radiopaque solution should not be given with great force. Care should be taken to avoid over flow into the soft tissues. After essential radiographs are taken, it is advisable to remove the contrast material by aspiration; remainder of the dye will disperse and be absorbed.

Contrast medium is also useful to follow the progress of regression of a marsupialized lesion.

Aspiration

Aspiration is a valuable diagnostic aid, which may be helpful in distinguishing between a maxillary cyst and the maxillary sinus, between a cystic lesion and a solid tumor mass, between an aneurysmal bone cyst and a central cavernous hemangioma and further it would help in distinguishing various cysts **(Table 37.4)**.

After application of topical anesthesia or after infiltrating a small amount of local anesthetic solution

Table 37.4: Various aspirates

Sl. no.	*Pathology*	*Aspirate*	*Other findings of aspirate*
1.	Dentigerous cyst	Clear pale, straw-colored fluid	Cholesterol crystals
			Total protein in excess of 4.0 g/100 mL (resembling serum)
2.	Keratocystic odontogenic tumor	Dirty, creamy white viscoid suspension	Parakeratinized epithelium
			Total protein less than 5.0 g/100 mL most of which is albumin
3.	Periodontal cysts	Clear, pale yellow straw-colored fluid	Varying amounts of cholesterol crystals
			Total protein content is between 5 g/100 mL and 11 g/100 mL
4.	Infected cyst	Pus or brownish fluid, seropurulent/ sanguinopurulent fluid, at times paste like or caseous consistency	Polymorphonuclear leukocytes Foam cells Cholesterol clefts
5.	Mucocele, ranula	Mucus	
6.	Gingival cysts	Clear fluid	
7.	Solitary bone cyst	Serous or sanguineous fluid, blood or empty cavity	Necrotic blood clot
8.	Stafne's bone cavity	Empty cavity will yield air	
9.	Dermoid cysts	Thick sebaceous material	
10.	Fissural cysts	Mucoid fluid	
11.	Vascular cyst walls	Fresh blood	
12.	Intramedullary cavernous hemangioma	Syringe full of venous blood	
13.	Arterial or arteriovenous malformation	Bright red blood Pulsatile, pushes plunger	

into the overlying mucosa, aspiration is done with a wide bore needle (18 gauge) and a 5 or 10 mL syringe.

A failure to aspirate liquid usually means that a solid tumor is present.

Biopsy

Biopsy is a valuable diagnostic aid, in the differential diagnosis of the nature of the cyst or the differentiation in the basic diagnosis between a cyst or tumor. Biopsy is generally performed under local anesthesia or conscious sedation. Care should be taken to place the biopsy incision in such a manner, keeping in mind future surgical exposure, that it will facilitate accurate closure and prevent the setting in of infection, which may delay treatment. The material is then despatched to the pathologist for histopathological examination.

Biopsy prior to surgery is generally advisable for large cystic lesions and when doubt exists.

Assessment

This includes the following:

- Estimation of the size of the cystic lesion
- Extent of bone loss
- Should there be risk of pathological fracture, preparation for suitable splints or intermaxillary ligation (IML) or planning for immediate grafting
- Relationship of the cyst to adjacent structures, i.e. floor of the nose, maxillary sinus, inferior dental nerve, infraorbital nerve, floor of the orbit
- Vital teeth that have a satisfactory periodontal condition and are functional should be preserved
- Nonvital teeth, which are embedded in sound bone, should be treated by root canal filling and apicoectomy
- Nonvital teeth which are nonfunctional, mobile and beyond restoration should be extracted
- If bone loss is going to be extensive as in surgical excision, then, consent and preparation for rehabilitation methods such as reconstructive plates, bone grafts and use of other materials, e.g. hydroxyapatite crystals, should be planned
- Acutely infected cysts should be treated with antibacterial drugs, or even drainage prior to surgery should be considered
- In case of multicystic lesions, efforts should be made to identify a possible syndrome
- Postoperative monitoring of teeth by vitality tests should be done until bone formation is complete.

Operative Procedures

Cysts of the jaws may be treated by one of the following basic methods:

- Marsupialization (decompression)
  - Partsch I
  - Partsch II (combined marsupialization and enucleation)
  - Marsupialization by opening into nose or antrum.
- Enucleation
  - Enucleation and packing
  - Enucleation and primary closure
  - Enucleation and primary closure with reconstruction/bone grafting.

Marsupialization (Decompression)

Principle: *Marsupialization (Partsch) or decompression refers to creating a surgical window in the wall of the cyst, and evacuation of the cystic contents.* This process decreases intracystic pressure and promotes shrinkage of the cyst and bone fill. The only portion that is removed is the piece removed to produce the window.

Indications:

- **Age:** In a young child, with developing tooth germs, or when development of the displaced teeth has not progressed, enucleation would damage the tooth buds.
- In the elderly, debilitated patient, marsupialization, is less stressful and a reasonable alternative.
- **Proximity to vital structures:** When proximity of the cyst to vital structures could create an oronasal or oroantral fistula, injure neurovascular structures or damage vital teeth, then marsupialization should be considered.
- **Eruption of teeth:** In a young patient with a dentigerous or pseudofollicular keratocyst, marsupialization will permit the eruption of the unerupted tooth or any other developing teeth that have been displaced.
- **Size of cyst:** In very large cysts, where enucleation, could result in a pathological fracture, marsupialization, can be accomplished, through a more limited bony opening.
- **Vitality of teeth:** When the apices of many adjacent erupted teeth are involved within a large cyst, enucleation could prejudice the vitality of these teeth.

Advantages:

- Simple procedure to perform
- Spares vital structures
- Allows eruption of teeth
- Prevents oronasal, oroantral fistulae

- Prevents pathological fractures
- Reduces operating time
- Reduces blood loss
- Helps shrinkage of cystic lining
- Allows for endosteal bone formation to take place
- Alveolar ridge is preserved.

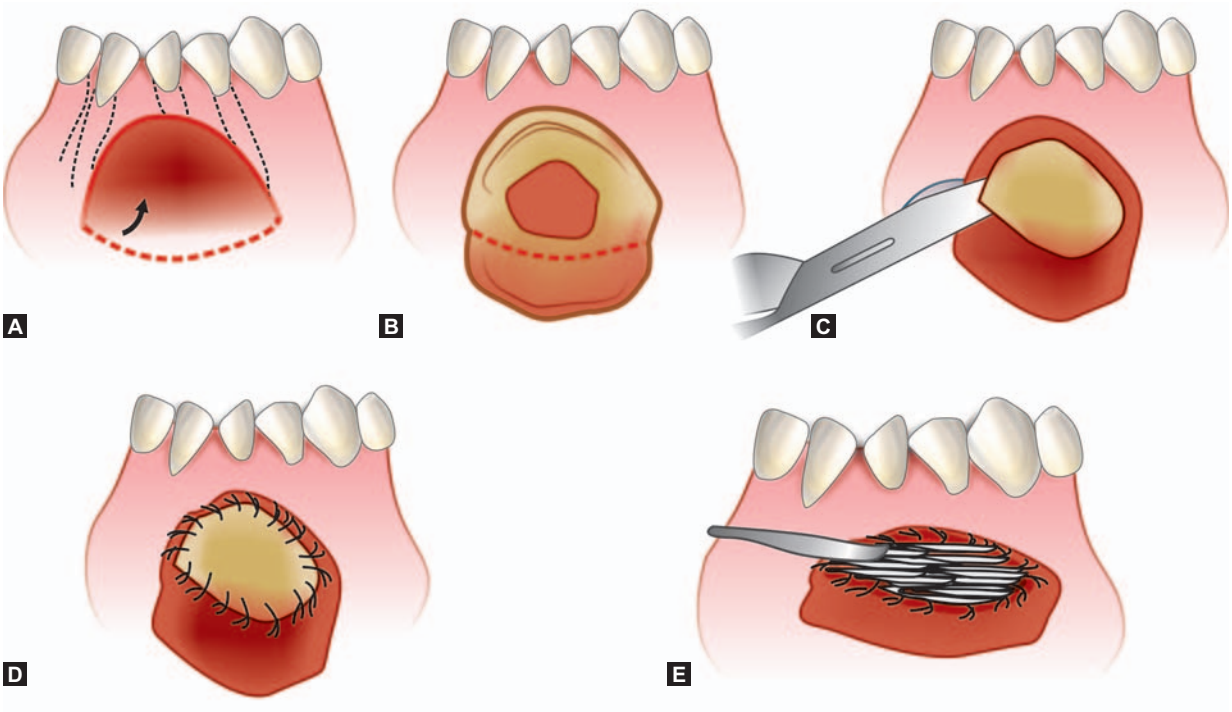
Disadvantages:

- Pathologic tissue is left *in situ*
- Histologic examination of the entire cystic lining is not done
- Prolonged healing time
- Inconvenience to the patient
- Prolonged follow-up visits
- Periodic irrigation of cavity
- Regular adjustments of plug
- Periodic changing of pack
- Secondary surgery may be needed
- Formation of slit-like pockets that may harbor foodstuffs
- Risk of invagination and new cyst formation.

Surgical Technique

Partsch I

- **Anesthesia:** The administration of general anesthesia/conscious sedation or simple local anesthesia of the area.
- **Aspiration:** Cystic contents are aspirated.
- **Incisions:** *types*:
  - A circular, oval or elliptic incision can be taken, 1 cm or larger in size leaving a margin of 0. 5–1 cm from the gingival margins of the teeth or alveolar crest in the edentulous patient.
  - Alternatively, an inverted U-shaped incision can be taken with a broad base towards the buccal sulcus, the mucoperiosteum is then reflected in this case **(Figs 37.19A and B)**.
- **Removal of bone:** Thin bone—when the bone is expanded and thinned out, the initial incision can be extended through the mucoperiosteum, bone and cystic lining into the cystic cavity. The cystic lining and contents are then submitted for histological examination **(Fig. 37.19C)**.



Figs 37.19A to E: Surgical procedure of marsupialization of a cyst in the mandible: (A) U-shaped incision taken on the buccal aspect; (B) Mucoperiosteal flap reflected and bony window created to uncover the cyst; (C) Cystic lining incised with scalpel, portion removed for histopathological examination; (D) Lining sutured to edge of mucosa, U-shaped flap can be tucked into the cavity or excised; (E) Cavity packed with roller gauze

- **Thick bone:** When the overlying bone is thick, bur holes are drilled in a circular shape, which are then connected and the overlying bone is removed carefully with a pair of rongeurs or mosquito forceps.
- **Removal of cystic lining specimen:** The cystic lining is then removed by stabbing a scalpel through the lining against the bone edge, the specimen of lining is then sent for histological examination.
- *Visual examination of residual cystic lining.*
- *Irrigation of the cystic cavity.*
- **Suturing:** The remaining cystic lining is sutured with the edge of the oral mucosa by continuous sutures or interrupted sutures **(Fig. 37.19D)**.

  Alternatively, when a U-shaped incision is taken, then the mucoperiosteal flap which is based on the buccal sulcus can be turned into the cyst cavity covering the margin. The remaining perimeter is sutured to the oral mucosa. It does not matter if the flap overlaps the lining as the cyst epithelium will be destroyed.
- **Packing:** The cavity is then packed with a half or one inch width ribbon gauze, which may be impregnated with an antibiotic ointment, Whitehead's varnish, tincture of benzoin or bismuth iodoform paraffin paste (BIPP). The pack helps to prevent contamination of the cavity with food debris and also provides coverage of the wound margins. With the help of a nontoothed forceps, the ribbon gauze is first laid along the floor of the cavity and is then inserted running from side to side. All packs are generally secured by sutures. The pack is left inside for 7–14 days. By the end of 2 weeks, the junction between the lining of the cyst and the oral mucosa around the periphery of the window will have healed **(Fig. 37.19E)**.
- **Maintenance of cystic cavity:** Careful instructions are given to the patient regarding cleansing and irrigation of the cavity by regular flushing with an oral antiseptic rinse, preferably with a disposable syringe.
- **Use of plug:** A plug may be designed to prevent the contamination of the cystic cavity and preserve the patency of the cyst orifice. The plug should be stable, retentive and of a safe design so that it cannot be inhaled or swallowed. Initially, a plug should be made of a resilient material to avoid irritation to the raw margins, later a well-fitting acrylic plug can be made, after taking an impression of the cavity with modeling wax or impression compound. In case of dentures, the plug can be attached to it. The plug may be vented to prevent a pressure build up.
- **Healing:** The cavity may or may not obliterate totally. With time, some degree of a permanent depression remains in the alveolar process.

Composition of Whitehead varnish:
Tincture: benzoin 10 g, iodoform 10 g, storax 7.5 g, balsam of Tolu 5 g, solvent ether to make 100 mL.

Modifications of Marsupialization

- **Waldron's method (1941) or Partsch II:** This is a two stage technique that combines the two standard procedures, in which, first marsupialization is performed and at a later stage, when the cavity becomes smaller, the procedure of enucleation is performed and the entire tissue is examined histopathologically.

Indications:
- Bone has covered the adjacent vital structures
- Adequate bone fill has strengthened the jaw to prevent fracture during enucleation
- Patient finds it difficult to clean the cavity
- For detection of any occult pathologic condition.

Advantages:
- Development of a thickened cystic lining, which makes enucleation easier
- Spares adjacent vital structures
- Combined approach reduces morbidity
- Accelerated healing process
- Allows histopathological examination of residual tissue.

Disadvantages:
- Patient has to undergo secondary surgery and the possible complications that are involved with any surgical procedure.

Marsupialization by Opening into Nose or Antrum

Advantages:
- Primary closure of the oral wound
- Cystic cavity is opened into the maxillary sinus or nasal cavity, thereby reducing intracystic pressure
- Cystic cavity becomes lined with respiratory maxillary sinus or nasal cavity
- Adjacent structures are protected
- Restoration of the normal anatomy of the antral space and nose.

Disadvantages:
- Development of an oroantral or oronasal fistula, if there is a breakdown of the wound.

Surgical technique: Cysts that have destroyed a large portion of the maxilla and have encroached on the antrum or nasal cavity, then the cyst is approached from the buccal aspect of the alveolar region.

A gingival curvilinear incision is taken along the involved teeth. Two releasing incisions are made at either

end at a 45º angle and extending into the buccal sulcus. Depending upon the status of the teeth, they are either extracted or endodontically treated. A mucoperiosteal flap is raised with a Howarth's periosteal elevator. Generally, in large cysts, an opening already exists in the buccal cortical bone, otherwise, it may need to be enlarged with a pair of rongeurs taking care to avoid damage to adjacent structures such as the infraorbital nerve and the underlying cystic lining.

At this stage, a window is made by removing a portion of the cystic lining as described in the Partsch I technique, alternatively, it is advocated that the entire cystic lining can be enucleated in one piece.

A second unroofing is then performed by removing the antral lining present between the two cavities. Thus, providing continuity between the cavities. This allows the cyst cavity to become lined with normal ciliated and mucus-secreting epithelium regenerating from the respiratory mucosa rather than a squamous epithelium. If the cystic lining has not been removed in toto, then by this technique, it becomes continuous with the lining of the antrum or nasal cavity. Additionally, an intranasal antrostomy may be performed. The cavity may be packed with a ribbon gauze soaked with tincture of benzoin or an antibiotic ointment or an antral balloon. This helps to prevent the formation of a postoperative hematoma. The flap is then replaced and a watertight primary closure is done **(Figs 37.20A and B)**.

Enucleation

Principle: Enucleation allows for the cystic cavity to be covered by a mucoperiosteal flap and the space fills with blood clot, which will eventually organize and form normal bone.

Indications:

- Treatment of odontogenic primordial cysts
- Recurrence of cystic lesions of any cyst type.

Advantages:

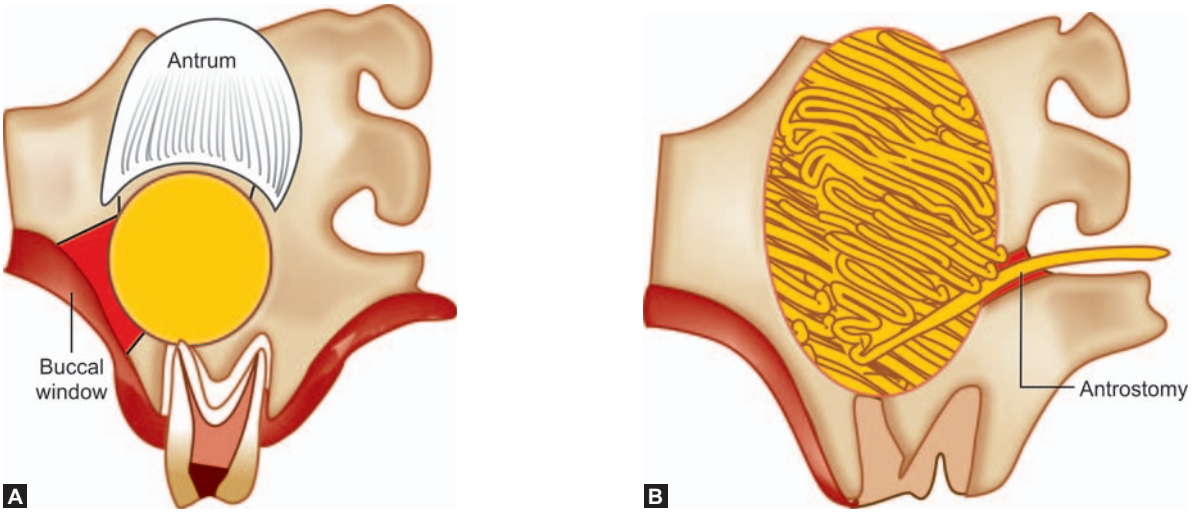
- Primary closure of the wound
- Healing is rapid
- Postoperative care is reduced
- Thorough examination of the entire cystic lining can be done.

Disadvantages:

- After primary closure, it is not possible to directly observe the healing of the cavity as with marsupialization
- In young persons, the unerupted teeth in a dentigerous cyst will be removed with the lesion
- Removal of large cysts will weaken the mandible, making it prone to jaw fracture
- Damage to adjacent vital structures
- Pulpal necrosis.

Surgical technique:

- **Enucleation and packing:** This technique if advocated, when it is believed that due to a previous infection or



Figs 37.20A and B: Large maxillary cyst extending into the antrum: (A) Cyst approached, buccally a bony window is created, involved tooth is treated endodontically or removed; (B) Portion between cyst and antrum is completely removed. A large nasal antrostomy made, cavity is packed with ribbon gauze

in infected large cysts, a primary closure would be unsuccessful as it could lead to a breakdown of the wound; or where there is difficulty in approximating the wound edges. In such instances, enucleation is performed and then the cavity is packed as in marsupialization. The wound heals with granulation tissue until epithelialization is complete.

- This method is also used as a secondary measure, when there is a dehiscence after primary closure.

Enucleation with Primary Closure

Surgical Technique

1. **Enucleation of small cystic lesions from an intraoral approach:** Surgery can be performed under local anesthesia, conscious sedation or general anesthesia by an intraoral approach **(Figs 37.21A to C)**.

   Incision is carried around the necks of the involved teeth and the adjoining teeth on either side, so that the flap will lie on sound bone. In case of the edentulous patient, incision is placed on the alveolar crest, down to bone. Releasing incisions are given at either ends, which extend into the buccal sulcus, so that the base of the flap is broader. Depending upon the location of the cyst, incision is placed buccally or palatally. A three-sided flap also termed as an envelope flap or trapezoidal flap is reflected **(Fig. 37.21D)**. Reflection of the flap is done with a periosteal elevator beginning from under the periosteum of the anterior buccal incision, working parallel to the gingival margin to detach the papillae and push distally **(Fig. 37.21E)**. In certain areas, where a sinus tract may be present or where the cyst has eroded through the cortex and is lying in contiguity with the periosteal layer, reflection may prove to be difficult. Bone is then removed to expose the underlying cystic lesion. In some instances, a window in the bone may already exist, this is expanded with the help of a rongeur. In cases, where the bone is intact, a broad opening is made with the help of a chisel mallet or bone burs. At times a thin layer of fragmented bone is evident on raising the flap, these tiny pieces are carefully peeled off. The underlying cystic lining is separated with the help of a mosquito forceps and periosteal elevator **(Fig. 37.21F)**.

   The underlying cyst lining is now gently eased away from the cavity wall with the help of curved curettes, Mitchell's trimmer or a periosteal elevator. The instrument is applied in such a manner that the concave surface faces the cystic lining **(Fig. 37.21G)**. Care should be taken to prevent rupture of the lining. In areas, where the cystic lining is adherent, a peanut gauze held in the beaks of a hemostat and inserted between the lining and the bony bed, helps to release the cystic lining. Alternately, the cystic contents can be aspirated, so that the size of the sac shrinks and visibility improves. In case of mandibular cysts, separation from the neurovascular bundle is done along the length of the nerve, never across it, or from inside the cyst. The same is applicable for maxillary cysts involving the infraorbital nerve. Difficulty may be encountered when peeling the cyst off the apices of the teeth within the cyst. As far as possible, the cyst should be removed in one piece **(Fig. 37.21H)**.

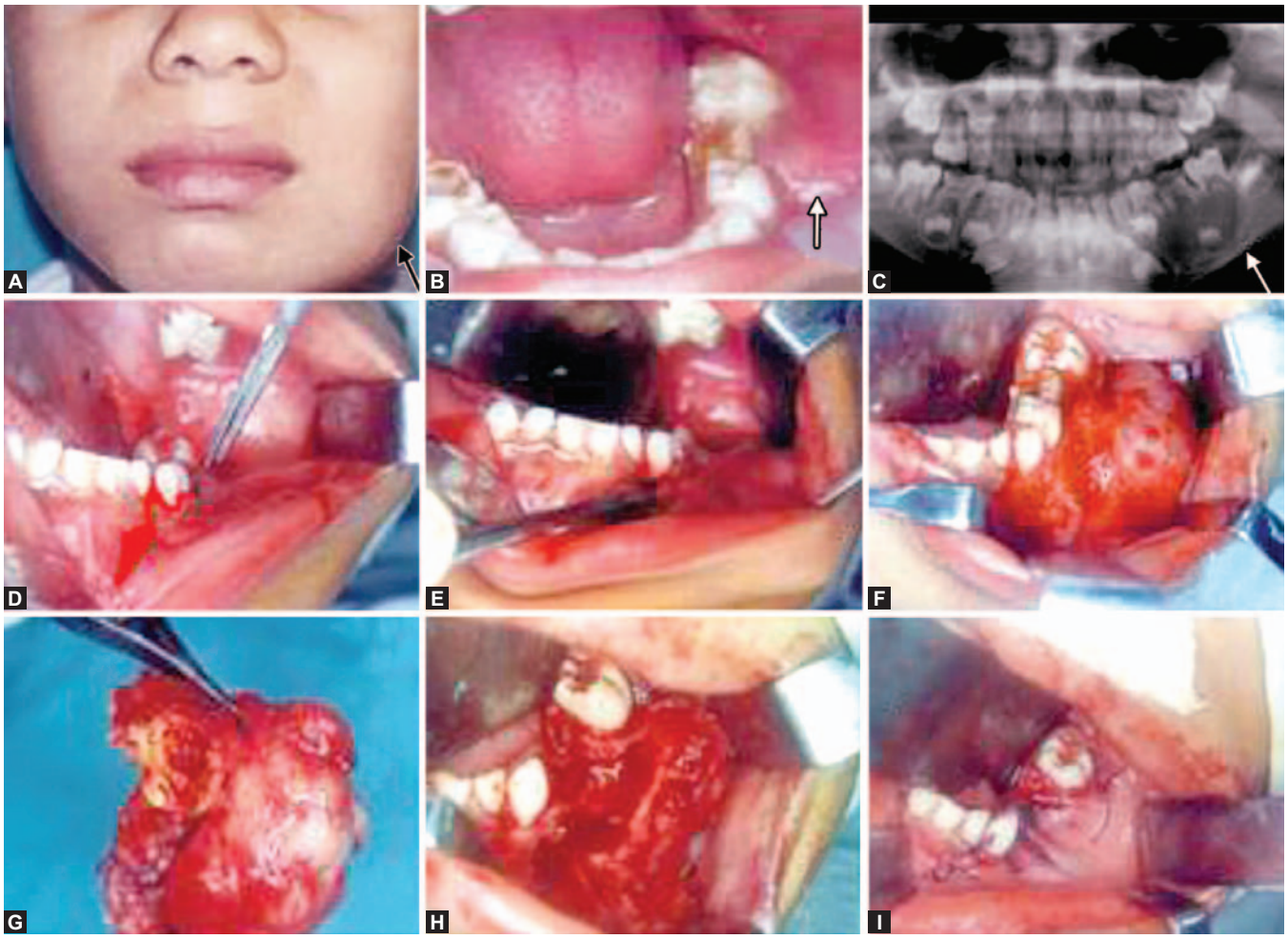
   Teeth that required to be removed are now extracted. In case of endodontically restored teeth, apicoectomy is done and their apices are sealed. Root apices other than planned, if they get exposed during surgery may later require to be filled endodontically. The cyst cavity is then inspected, any residual remnants are removed separately with a mosquito artery forceps. Any tears in the nasal mucosa or antral mucosa are sutured with 3-0 catgut or other absorbable suture materials. Bleeding points are arrested with the help of pressure packs, bone wax, gelfoam, surgical diathermy. Wound is now flushed with normal saline and an antiseptic solution such as povidone-iodine (2%) **(Fig. 37.21I)**.

   The cavity may be left to heal or various filling materials have been recommended for packing to obliterate the cavity prior to closure, e.g. resorbable sponge, hydroxyapatite crystals, autogenous bone chips, allogenous bone powder, etc.

   The flap is now replaced and interdental sutures are given **(Fig. 37.21I)**.

2. **Enucleation of large, inaccessible mandibular lesions from an extraoral approach:** Large cystic lesions like the pseudofollicular dentigerous cysts that involve the ascending ramus, body and angle mandible are best accessible from an extraoral approach.

   Surgery is performed under general anesthesia. Local infiltration is done with normal saline and adrenaline in the concentration of 1:300,000, this helps in local hemostasis and definition of tissue planes. A submandibular incision, which may at times be required to extend into the postramal region, is taken 1.5–2 cm below the inferior border



Figs 37.21A to I: Radicular cyst: (A) Extraoral swelling on left side mandible; (B) Intraoral view, buccal expansion and carious 75; (C) Unilocular radiolucency, carious 75, resorption of roots, developing tooth buds; (D) Incision; (E) Mucoperiosteal flap being raised; (F) Cyst exposed; (G) Entire cyst removed with carious tooth; (H) Wound defect; (I) Wound sutured primarily

of the mandible. The incision extends through skin and subcutaneous tissues. Blunt and sharp dissection is carried out layerwise through tissue planes, i.e. superficial cervical fascia, platysma and deep cervical fascia. Care is taken to salvage the marginal mandibular nerve, facial artery and vein are clamped and ligated.

Small bleeders are cauterized with a diathermy. The pterygomasseteric sling is divided, the periosteum is incised down to bone and the flap is raised superiorly to expose the underlying bone. Commonly, a bony window already exists, which is then enlarged as described earlier. If not, a suitably sized window is created with a chisel and mallet or bone burs to expose the underlying cystic lining.

Depending upon the extent of the cystic lesion and involvement of surrounding tissues, the surgical procedure of enucleation or marginal excision is performed as advocated by Bramley.

The tissue is sent for histopathological examination. The wound is then inspected. Any remnants of tissue are curetted out as the cystic lining is often thin and easily fragmented. A sharp curette or a bone bur, e.g. a vulcanite round bur with constant sterile irrigation is used to remove a 1–2 mm layer of bone around the complete periphery of the cyst cavity.

Stoelinga has advocated the use of Carnoy's solution to reduce the percentage of recurrence of the cysts. The cavity is then cleansed and closed in layers. In very large cysts beyond 4–5 cm in size, it

is advisable to maintain a vacuum drain in place through the submandibular skin where it is fixed in place. This helps to reduce the dead space and prevents hematoma formation. Deeper layers are sutured with absorbable sutures, skin is approximated with interrupted sutures, vertical mattress sutures or subcuticular sutures for an esthetic scar. The drain is left in place for 48–72 hours. Pressure dressing is given.

3. **Enucleation and primary closure with reconstruction/bone grafting:** In large cystic lesions that have perforated and destroyed the cortical plates and inferior border of the mandible that is beyond salvage or is nonexistent. It is advisable to reconstruct primarily with a stainless steel or titanium reconstructive plate. Occasionally, autogenous bone grafts, e.g. iliac crest or costochondral grafts can be used for reconstruction procedures, replacing the lost bone. A watertight closure has to be achieved both intra- and extraorally. Intermaxillary ligation is necessary to help provide immobilization during the healing phase for 4–6 weeks.

Complications following Cystic Lesion Surgery

- Injury to inferior alveolar nerve
- Injury to adjacent teeth
- Oroantral communication
- Hematoma formation
- Fracture of the jaw (pathological)
- Infection prior to surgery may be acute or chronic
- Postoperative wound dehiscence
- Loss of vitality of teeth
- Neuropraxia in infected cysts
- Postoperative infection
- Recurrence in some cysts
- Dysplastic, neoplastic or even malignant transformation.

Suggested Follow-up

- Long-term follow-up, at least up to 8 years for primordial cysts for early detection of dealing with any recurrence
- To check postoperative vitality of teeth
- Unerupted teeth that may require orthodontic assistance for eruption
- Orthodontic assistance for alignment of displaced teeth
- Long-term follow-up of patients with Gorlin's syndrome.

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Points to Remember

- Cyst formation
- Classifications of cysts of orofacial region
- Theories of cyst initiation,enlargement,bone resorption and regression
- Intraosseous cysts
- Soft tissue cysts
- General principles of treatment of cysts of the oral cavity
- Complications following cyst surgical treatment.

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CHAPTER 38 Benign Tumors of the Jaw Bones

INTRODUCTION

Tumor or neoplasm is an abnormal new, uncoordinated growth in the body, which results from excessive, autonomous, purposeless proliferation of cells, which continues its growth, even after cessation of stimuli (Tumor-swelling). Tumors are broadly divided into two groups— benign and malignant, depending upon their behavior pattern and cellular structure.

A benign tumor is a mass of cells, tissues/organs resembling those normally present, but arranged atypically and behaves abnormally. It grows slowly and is usually encapsulated and it enlarges by peripheral expansion, pushes away the adjoining structures and exhibits no metastasis, however, it may be locally aggressive. (The term benign implies mild and nonprogressive).

A malignant tumor, rapidly infiltrates the surrounding tissues, including vital structures and endangers the life of its host. It also shows metastasis in the distant parts of the body usually through lymph and blood streams.

The benign jaw tumors are divided into two broad categories:

1. Odontogenic tumors
2. Nonodontogenic tumors

ODONTOGENIC TUMORS

The human odontogenic structures are formed by the inductive interactions between epithelium and mesenchyme. The formation of these structures begin during 5th and 6th week of intrauterine life and continues till about 16th year after birth. During this long period, there is always a possibility of odontogenic lesions developing from these tissues exists; resulting in the development of malformations, hamartomas and neoplasms.

Whenever such lesions are discovered in the oral cavity, clinically or radiologically, the distinctions among these three forms should be made on the basis of clinical and histologic studies.

A malformation: It is not neoplastic, but it can cause a functional or esthetic problem, because of its size or anatomical site.

A hamartoma: It is a benign lesion composed of a new growth of mature cells on existing blood vessels. (A lesion resulting from faulty development of the embryo.)

Odontogenic tumors: A group of neoplasm or tumor like malformations arising from cells of odontogenic apparatus or their remnants. The abnormal tissue in each of these tumors often can be correlated with similar tissue in normal odontogenesis **(Table 38.1A)**.

A benign odontogenic cyst or self-limiting tumor: It may show an aggressive or malignant transformation (MT). Therefore, management of such a lesion is always surgical. The surgical modality will vary for individual lesion depending on biological behavior and growth potential of the lesion.

Classification of Benign Odontogenic Tumors

The permutation of different cells of different origin makes the odontogenic tumors a highly complicated group of lesions. Odontogenic tumors are not all neoplasms in the strict sense, as some are of a hamartomatous or

Table 38.1A: The origin of odontogenic tumors

Ectodermal—Epithelial origin	*Mesenchymal—Connective tissue origin*
• Dental lamina—epithelial rests of Serres	• Dental papilla
• Enamel organ—reduced enamel epithelium	• Dental sac
• Hertwig's epithelial root sheath (HERS)	

Table 38.1B: Classification of benign odontogenic tumors

A.	*Odontogenic epithelium without odontogenic ectomesenchyme*
1.	Ameloblastoma
2.	Calcifying epithelial odontogenic tumor (CEOT). Pindborg tumor
3.	Clear cell odontogenic tumor
4.	Squamous odontogenic tumor
B.	*Odontogenic epithelium with odontogenic ectomesenchyme, with or without dental hard tissue formation*
1.	Ameloblastic fibroma
2.	Ameloblastic fibrodentinoma (dentinoma)
3.	Odontoameloblastoma
4.	Adenomatoid odontogenic tumor (AOT)
5.	Complex odontome
6.	Compound odontome
C.	*Odontogenic ectomesenchyme with or without inclusion of odontogenic epithelium*
1.	Odontogenic fibroma
2.	Myxoma (odontogenic myxoma, myxofibroma)
3.	Benign cementoblastoma (true cementoma)

Source: Kramer IR, Pindborg JJ, Shear M. The WHO Histological Typing of Odontogenic Tumours. A commentary on the Second Edition. Cancer. 1992;70(12):2988-94.

malformation like nature. In 1946, *Thoma* and *Goldman*, described a classification of odontogenic tumors, based on the tissue cell of origin. It described the induction effects of one tissue (epithelium) on another (mesenchyme) in the pathogenesis of odontogenic tumors. They put these tumors into three broad groups:

1. The lesions primarily derived from epithelium
2. Those originated predominantly from mesenchyme
3. A mixed group—both epithelial and mesenchymal tissue shared in the formation of a lesion.

Kramer, Pindborg, Shear in 1992, revised the classification of odontogenic tumors **(Table 38.1B)**. This classification is based on embryologic principles, that is, the embryonal inductive influence that the cells of one tissue exert upon the cells of another tissue. In the odontogenic tumors, the tissues are either derived from the ectoderm, namely the enamel organ or the mesenchyme proper (mesoderm). In this classification, the principle of ectomesenchyme was introduced. The ectomesenchyme is derived from cells of the neural crest during an early phase in embryogenesis.

In 2005, World Health Organization (WHO) put forward a new classification, which is known as histological classification **(Table 38.2)**. In this classification, the term odontogenic keratocyst (OKC), which was considered as primordial cystic lesion earlier, is redesignated as keratocystic odontogenic tumor (KCOT) and is newly introduced. This entity will be discussed at the end of this chapter as a special new reclassified lesion.

Table 38.2: Histological classification—WHO 2005

Classification of Benign Odontogenic Tumors	
A.	*Odontogenic epithelium with mature, fibrous stroma without odontogenic ectomesenchyme*
1.	Ameloblastoma, solid/multicystic type
2.	Ameloblastoma, extraosseous/peripheral type
3.	Ameloblastoma, desmoplastic type
4.	Ameloblastoma, unicyclist type
5.	Squamous odontogenic tumor
6.	Calcifying epithelial odontogenic tumor (CEOT)
7.	Adenomatoid odontogenic tumor (AOT)
8.	Keratocystic odontogenic tumor (KCOT)
B.	*Odontogenic epithelium with odontogenic ectomesenchyme, with or without hard tissue formation—mixed odontogenic tumors*
1.	Ameloblastic fibroma
2.	Ameloblastic fibrodentinoma
3.	Ameloblastic fibro-odontoma
4.	Odontoma
5.	Odontoma, complex type
6.	Odontoma, compound type
7.	Odonto-ameloblastoma
8.	Calcifying cystic odontogenic tumor
9.	Dentinogenic ghost cell tumor
C.	*Mesenchyme and/or odontogenic ectomesenchyme with or without odontogenic epithelium*
1.	Odontogenic fibroma
2.	Odontogenic myxoma/myxofibroma/fibromyxoma
3.	Cementoblastoma

Earlier Pindborg and Clausen had proposed a classification (1958) of odontogenic tumors based on embryologic principles, which was modified by Gorlin in 1961 **(Table 38.3)**.

NONODONTOGENIC TUMORS

Nonodontogenic tumors of the jaw include a wide spectrum of different lesions originating from different tissues **(Tables 38.4 and 38.5)**.

Table 38.3: Classification of odontogenic tumors

1.	*Epithelial Odontogenic Tumors*
	A. *Minimal inductive change in connective tissue (ectodermal origin)*
	1. Ameloblastoma
	2. Adenomatoid odontogenic tumor
	3. Calcifying epithelial odontogenic tumor (CEOT)
	B. *Marked inductive change in connective tissue (mixed origin)*
	1. Ameloblastic fibroma
	2. Ameloblastic odontoma
	3. Odontoma
	4. Complex odontoma
	5. Compound odontoma
2.	*Mesodermal Odontogenic Tumors*
	1. Odontogenic myxoma
	2. Odontogenic fibroma
	3. Cementoma
	a. Periapical cemental dysplasia (PCD)
	b. Benign cementoblastoma
	c. Cementifying fibroma
	d. Familial multiple (gigantiform) cementoma (Florid osseous dysplasia (FOD)

Source: Gorlin RJ, Chaudhry AP, Pindborg JJ. Odontogenic tumors. Classification, histopathology, and clinical behavior in man and domesticated animals. Cancer. 1961;14:73-101.

Table 38.4: Nonodontogenic tumors and fibro-osseous lesions of the jaw bones

A.	Nonodontogenic Tumors
	1. Central fibroma
	2. Myxofibroma
	3. Ossifying fibroma
	4. Osteoma
	5. Osteoid osteoma
	6. Benign osteoblastoma
	7. Chondroma
	8. Giant cell granuloma
	9. Central hemangioma
	10. Benign tumors of nerve tissue
B.	Fibro-osseous Lesions
	1. Fibrous dysplasia of bone
	2. Cherubism (Inherited fibro-osseous bone disease)
	3. Ossifying fibroma
	4. Central giant cell granuloma

Table 38.5: WHO classification of nonodontogenic tumors of the jaws

I.	Osteogenic Neoplasms
	Cemento-ossifying fibroma
II.	Nonneoplastic Bone Lesions
	1. Fibrous dysplasia of the jaws
	2. Cemento-osseous dysplasias
	a. Periapical cemento-osseous dysplasia
	b. Focal cemento-osseous dysplasia
	c. Florid cemento-osseous dysplasia (gigantiform)
III.	Other Cemento-Osseous Dysplasias
	a. Cherubism
	b. Central giant cell granuloma

Source: Kramer IR, Pindborg JJ, Shear M. The WHO Histological Typing of Odontogenic Tumours. A commentary on the Second Edition. Cancer. 1992;70(12):2988-94.

GENERAL PRINCIPLES OF MANAGEMENT OF A JAW LESION

History of the Lesion

Duration: It is very important to know the duration of the lesion.

- Prolonged duration
- Long duration without pain
- Short duration, rapid growth
- may be congenital
- benign neoplasm
- malignant growth

Mode of onset and progress: History of trauma may be obtained in many bone lesions like osteogenic sarcoma. Spontaneous swelling and rapid growing lesion may be malignant, while very slowly growing lesion may be benign growth.

Exact site and shape: In a huge swelling it is essential to know the exact site and shape of the swelling for knowing the origin of the lesion.

Progress of the lesion: Whether the swelling has been growing slowly or it has remained stationary for a long time (benign growth). Has it been growing again after a stationary period of months/years (MT in a benign lesion) or has it been continuously increasing in size (malignant growth)?

Change in character of a lesion: Whether there are ulcerations over the lesions? Fluctuation, softening, etc. are noticed by the patient recently? Whether painless swelling has become painful—secondary infection may have set in the lesion.

Associated symptoms: Pain, abnormal sensations, anesthesia, paresthesia over a region, dysphasia, nasal obstruction—breathing difficulty, tenderness, lymphadenopathy.

Restriction of the oral opening or trismus—due to involvement of pterygoid plates by the lesion it can be noticed.

Similar swelling elsewhere in the body: Multiple involvements due to metastasis.

Loss of body weight: Malignant growth.

Recurrence

Whether the lesion has recurred after the previous surgery?

Any habits leading to the development of lesion: smoking, tobacco chewing, etc.

CLINICAL EXAMINATION OF THE LESION

Thorough clinical examination of the lesion, as well as of the entire oral cavity and external facial area including all regional lymph nodes is a must. The quick assessment of general physical examination also should be noted down.

In the oral and maxillofacial region, the examination of the lesion will include inspection and palpation. Percussion is only done for dentition examination and auscultation is reserved for examining suspected vascular lesions. The large lesions should be examined by bimanual palpation to know the intra- and extraoral extent of the lesion.

Inspection

- Number—whether single or multiple lesions
- Size
- Site or anatomical location of the lesion— palatal swellings may have salivary gland origin, and may not have odontogenic origin
- Shape and size of the lesion— whether ovoid, spherical, localized, diffuse, etc.
- Color of the lesion—whether red or purple (hemangioma), blue (ranula)
- Surface—whether smooth, lobulated (benign) or irregular, ulcerated, fungating growth (malignancy)
- Whether it is pedunculated or sessile?
- Skin over the swelling—red, hot skin will suggest secondary infection.

Palpation

Palpation should be carried out gently and systematically.

Consistency of the lesion: Soft (lipoma), hard or indurated, firm (fibroma), bony hard (osteoma), cystic, etc. It should be also noted whether the consistency is uniform throughout or variable. Whether there is egg shell crackling present? Fluctuation is present?

Presence of pulsations: If the palpation of a lesion reveals a pulsatile quality, a large vascular component is indicated. The "thrill" can be felt along the lesion. The auscultation with a stethoscope may reveal "a bruit" or audible murmur.

Fixity: Fixity to the overlying skin/mucosa/underlying structures.

Lymph node examination: Systematic lymph node palpation should be carried out.

Imaging

Imaging modalities like *plain radiographs, computed tomography (CT), CT three-dimensional reconstruction* can be used to know the extent of the lesion. These modalities are mainly used to know the lesion's site, size, shape, presence or absence of intralesional calcifications, any cystic degeneration within the lesion, association or inclusion of the vital anatomic structures, displacement of teeth and root resorption and extent of the lesion, etc. (whether confined to the bone or extended into adjacent soft tissue). In case of malignancy, a *complete bone scan or scintigraphy* can be carried out to find out distant metastasis. *Magnetic resonance imaging (MRI)* is helpful for knowing the soft tissue extensions and lymphadenopathy. *Angiographic studies* are carried out for vascular tumors. The actual confirmatory diagnosis of the lesion is made by carrying out histopathological examination following biopsy of a lesion.

Biopsy

Here the tissue is obtained from a living person and sent for histopathological examination for final diagnosis of a lesion. A trained pathologist will process the tissue with different staining and use the microscopic examination for final interpretation of the lesion.

Selection of a Biopsy Technique

Depending on the nature of lesion, access to the lesion, extent of the lesion and nature of the tissue to be examined, the particular biopsy technique is chosen. *Exfoliative*

cytology, aspiration biopsy, incisional biopsy, excisional biopsy—these are the various biopsy techniques, which can be used for oral lesions. *Intraoperative frozen section study* can also be used to know the extent of the surgery. Depending on the patient's age, physical health and emotional status, the biopsy procedure can be planned with local anesthesia, sedation or general anesthesia.

Exfoliative cytology: It does not have any role in closed jaw lesion. However, in case of suspected malignancy of the jaw bone, the initial screening can be done by scraping the lesion. The cells obtained from the scrapings are transferred on the glass slide and are stained and examined under the microscope. On many occasions this can give false negative report and hence is not a reliable substitute for biopsy procedure.

Aspiration biopsy: It is done by using a needle and syringe to penetrate the lesion and aspirating the contents of the lesion. It can give valuable information regarding the nature of the tissue. In solid lesions, there will be inability to aspirate the fluid or air. In a cystic lesion, a straw colored fluid can be aspirated, while in infected lesion, pus is obtained as an aspirate. Traumatic bone cavity will yield an air aspiration. In vascular lesion, the bright red blood can be aspirated without pulling the piston of the syringe. Bloody aspirate can be obtained from aneurysmal bone cyst or central giant cell granuloma, etc. **(Fig. 38.1)**.

Aspiration can be carried out for all the lesions, which contain fluid or for any intraosseous lesion prior to surgical intervention. Aspiration can be done by using 18-G needle with 5/10 cc syringe. The most fluctuant point of the lesion is selected for the needle penetration. The material obtained from the aspiration biopsy is submitted for (1) pathological examination (2) chemical analysis or (3) microbiologic culturing if necessary.

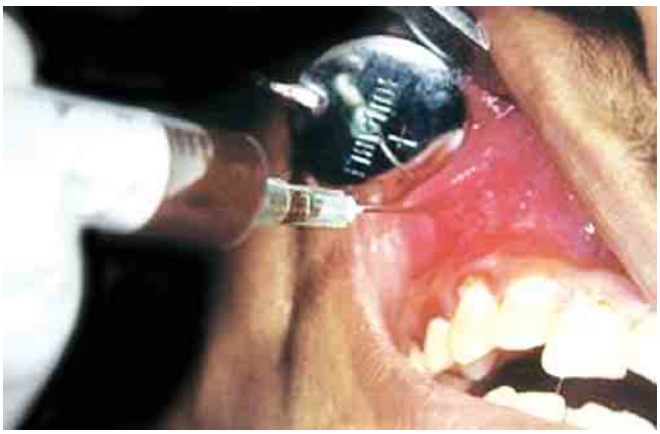


Fig. 38.1: Aspiration biopsy

Fine-needle aspiration cytology (FNAC): It can be useful for deep seated lesions, e.g. neoplasms of the salivary glands, masses in the neck or soft tissue tumors in the bones. With Silverman needle, it is possible to get a strip of intact tissue 1.5 mm wide and about 1.5 cm long, which can be sectioned and studied like an ordinary surgical biopsy. A negative biopsy is often unreliable. It should be used only as an adjunct to diagnosis.

Excisional biopsy: This is the complete removal of the pathological lesion, which is submitted for histopathological review. Some amount of normal surrounding tissue is also included during total excision of the lesion. It is usually employed for smaller lesions, which can be excised easily without causing much mutilation.

Incisional biopsy: In the larger lesions, the small wedge of tissue is obtained to represent the entire lesion and subjected for histopathological examination. Some rules to be followed during this procedure.

- The site of biopsy is chosen carefully after completing the clinical and radiological examination
- The aspiration should be always tried before incisional biopsy
- The incision should be planned keeping in view, the final surgical procedure
- Representative areas of the lesion should be incised in a wedge fashion
- Some amount of normal tissue should be included
- Ulcerated areas, necrotic tissue should be avoided
- Incisional biopsy should be planned without causing injury to the nerves, teeth or blood vessels
- Sufficient amount of tissue should be obtained
- The specimen tissue should not be crushed
- Deeper biopsies are preferred over superficial one
- Proper hemostasis is achieved prior to closure
- A nonresorbable tissue barrier may be placed over the bony entrance of the lesion following incisional biopsy to prevent fluid or lesional cell escape into the noninvolved tissue
- The specimen should be well oriented and marked for proper identification
- The tissue should be immediately placed in 10% formalin solution completely immersed.

PRINCIPLES OF SURGICAL MANAGEMENT OF JAW TUMORS

The goal of treatment is (1) complete eradication of a lesion (2) preservation of the normal tissue as permissible

(3) excision with least morbidity (4) restoration of tissue loss, form and function (5) Long-term follow-up for recurrence.

Before planning the surgical procedure, the oral and maxillofacial surgeon should discuss the biological behavior, histologic tissue pattern, recurrence rate, etc. with the pathologist and should correlate the clinical, radiological and histopathological findings.

Gold, Upton and Marx in 1991, have presented a standardized surgical terminology for the excision of lesions in the bone. All excisions of the lesions involving the jaw bone can best be described by the following terminologies:

- Enucleation
- Curettage
- Marsupialization
- Recontouring
- Resection without continuity defect (RsCD)
- Resection with continuity defect (RcwCD)
- Disarticulation.

Enucleation with or without curettage, marsupialization: are mainly used for the excision of the cystic lesions. Many small benign tumors are nonaggressive and they tend to grow by expansion rather than infiltration and they also can be treated by enucleation, with or without curettage. The surgical procedure is described in the earlier chapter.

Other group of benign tumors, which are locally invasive or aggressive, require inclusion of some amount of normal tissue, during excision to lessen the chance of recurrence.

Resection without continuity defect: It is used for such lesions. This is also known as marginal resection (En bloc resection).

Resection with continuity defect: It is carried out for more extensive lesions, which include resection of the inferior border of the mandible.

Partial resection: Here resection of a tumor by removing full thickness portion of the jaw is carried out. In the mandible, this can vary, depending upon the site of tumor, from a small continuity defect, segmental resection to hemi-mandibulectomy.

Disarticulation: Whenever condylar head is included in the resection of the part of the mandible, then the procedure is called as *hemimandibulectomy with disarticulation* and whenever the condylar head is retained for rehabilitation procedure, then the procedure is called as *hemimandibulectomy without disarticulation.*

Total resection: Excision of a tumor by removal of the involved bone is carried out. *Maxillectomy* or *mandibulectomy* procedures can be carried out.

Composite resection: The last group of tumors are the malignant ones. They require much more radical intervention, with wider margins of excision of uninvolved tissue. Surgery may include along with resection of the jaw-neck dissection and dissection of the lymph nodes. Radiotherapy or chemotherapy, either alone or in addition to the surgery, may be used depending on the type of tumor.

Factors to be evaluated before surgery: In order to choose the most appropriate surgical method for individual case, following factors are to be considered:

- **Anatomical location of the lesion:** The surgical access to the lesion is an important factor for prognosis. Small benign lesions involving inaccessible areas are more difficult to treat. Example— tumors in infratemporal region, at the pterygomaxillary fissure, etc. Aggressive tumors in the anterior mandible region will be more accessible and have better prognosis. Intraosseous tumors will be more difficult than extraosseous tumors.
- **Aggressiveness of the tumor:** Locally invasive tumors are treated with wider resection in order to prevent recurrence.
- **Size of the tumor and confinement to the bone:** The size of the tumor is important, especially in the mandible. If the inferior border is not involved in the lesion, marginal resection can be carried out without continuity defect. If the tumor is not confined to the bone, that means, if it has perforated the cortices and extended into the soft tissues, then one has to carry out wider resection sacrificing the more amount of normal soft tissue along with the resection of the bone.
- **Proximity to adjacent vital structures:** Preservation of the neurovascular structures and teeth is of importance. But, if the tumor is aggressive, then both these important structures have to be sacrificed.
- **Involvement of maxilla/mandible:** The maxillary tumors have poorer prognosis than those involving the mandible. Proximity to the maxillary sinus, nasal cavity, orbital cavity, cranial fossa, nasopharynx allow these tumors to grow asymptomatically and more extensively to attain a large size with late symptoms.
- **Rehabilitation or reconstruction methods:** The rehabilitation or reconstruction is much easier in the mandible than in the maxilla. The continuity of the resected mandible can be maintained by using reconstruction plates. Bone grafting can be done either as a primary reconstruction method or secondary reconstruction method.

The reconstruction of the smaller defects can be done by using bone grafts, alloplastic bone grafts or synthetic material or combination of the above materials.

In the maxilla, after maxillectomy, a denture with obturation can be given to improve speech and mastication.

The microvascular surgery can be considered to reconstruct the lost jaw portion and later dental implants can be given to complete rehabilitation of these patients.

Enucleation with or without Curettage

Indications

- Surgical excision of the tumors, which tend to grow by expansion, rather than by infiltration of the surrounding tissues
- Lesions occurring in the bone with a distinct separation between the lesion and the surrounding bone
- Often, there is a cortical margin of bone that delineates the tumor or cyst from the bone
- Indicated in following tumors:
  - *Odontogenic tumors*
    - Odontoma
    - Ameloblastic fibroma
    - Ameloblastic fibrodontoma
    - Adenomatoid odontogenic tumor
    - Cementoblastoma
  - *Fibro-osseous lesions and nonodontogenic tumors*
    - Ossifying fibroma
    - Cherubism
    - Central giant cell granuloma
    - Osteoblastoma
  - *Other lesions*
    - Hemangioma
    - Eosinophilic granuloma
    - Neurofibroma
    - Neurilemmoma
    - Pigmented neuroectodermal tumor.

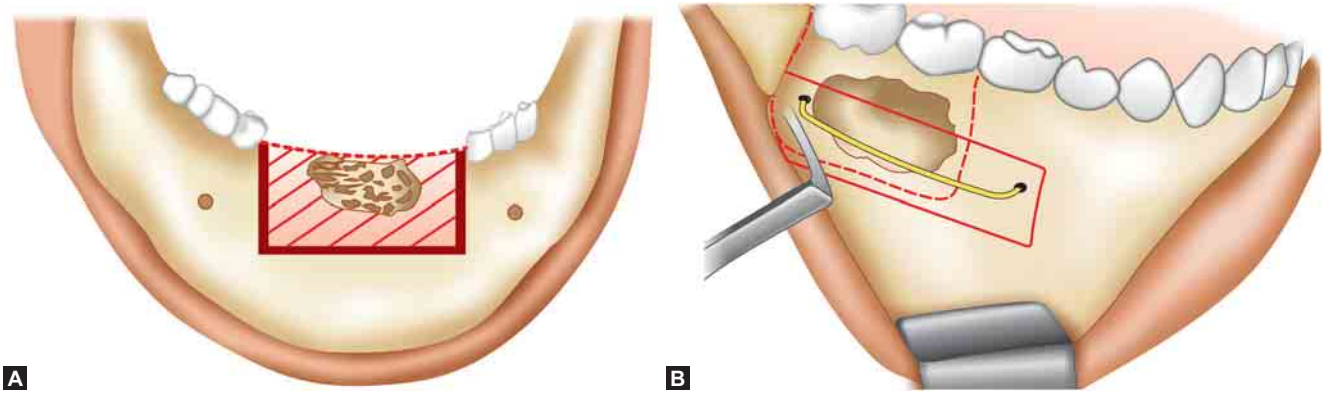
Marginal Resection or Resection without Continuity Defect/Peripheral Osteotomy/ En Block Resection

Enucleation of the locally aggressive lesion is not a safe procedure and it makes recurrence almost inevitable. En bloc or marginal resection is indicated in the benign lesions with a known propensity for recurrence, or in those lesions that are incompletely encapsulated or tend to grow beyond their surgically apparent capsule. It is also indicated for recurrent lesion, previously treated by enucleation alone.

Ameloblastoma, calcifying epithelial odontogenic tumor (CEOT), myxoma, ameloblastic odontoma, squamous odontogenic tumor, benign chondroblastoma, hemangioma are the lesions treated by this method.

This procedure allows complete excision of the tumor, but at the same time a continuity of the jaw bone is retained and thus deformity, disfigurement and the need for secondary cosmetic surgery and prosthetic rehabilitation are avoided.

Intraoral marginal resection: Surgical procedure (Figs 38.2A and B): The circumgingival incision is taken and the releasing incisions can be extended into the buccal mucosa on either side of the lesion leaving at least one or two adjacent teeth on either side. The full thickness mucoperiosteal flap is reflected by using periosteal elevator. Care is taken not to perforate the lesion. If the lesion is perforated, then overlying mucosa should be sacrificed along with the excision of the tumor. The tooth



Figs 38.2A and B: (A) Intraoral marginal resection in the anterior region of mandible; (B) Intraoral marginal resection in the posterior region of mandible

next to the tumor mass should be extracted on either side. The vertical osteotomies are performed through the sockets of the extracted teeth on either side using bur or saw blade.

Both the vertical osteotomy cuts are extended from the buccal to lingual cortex. These cuts are joined with a horizontal cut, placed well beyond the tumor mass including margin of the normal bone. Horizontal cut is also completed through and through the buccal and lingual cortex. The complete excision of the tumor along with some amount of normal bone is carried out by using osteotome. Teeth involved in the tumor mass are removed with the block in toto. The remaining bony margins should be checked for sharp areas and contoured by using round bur or bone file. The excess mucoperiosteal flap is trimmed off and approximated to suture the wound. This type of excision can be done under local anesthesia with sedation for smaller lesions or it can be planned under general anesthesia.

Extraoral peripheral osteotomy (Fig. 38.3): Since complete resection of large segments involving both the horizontal and the ascending rami or disarticulation of the segment causes considerable amount of disability, this method is useful, which will allow complete removal of the pathology, but is less debilitating than complete resection. The procedure is based on the observation that the cortical inferior border of the horizontal body, the posterior border of the ascending ramus and the condyle are not generally involved in the benign tumor process. Bone regeneration will start from such areas even though a thin rim of bone is preserved, especially in young patients, result in considerable restoration of the jaw anatomy.

Indications: Large lesions involving posterior mandible.

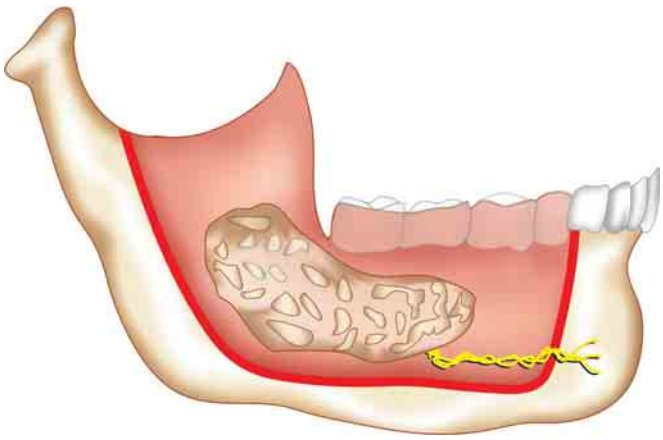


Fig. 38.3: Extraoral peripheral osteotomy

Operative procedure: In dentulous patients, intraoral crevicular gingival incision is taken around dentulous area, both buccally as well as lingually. Buccinator and mylohyoid muscles are separated after reflecting the mucoperiosteal flap. In edentulous patients there is no need to take intraoral incision.

Extraoral submandibular incision is taken and the inferior border of the mandible is exposed, if required posterior border of the ramus is also exposed. The site of peripheral osteotomy is already decided by studying CT scans or radiographs. The drill holes are made with the electrical dental drill in the healthy bone around the periphery of the lesion. These holes are connected until the tumor mass is separated from the thin span of bone to be retained. The part to be excised is now separated from the attached soft tissue on the external surface. The masseter and buccinator muscles are detached with care, so that not to injure the branches of the facial nerve. Then the mucoperiosteum of the alveolar process is elevated and the specimen is turned outwards to get access to the inner surface to detach the mylohyoid and the internal pterygoid muscles. The temporalis muscle is severed above the coronoid, after which the inferior alveolar nerve and vessels are identified and grasped with a hemostat, ligated and cut off. The remaining bone is now carefully inspected. Intraoral wound is closed with water tight suturing. An immediate bone graft can be inserted through the extraoral wound and fixed with intraosseous wires or bone plates. The wound is closed in layers with a small rubber drain inserted to prevent formation of a hematoma. An external pressure bandage is applied. Careful long-term following up is mandatory.

Segmental Resection of the Jaw (Intraoral Approach) (Fig. 38.4)

Indications

- For treatment of lesions that are infiltrative or have a tendency to recur
- Those lesions which extend close to the inferior or posterior border of the mandible, the maxillary sinus or the nasal cavity
- It is also used for malignant lesions with high recurrence potential
- Recurrent odontogenic tumors with difficulty in examining and gaining an access surgically
- Maxillary ameloblastomas with high recurrence rate
- Lesions close to the borders of the jaw, with the possibility of postoperative pathologic fracture.

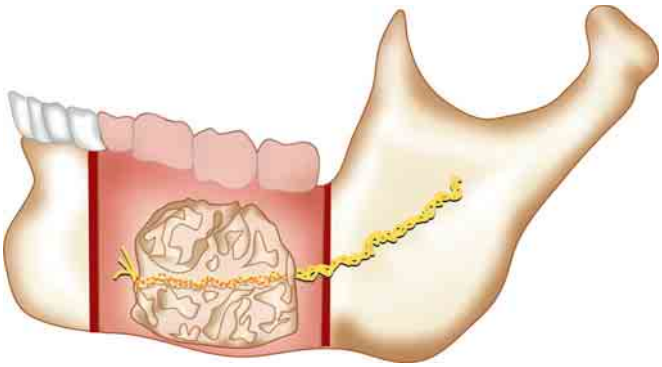


Fig. 38.4: Segmental resection of jaw (intraoral approach)

Preoperative assessment: A thorough clinical, radiographic and histologic assessment should be carried out.

Advantages of Intraoral Approach

- Excision of overlying mucosal tissue involved in the lesion is facilitated
- Easy access for application of arch bars, extraction of involved teeth, ligation of the inferior alveolar neurovascular bundle, closure of the maxillary sinus and maintaining the forward stability of the tongue, whenever required
- An external scar is avoided
- An extraoral tissues are preserved for a later reconstruction procedure.

Disadvantages of Intraoral Procedure

- Contamination of the surgical wound by the oral flora
- Lack of dependent drainage of the dead space
- Difficult access to the most posterior portions of the mandible
- The risk of damage to the branches of the internal maxillary artery, deep in the wound
- Immediate bone graft reconstruction by oral route has a higher rate of infection and loss of the bone graft (30%).

The patient should be informed of and prepared psychologically for the resulting facial and functional deformity and the reconstruction procedure.

- **Surgical procedure:** For mandibular lesion extending posterior to the mental foramen, ligation of the inferior alveolar neurovascular bundle prior to resection may prevent significant intraoperative hemorrhage. The incision is designed to expose the lesion on both the facial and lingual aspect with or without inclusion of overlying tissues in the specimen. The same incision is extended posteriorly through the buccal mucosa approximately 7 mm lateral and parallel to the anterior border of the ascending ramus and external oblique ridge. Blunt dissection is carried out along the surface of the buccinator muscle to expose the periosteum over the external oblique ridge and anterior border of the ramus. A sharp incision is made through the periosteum and the periosteum is elevated lingually to expose the retromolar area of the mandible, internal oblique ridge and medial surface of the ramus, till the lingula. The inferior alveolar neurovascular bundle is located and a curved aneurysmal needle can be passed around it with a ligature threaded through its eye. The neurovascular bundle is ligated at the higher level above the lingula.

After this, the entire lesion is exposed by reflecting the mucoperiosteal flap on buccal and lingual side till the inferior margin of the mandible. The anterior and posterior bony cuts are then outlined as planned and the cuts are finished by using bur or saw blade from buccal to lingual cortex. In the tooth-bearing area, one or two teeth may be removed prior to sectioning the jaw, bony cut can be carried out through an empty socket. Separation of the bony cuts can be completed with an osteotome. The specimen is separated from its bony and soft tissue attachments and inferior alveolar neurovascular bundle is sectioned below the ligature level. Whenever the anterior portion of the mandible is removed, it is mandatory to hold the genioglossus muscles with the hemostat prior to separation from the specimen and then these muscles should be secured with a suture in the forwards position to the soft tissues of the chin or to the reconstruction plate to prevent airway obstruction due to tongue fall postoperatively. Primary closure of the wound is done. Intermaxillary fixation or reconstruction plate is necessary to preserve the alignment of the fragments.

Extraoral approach: It may be necessary for difficult approach. The surgical procedure will be same as described earlier for the marginal resection **(Fig. 38.5)**.

1. **Segmental resection including the condyle (Disarticulation) (Fig. 38.6):** The surgical approach is through a combined postramal (Hinds) and submandibular (Risdon) incision placed at least 2 cm below and parallel to the inferior and posterior borders of the mandible. After the incision through the skin, subcutaneous tissue and platysma is taken, the dissection plane is made deep to the platysma, along the investing fascia to the inferior border of the mandible. The pterygomasseteric muscle sling and periosteal layer is divided at the inferior border of the mandible.

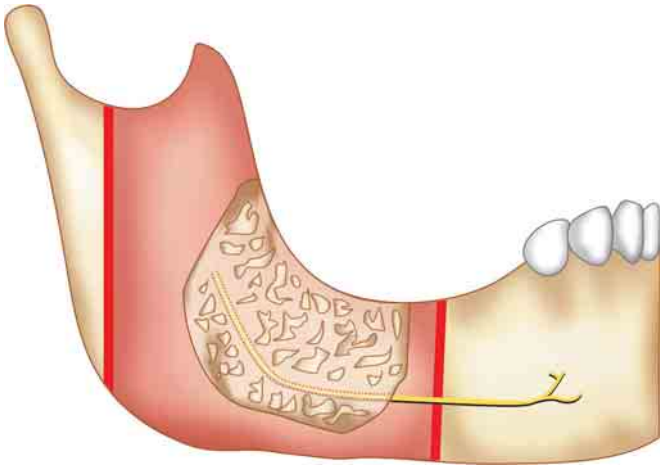


Fig. 38.5: Segmental resection without disarticulation (extraoral approach)

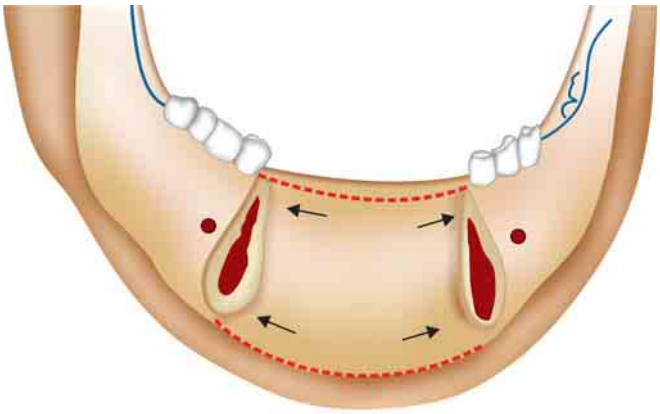


Fig. 38.7: Intraoral segmental resection involving mandibular midline

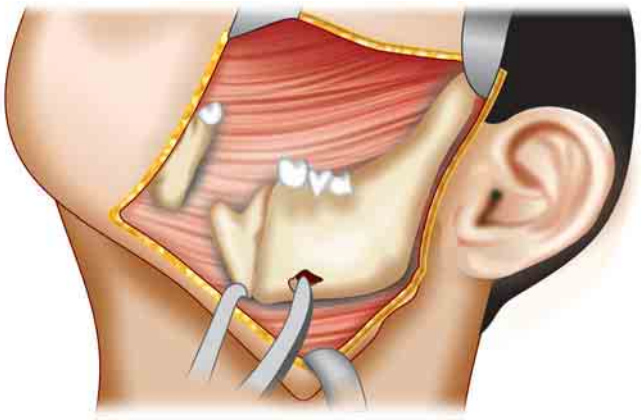


Fig. 38.6: Segmental resection including condyle (disarticulation)

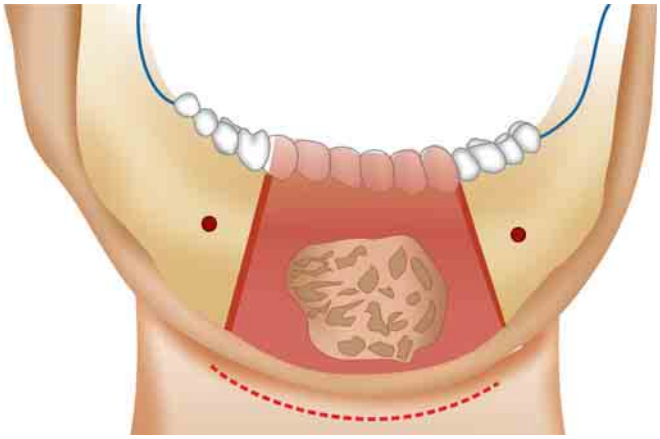


Fig. 38.8: Extraoral segmental resection involving mandibular midline

Subperiosteal reflection of the masseter muscle is done along the lateral surface of the mandible to expose the coronoid process, sigmoid notch and condylar neck. The anterior portion of the resection is determined and dissected. Care should be taken to prevent an intraoral communication. (In teeth bearing area the intraoral incision is unavoidable), using the bur or saw blade, the osteotomy is completed. By swinging the specimen laterally, it is freed from its medial attachments subperiosteally. The temporalis muscle is detached from the coronoid process. The condylar head is separated from lateral pterygoid muscle attachment. Care is taken to prevent damage to the maxillary artery and its branches. The specimen is completely removed and the surgical wound is irrigated. The proximal portion of the segment is smoothened to prevent intraoral perforation. Reconstruction plate with condylar prosthesis is placed and fixed on to the proximal stump with screws. The wound is closed in layers after proper hemostasis.

2. **Segmental resection involving the mandibular midline (Figs 38.7 and 38.8):** An incision is made at least 2 cm below the inferior border of the mandible.

Dissection: Incision is taken through skin, subcutaneous tissue. At the level of platysma muscle, the tissues are undermined. Platysma is cut sharply and dissection is followed to the investing layer of the deep cervical fascia. Incision through this layer is taken till the periosteum at the inferior border of the mandible. The dissection is continued subperiosteally to detach the left and right

diagastric as well as the mylohyoid muscle from the medial aspect of the mandible. The genioglossus and geniohyoid muscle attachments are located and a suture is passed around them. Then the muscles are detached from the genial tubercles. The subperiosteal dissection is carried on the buccal surface of the mandible to expose the planned resection portion. The mental nerves are identified and protected. The lateral extent of the resection is defined in the dentulous jaw by extracting the teeth and placing the bony cuts through the sockets. A mucoperiosteal flap is developed intraorally to free the specimen from the soft tissue attachments. Prior to the removal of the specimen, the remaining segments should be stabilized by carrying out temporary intermaxillay fixation. The reconstruction plate is contoured prior to the excision of the bone and immediately secured it following the resection by means of screws. This prevents the collapse of the segments and allows jaw function during healing and prior to final reconstruction and also prevents scar contraction. The oral mucosa is closed intraorally, using a horizontal mattress suture to obtain as watertight seal as possible. The genioglossus and geniohyoid muscles are pulled forwards with suture, which is secured to the reconstruction plate. Extraoral wound is closed in layers.

Maxillectomy

Access to the maxilla is generally obtained by designing the classic Weber-Fergusson incision. The eyelids are closed temporarily by taking tarsorrhaphy sutures. For esthetic good result, it is recommended to tattoo the vermilion border and the other points on both sides of the incision with methylene blue. These points are then matched during closure. The typical incision splits the midline of the upper lip **(Fig. 38.9)**. But better cosmetic results can be obtained by incising along the philtral ridges and then offsetting the incision at the vermilion border **(Figs 38.10A and B)**. The incision is turned laterally at the base of the columella, then around the alar base and along the side of the nose to within 2 mm of the medial canthus. Intraorally the incision is continued down through the gingival margin. It is connected with a horizontal incision at the depth of the labiobuccal vestibule, extending back to the maxillary tuberosity. From here, the incision turns medially across the posterior edge of the hard palate. It then turns 90° anteriorly, several millimeters to the proximal side of the midline, if possible to cross the gingival margin once again **(Fig. 38.11)**.

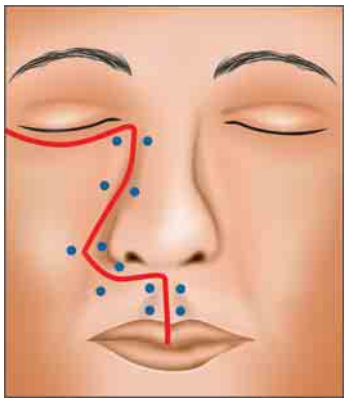
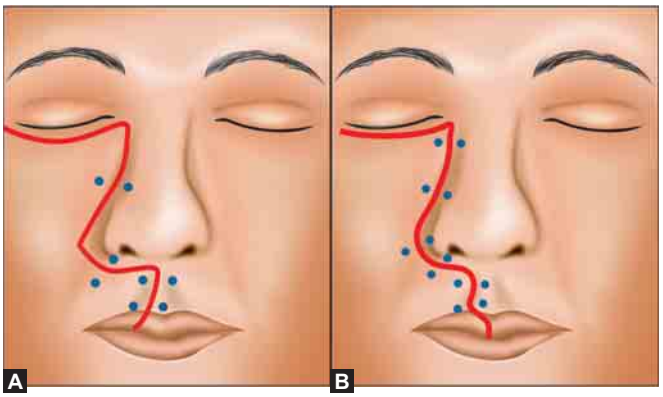


Fig. 38.9: Weber-Fergusson incision



Figs 38.10A and B: Variation of lip split for better cosmetic results

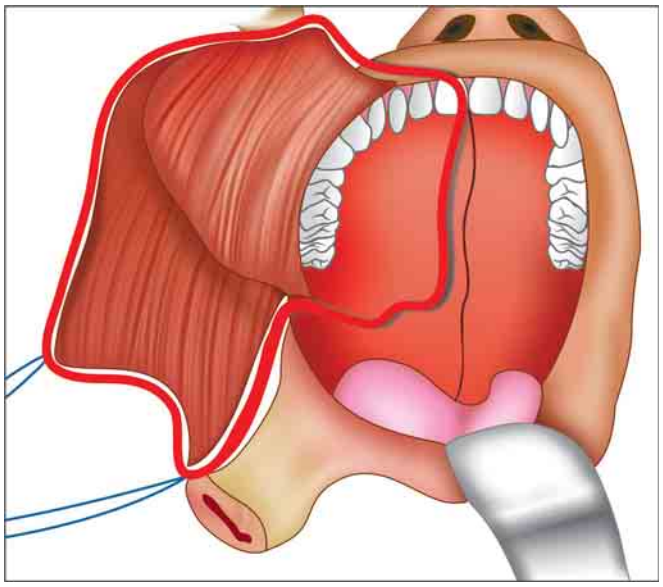


Fig. 38.11: Intraoral incision for exposure of tumor

The incision is carried to the bone, except beneath the lower eye lid, where the orbicularis oculi muscle is preserved. The cheek flap is then reflected back to the tuberosity **(Fig. 38.12)**. The central incisor on the involved side is extracted and the gingival and palatal mucosa are elevated back to the midline. The incision extending around the nose is then deepened into the nasal cavity. The palatal bone is then divided near the midline with a saw blade or bur. The basal bone is then separated from the frontal process of the maxilla with an osteotome. The orbicularis oculi muscle is retracted superiorly, and the bone cut is extended across the maxilla, just below the infraorbital rim, into the zygoma. If the posterior wall of the maxillary sinus has not been invaded by tumor, it is separated from the pterygoid plates with a pterygoid chisel **(Fig. 38.13)**. The entire specimen is removed by severing the remaining attachments with a large curved scissors placed behind the maxilla.

After the removal of the specimen, some amount of brisk bleeding is expected, which is controlled with packing and electrocautery. Branches of the maxillary artery in the pterygomaxillary fissure area may require ligation. While the packing is in place, the specimen should be inspected to make sure that complete tumor has been excised. All sharp bony projections should be trimmed. The flap of the retained palatal mucosa is turned up to cover the medial bony margin. A split thickness skin graft is then sutured to the wound margins to cover the entire defect. Graft is maintained in place by placing softened impression compound ball in the defect. The surgical obturator, which is prefabricated, is placed to seal the defect and support the packing. The obturator is fixed to the remaining teeth by means of interdental wiring. The main cheek flap is then turned back and closed in layers **(Figs 38.14A to D)**.

Modifications

- When the tumor extends up to the roof of the maxillary sinus (but does not invade) the orbital floor should be included in the resection **(Fig. 38.15)**.

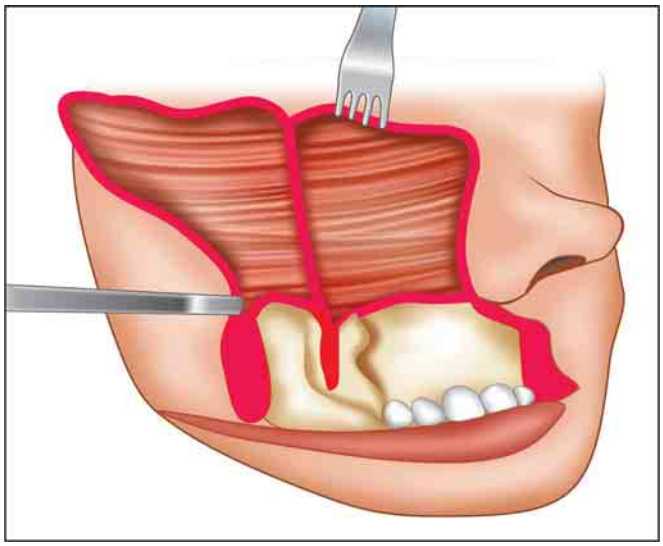


Fig. 38.12: Reflection of cheek flap for maxillectomy

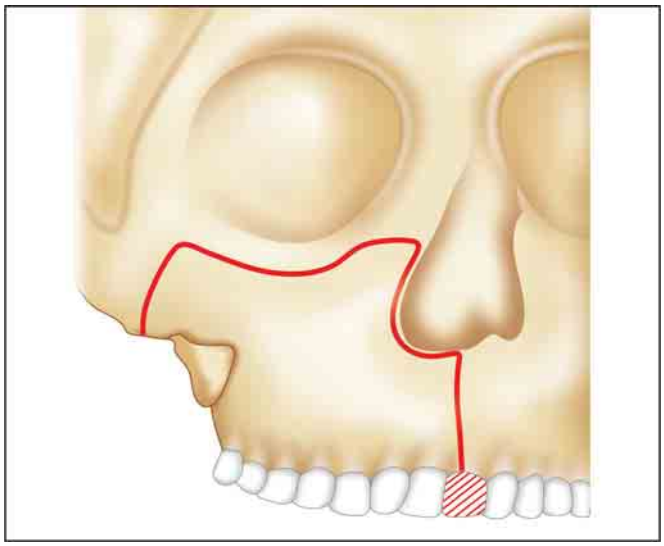
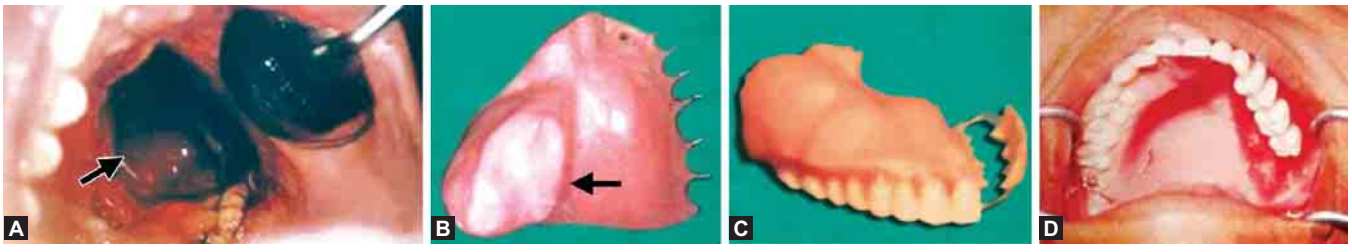


Fig. 38.13: Bony cuts for maxillectomy



Figs 38.14A to D: Rehabilitation of maxillectomy defect. (A) Skin graft in place; (B and C) Obturator with hollow bulb; (D) Rehabilitation with obturator

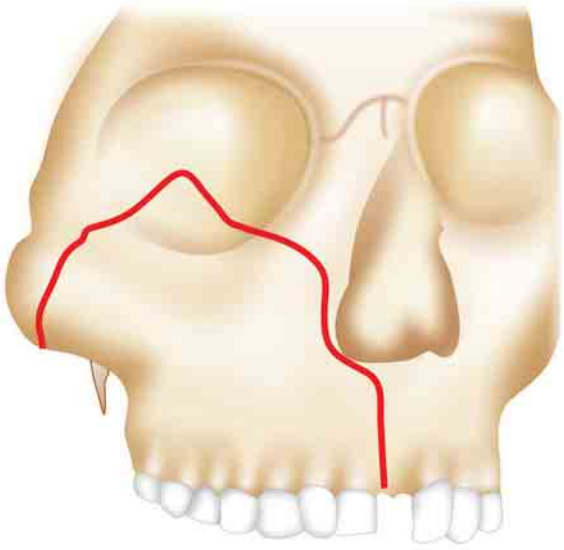


Fig. 38.15: Inclusion of the orbital floor in maxillectomy– bony cut

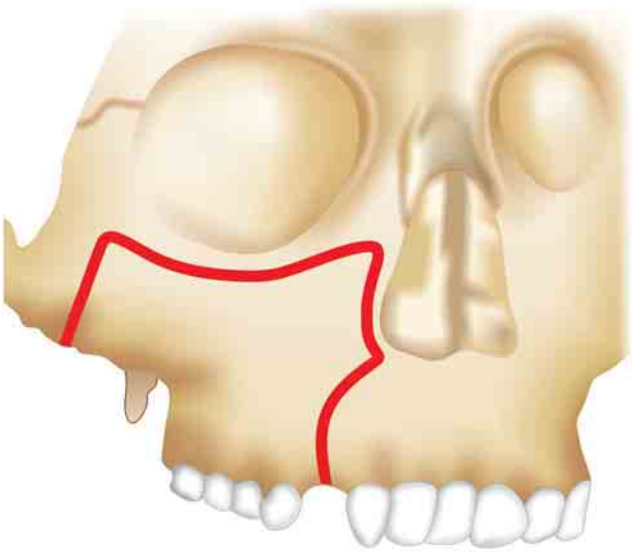


Fig. 38.17: Maxillectomy cut without inclusion of premaxilla

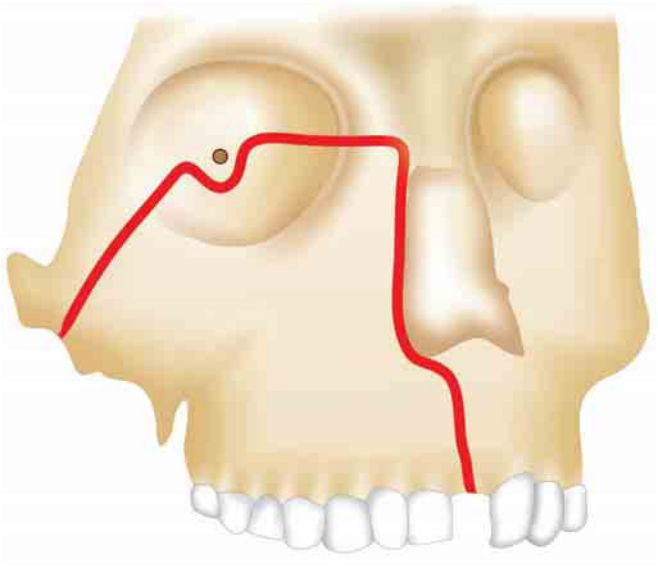


Fig. 38.16: Bony cuts for the orbital exenteration along with maxillectomy

- When the tumor invades the roof of the maxillary sinus, the orbit or the ethmoid sinuses, orbital exenteration is mandatory **(Fig. 38.16)**.
- The tumors which are confined to the posterior aspect of maxillary sinus may be managed with a more conservative resection that spares the premaxilla **(Fig. 38.17)**.

Postoperative management: Patients are kept in an intensive care unit for the first one or two days for cardiovascular monitoring and necessary maintenance of fluid, electrolyte balance. The patient is kept on liquid diet. Instructions are given for maintenance of oral hygiene. Prophylactic antibiotic therapy is advocated for 5–7 days. The surgical obturator is removed after 15 days and the wound is irrigated with warm saline and hydrogen peroxide. Excess skin graft and other debris are removed.

Long-term follow-up is necessary.

Reconstruction

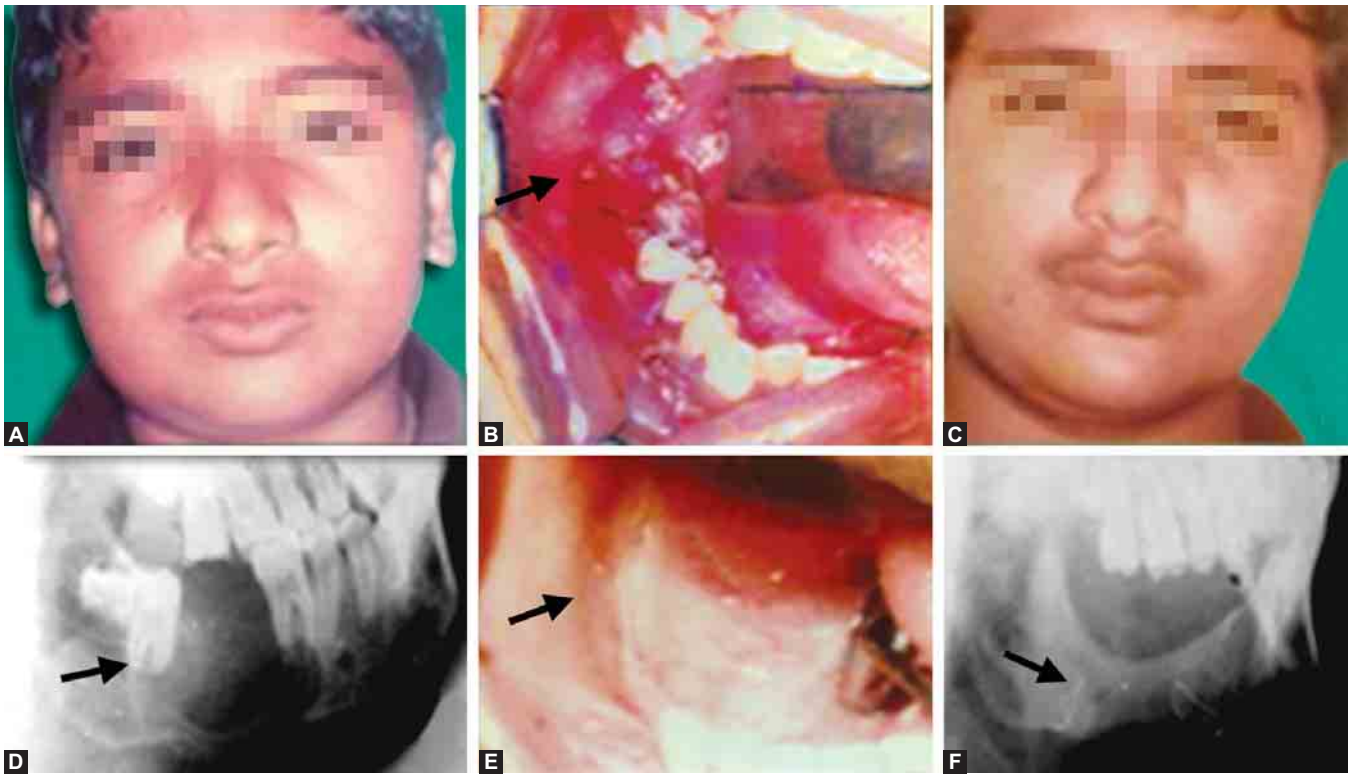
After surgical RcwCD, there is facial disfigurement. Deviation of the mandible along with resultant altered mandibular movements with facial asymmetry is seen in case of hemimandibulectomy.

Need for Reconstruction

- For the restoration of movements and equilibrium of mandible
- For maintenance of normal occlusal plane, floor of the mouth and tongue's anatomical position
- For restoration of near normal feeding/mastication of food
- For acceptable esthetics and function, establish speech
- For more favorable social acceptance.

Timing of Reconstruction

A. *Immediate Reconstruction* ***(Figs 38.18 to 38.20)***
Advantages
   - Single stage surgery



Figs 38.18A to F: (A) A 15-year-old male patient with ameloblastoma in right body mandible, preoperative frontal view; (B) Intraoral lesion view; (C) Postoperative frontal view; (D) Preoperative radiograph showing extent of lesion; (E) Postoperative intraoral view of the healing after segmental resection of the tumor and immediate iliac crest bone graft reconstruction; (F) Postoperative radiograph after 6 months follow-up showing take of the graft

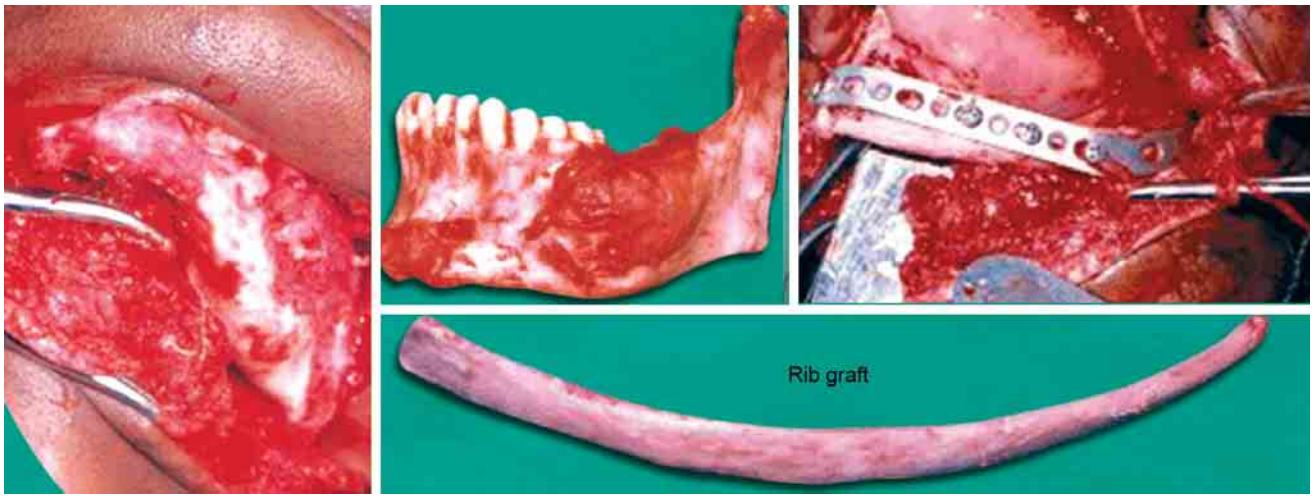


Fig. 38.19: A 30-year-old male patient with ameloblastoma of left ramus and body. Hemimandibulectomy with disarticulation was done, immediate reconstruction with rib graft was carried out

- Early return of function
- Minimal compromise of esthetics

Disadvantages

- Possible recurrence in grafted bone
- Loss of graft from infection

Immediate reconstruction can be done by three different ways:

1. Performing surgical excision and grafting, both via intraoral approach.
2. Surgial excision utilizing both intraoral and extraoral approach, first obtaining water tight oral closure and grafting done through extraoral approach.
3. Earlier extraction of involved teeth and waiting of 6–8 weeks for oral healing and then surgery at second stage, with complete procedure via extraoral approach to avoid oral communication of the graft.

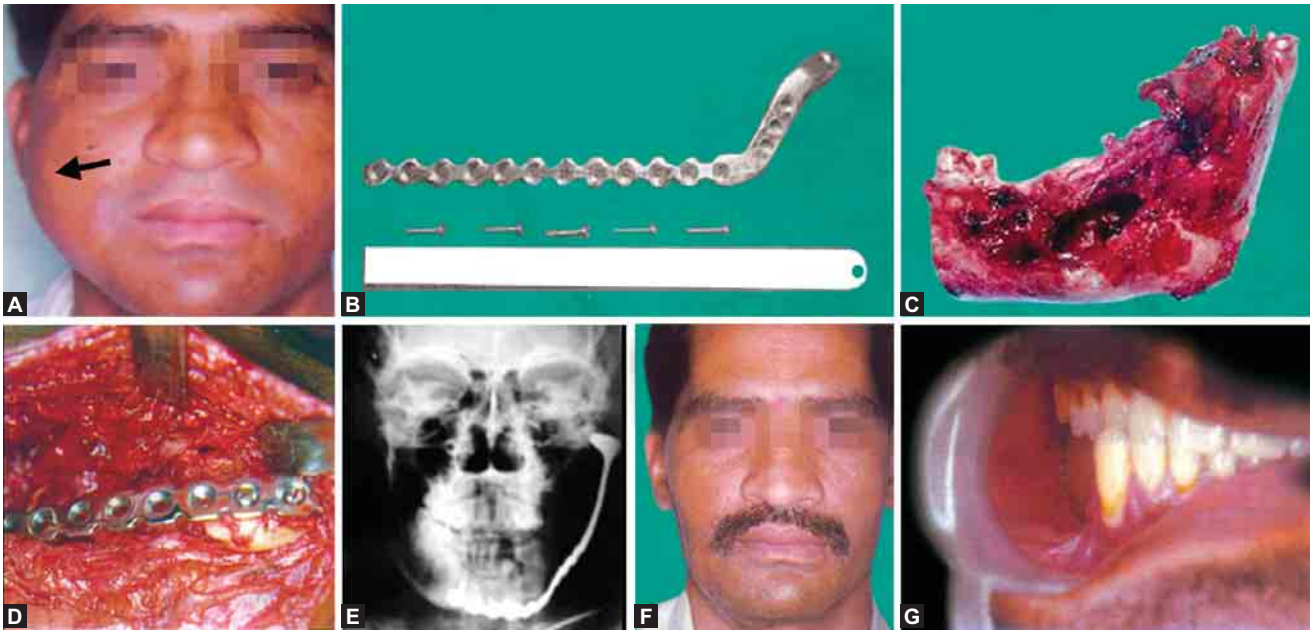
B. **Delayed reconstruction (second stage)** ***(Figs 38.21A to G)***

Here the consideration should be given to maintain the residual mandibular fragments with their normal anatomic relationship with intermaxillary fixation or using a reconstruction plate.

This is to avoid cicatrical and muscular deformation and displacement of segments, which



Figs 38.20A to C: (A) Marginal resection of ameloblastoma leaving posterior and inferior border intact; (B) Tumor specimen; (C) Immediate reconstruction with rib graft



Figs 38.21A to G: Delayed reconstruction (use of reconstruction plate). (A) Extraoral swelling on right side of the face in a 36-year-old male. Amelobastoma involving (right) body and ascending ramus mandible; (B) Reconstruction plate; (C) Tumor specimen after hemimandibulectomy with disarticulation; (D) Reconstruction plate fixation surgery; (E) Postoperative radiograph; (F) Postoperative facial symmetry; (G) Maintenance of occlusion and intraoral postoperative healing

aids in secondary reconstructive efforts at a later date. Usually 6 months waiting period is observed for recurrence.

ODONTOGENIC TUMORS OF VARIOUS ORIGINS

Tumors Arising from Odontogenic Epithelium without Odontogenic Ectomesenchyme

Ameloblastoma

One of the most significant tumors, which has a long history of recognition and controversy. Opinions differ regarding its terminology, etiology, histological pattern, classification, clinical and biological behavior, diagnosis, treatment aspect and malignant potential, etc.

History: First recognized by Cuzack in 1827. Later on Falksson described it in 1879, as follicular cystoid tumor. The term "Adamantinoma" was used by Malassez in 1885.

Ivy and Churchill coined the term "ameloblastoma" in 1934.

Robinson has described it as 'usually unicentric, nonfunctional, intermittent in growth, anatomically benign and clinically persistent.

WHO— it is a true neoplasm of enamel organ type tissue, which does not undergo differentiation to a point of enamel formation.

In 1992, WHO classification categorized ameloblastoma as a benign, but locally invasive epithelial odontogenic neoplasm, with strong tendency to recur.

Pathogenesis (origin): According to Thoma, Williams in 1993, the tumor may be derived from various origins.

- **Late developmental sources:** Cell rests of enamel organ, either remnants of dental lamina or epithelial cell rests of Malassez or remnants of Hertwig's sheath, follicular sacs.
- **Early embryonic sources:** Disturbances of developing enamel organ, dental lamina, tooth buds.
- **Basal cells of the surface epithelium of the oral mucosa.**
- **Secondary developmental sources:** Epithelium of odontogenic cysts, particularly primordial, lateral periodontal cyst, dentigerous cyst and odontomas.
- **Heterotropic epithelium in other parts of body**, *especially from the pituitary gland.*

Incidence: It accounts for approximately 1% of all oral tumors and 18% of all odontogenic tumors.

Age: The age at which the lesion may become clinically evident is as early as the first decade or as late as the 7th decade. Overall average age is 36 years.

No sex predilection: It can occur equally in men and women.

Site: The lesion may occur in either of the jaws. The ratio of ameloblastoma of the mandible to maxilla is 5:1. The sites of predilection are the posterior maxilla and the posterior molar— ramus region of the mandible (60%). In blacks, ameloblastomas occur more frequently in the anterior region of the maxilla. Relative distribution of ameloblastoma in the jaws is as follows– Maxilla– 6% in anterior, 1% in premolars, 6% in posterior region. Mandible– 10% in anterior, 11% in premolar, 66% in molar region.

Classification

- Central or intraosseous—99%, Unicystic—13%, Multicystic/solid— 86%.
- Peripheral or extraosseous. Found in the gingiva and mucosa of the alveolar process—1%.

Types of Central Ameloblastoma

- Simple solid—multicystic ameloblastoma with its histological varients—follicular, plexiform.
- Unicystic ameloblastoma with its histological variants. (1) Luminal—epithelial lining changes into ameloblastic epithelium. This change is confined within the luminal surface of the cystic lesion, (2) Intraluminal—the nodules of ameloblastoma proliferate and project into cystic lining, (3) Mural—the fibrous connective tissue wall of the cystic lesion is infiltrated by ameloblastic masses.

Clinical features (signs and symptoms): Ameloblastoma is typically asymptomatic and therefore seldom diagnosed in the early stages of development. Remaining undiscovered until the lesional growth produces intraoral and/or extraoral jaw swelling, tooth eruption and dental occlusion disturbances or incidental findings in the radiograph.

Patients complaint of slow growing, painless, hard, nontender, ovoid swelling, which is often large in size, as it causes little discomfort in early stage. Other complaints may be mobile teeth, exfoliation of teeth, ill-fitting dentures, malocclusion, ulcerations and nasal obstructions, inability to occlude properly. Later stage with nerve involvement, there will be sensory changes of the lower lip. Pain may be experienced if secondarily infected. Large persistent lesion may exhibit fluctuation, egg-shell crackling.

In the absence of treatment: The ameloblastoma keeps on enlarging and it causes thinning of surrounding bone leading to fluctuation and egg-shell crackling. Since it is not encapsulated tumor, it enlarges and invades into the neighboring tissues by replacing them rather than pushing them as seen in the cysts. Invasion of the medullary space is first feature (bone destruction by direct pressure and distension) when the tumor attains large size with bone erosion, then there is escape into periosteum and mucosa and muscles of the adjoining region. Facial asymmetry will be seen.

Root resorption is caused without osteoclastic activity. Locally aggressive invasion in maxillofacial area, may compress vital structures, obstruct airway, impair swallowing, erode major arteries or invade middle cranial fossa. The extensive tumors can cause gross facial deformity.

Size: It may range from lesion as small as 1 cm in diameter and up to disfiguring tumor measuring as large as 16 cm. In maxilla, it may enlarge to involve the maxillary sinus, nasal cavity leading to nasal obstruction and even proptosis of eye (The spread in the maxilla is more extensive, because of cancellous nature of the bone-rapid spread involving ethmoid sinuses, skull base).

Spread: Though it is a benign, locally invasive lesion, in some rare instances or late stages shows spread to distant sites.

The factors contributing to spread include:

- Duration
- Extensive local spread
- Multiple operations/radiotherapy
- Proximity to anatomical passage.

Occasional transformation into a malignant form (2–4%) metastasizing to lung and long bones.

Most common sites are lungs and it is considered to be the result of aspiration of tumor cells during extensive manipulation. Metastatic lesions prior to any surgical intervention, give an indication for hematological spread. Other sites, where metastasis is seen include regional lymph nodes, liver, spleen, kidney, long bones, skull, cranium, lumbar vertebrae, ilium, etc.

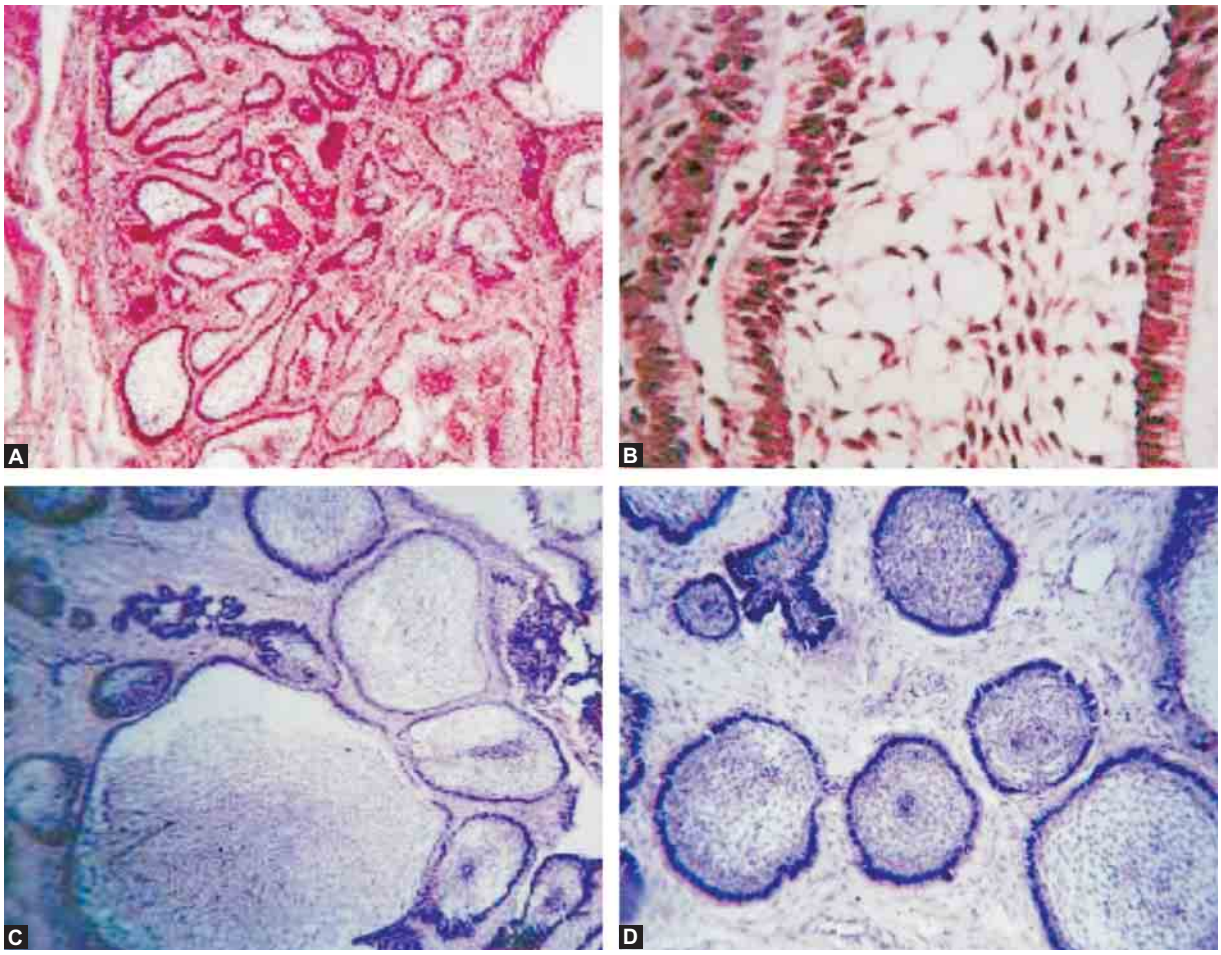
Radiographic Findings

- The ameloblastoma presents a unilocular (monocystic) or multilocular (multicystic) radiolucency in several different forms and shapes
- Eighty-six percent ameloblastomas appear as multilocular radiolucent lesions with sharp borders. One percent of the ameloblastomas are peripheral. Thirteen percent appear as unicystic lesions
- The apparent lesional edge may be distinct or indistinct
- Multilocular cyst like radiolucency with compartmentalized appearance due to bony septa. (Honey comb or soap bubble appearance) resembles fibromyxoma, giant cell lesions
- Small or large unilocular or multilocular lesion may contain unerupted deciduous or permanent teeth and may resemble a dentigerous cyst
- Lesions in dentulous area cause root resorption (30%) and tooth displacement
- Buccolingual cortical expansion (80%), this tendency is stronger than a cyst
- The displacement of neurovascular bundle at the inferior border is often seen
- Maxillary lesions often involve the maxillary sinus and change the normal radiolucency of the sinus to a more opacified appearance
- The radiographic image of ameloblastoma is at the most suggestive and not pathognomonic. CT scan – with 3D reconstruction will show the exact extent of the lesion
- One of the variants of the ameloblastoma—the desmoplastic ameloblastoma—most often found in the anterior maxilla or mandible appears as a relatively radiopaque lesion, because of its dense connective tissue content (solid type lesion)
- Differential diagnosis—multilocular lesion—Dentigerous cyst, OKC, cherubism, giant cell granuloma, odontogenic myxoma, aneurysmal bone cyst.

Histopathology: The ameloblastoma is composed of nests, strands and cords of ameloblastic epithelium, all separated by relatively small amounts of fibrous connective tissue stroma. The characteristic histological features of the ameloblastoma are the orientation of the outer epithelial cell nuclei, which are positioned (polarized) away from the basement membrane.

Two main patterns are seen:

1. **Follicular type (resembles tooth follicle):** It consists of small to large odontogenic epithelial nests (the follicles) and variously shaped and sized ameloblastomatous islands (more common pattern). Cyst formation is commonly seen **(Figs 38.22A to D)**
2. **The plexiform type:** It consists of interlacing strands of narrow or wide odontogenic epithelial trabeculae resembling the dental lamina. Both these patterns may be observed in the same tumor.



Figs 38.22A to D: Follicular ameloblastoma. (A) Multiple small/large follicles, ameloblastomatous islands in fibrous connective tissue; (B) Peripheral ameloblast like cells with central area resembling stellate reticulum; (C and D) Follicles showing close resemblance to enamel organ

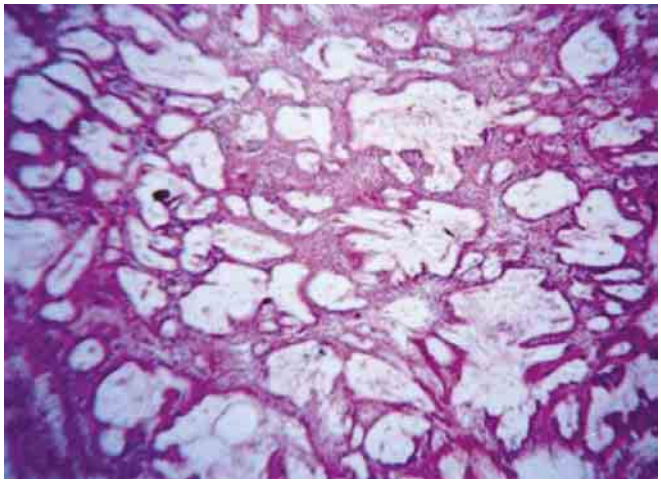


Fig. 38.23: Plexiform ameloblastoma: cord like extensions of odontogenic epithelium resembling the dental lamina, forming a meshwork

Both these types have a columnar or cuboidal outer epithelial cell layer bordering the connective tissue stroma and enclosing the inner epithelial cells **(Fig. 38.23)**.

Subtypes of Follicular Ameloblastoma-Histopathological Variants (First Three)

1. *Acanthomatous type*— compression of stellate reticulum into a squamoid mass with squamous metaplasia is seen. Sometimes keratin formation in the central portion of the tumor islands is noticed. Occasionally epithelial or keratin pearls may be seen. Usually seen in follicular type of ameloblastoma or peripheral ameloblastoma **(Fig. 38.24)**.
2. *Basal cell type*— bears resemblance to the basal cell carcinoma of the skin. The inner follicular and outer follicular cells may assume a basal cell appearance throughout the lesion.

3. *Granular cell type*— stellate reticulum like cells, get transformed into cells with coarse granular, eosinophilic cytoplasm. This type is found to be more aggressive type with high chances of recurrence and metastasis (MT) **(Fig. 38.25)**.

Other subtypes

4. *Desmoplastic type*— variant of connective tissue–stroma seen in solid ameloblastoma. Small islands and cords of odontogenic epithelium in a densely collagenized stroma. Abundant fibrous tissue stroma can be seen in this variety. Some areas of calcification/hyalynization also can be seen. Marked stromal desmoplasia is noticed. High recurrence rate **(Fig. 38.26)**.
5. *The mural ameloblastoma*— another name for unicystic lesion, which is found in children and young adults. The ameloblastic epithelium lines the laminal surface and may proliferate into the cyst (mural growth). Often "budding" aggregates of basal cells, follicular cells, or plexiform strands extend from the luminal lining into the cystic wall. Further growth of the lesion takes place by creation of microcystic and macrocystic formations in the budding ameloblastic elements that extend and enlarge the primary cystic lumen or the cyst wall by resorption of host bone **(Fig. 38.27)**.
6. *The peripheral ameloblastoma*—origin is from residual or displaced odontogenic tissue in the gingiva or

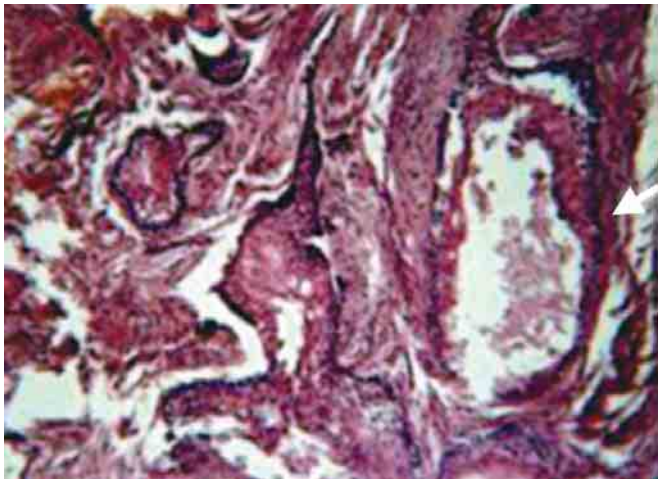


Fig. 38.24: Acanthomatous ameloblastoma: Compression of stellate reticulum into squamoid mass with squamous metaplasia. Arrow shows cystic degeneration in the island

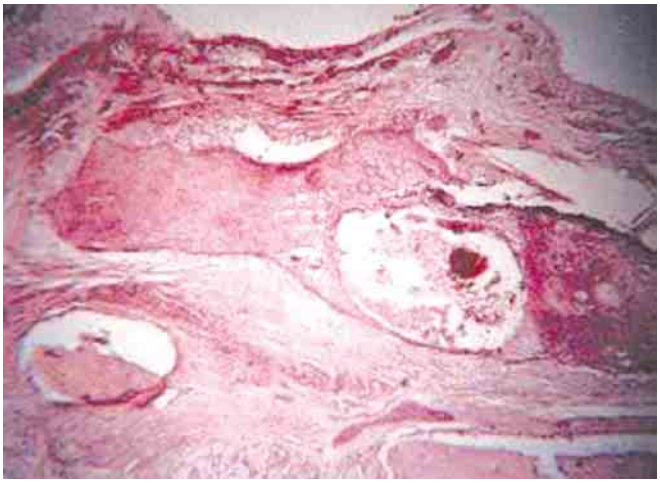


Fig. 38.26: Desmoplastic ameloblastoma: Large islands of odontogenic epithelium surrounded by abundant fibrous tissue stroma. Areas of calcifications noted

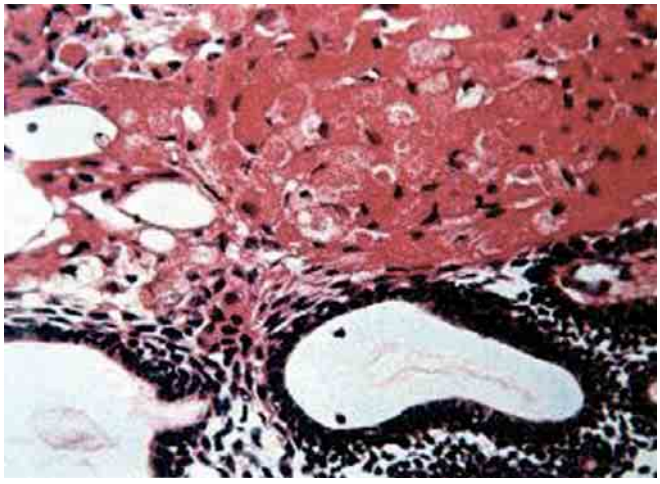


Fig. 38.25: Granular ameloblastoma: Transformation of stellate cells into granular cells seen in the center of the follicle

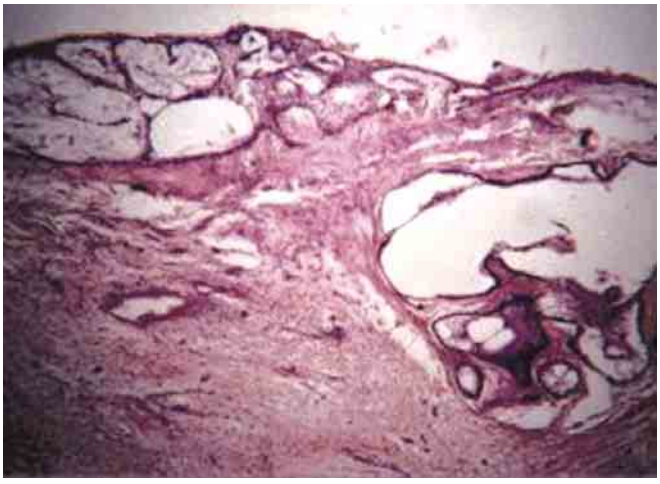


Fig. 38.27: Mural ameloblastoma: Ameloblastic epithelium proliferation into the cystic mural growth

mucosal surface overlying the alveolar process. It may be seen as smooth sessile lesion contained entirely within connective tissue below the epithelial surface or papillomatous type, which infiltrates the surface epithelium. This lesion is not encapsulated like the intrabony ameloblastoma, but is circumscribed by stromal connective tissue through which it can infiltrate into the surrounding mucosa as well as penetrate the periosteum and invade the bone **(Fig. 38.28)**.

7. *Malignant subtypes*—the term "malignant ameloblastoma" is applied, when the metastatic tumor resembles primary tumor with no histological transformation. The term "ameloblastic carcinoma" is used, when there has been obvious histological transformation towards malignancy of epithelial component and metastatic tumor resembles to a less well differentiated carcinoma, usually an epidermoid carcinoma. These types are rare, aggressive variants with obvious metastasis and poor prognosis, at times inoperable **(Fig. 38.29)**.

Management: Successful treatment is the treatment that renders an acceptable prognosis, causes minimal disfigurement and is based on the behavior and potential of the tumor, the growth patterns of the various physical forms, duration, the anatomic site of occurrence, the clinical extent and size of the tumor and histologic assessment. The treatment modality is also determined considering the age and general health of the patient.

- Complete eradication of lesion
- Reconstruction of the resultant defect **(Figs 38.30 and 38.31)**.

Curettage should never be considered as the treatment modality, since intraosseous multicystic lesions 'recurrence rate is 55–100% after curettage, and for intraosseous unicystic lesions— 18–25%.

The characteristic feature of this tumor is that it microscopically infiltrates bone beyond the tumor-bone interface seen in imaging. A safe margin of uninvolved bone is approximately 2 cm for solid and multicystic lesions. This may mean that important structures like inferior alveolar nerve may be resected en bloc with the tumor **(Figs 38.32A and B)**.

For Intraosseous, Solid/Multicystic Ameloblastoma

- En bloc resection or marginal RsCD
- Segmental RcwCD:
  - If cortical bone is resorbed and penetrated, the resection should include periosteal layer
  - A thin inferior border of the mandible in the first procedure may fracture, if a reconstruction plate is not used to span and support the segment. Retention of less than 1 cm in thickness of an inferior border is not practical and second surgical procedure should be opted
  - If the complete excision of the tumor is ascertained by clinical and radiographic examination of specimen or intraoperative frozen section, then immediate reconstruction can be undertaken
  - If there is uncertainty about resection margins, reconstruction should be delayed until no recurrence is seen, at least after six months postoperatively.

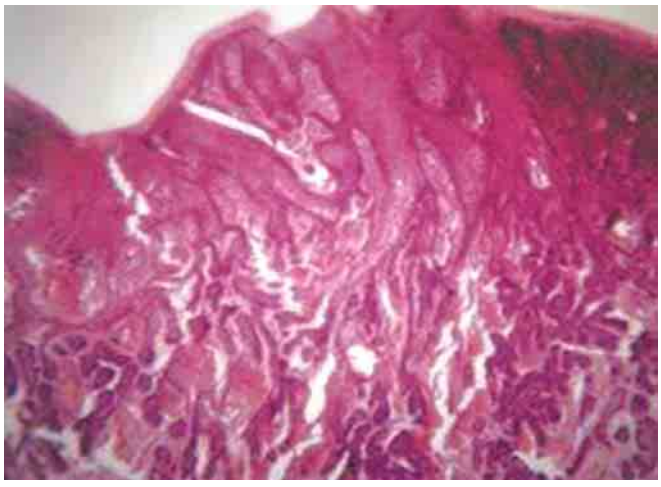


Fig. 38.28: Peripheral ameloblastoma: Streaming of epithelial cells and tumor mass continuity with oral epithelium

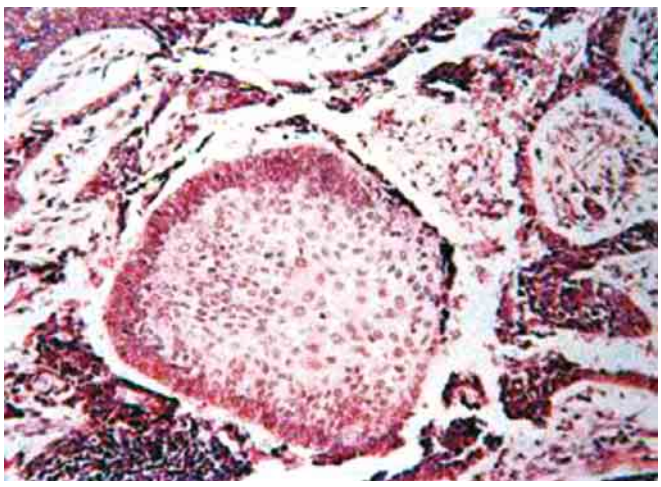
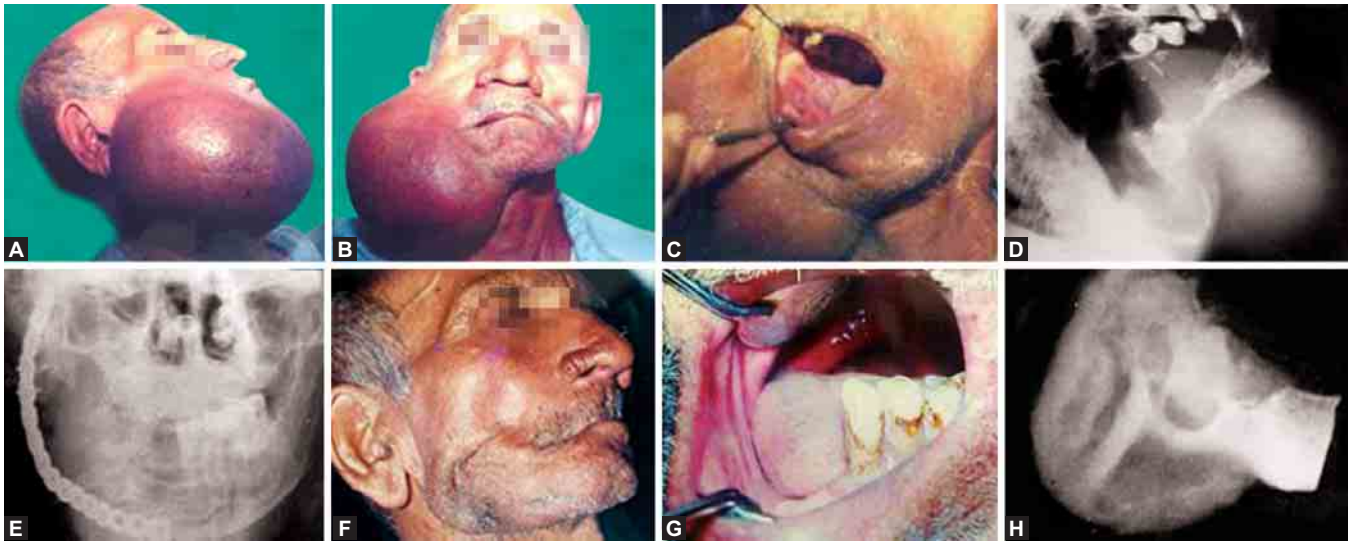
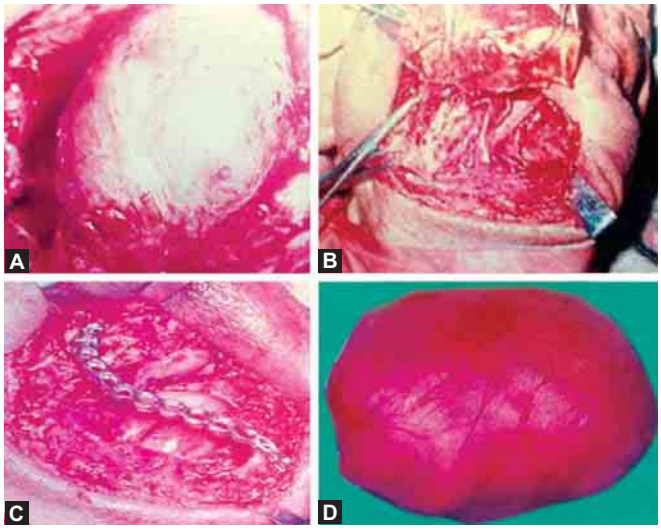


Fig. 38.29: Malignant ameloblastoma: Follicle surrounded by infiltrating cords of tumor



Figs 38.30A to H: Extensive ameloblastoma of right ramus and body in 80 years old male. (A and B) Extraoral view of the patient; (C) Intraoral view of the lesion; (D) Radiograph of the lesion; (E) Postoperative radiograph after hemimandibulectomy with disarticulation and reconstruction plate fixation; (F and G) Postoperative views, extraoral and intraoral respectively; (H) Radiograph of the tumor specimen showing safe margin



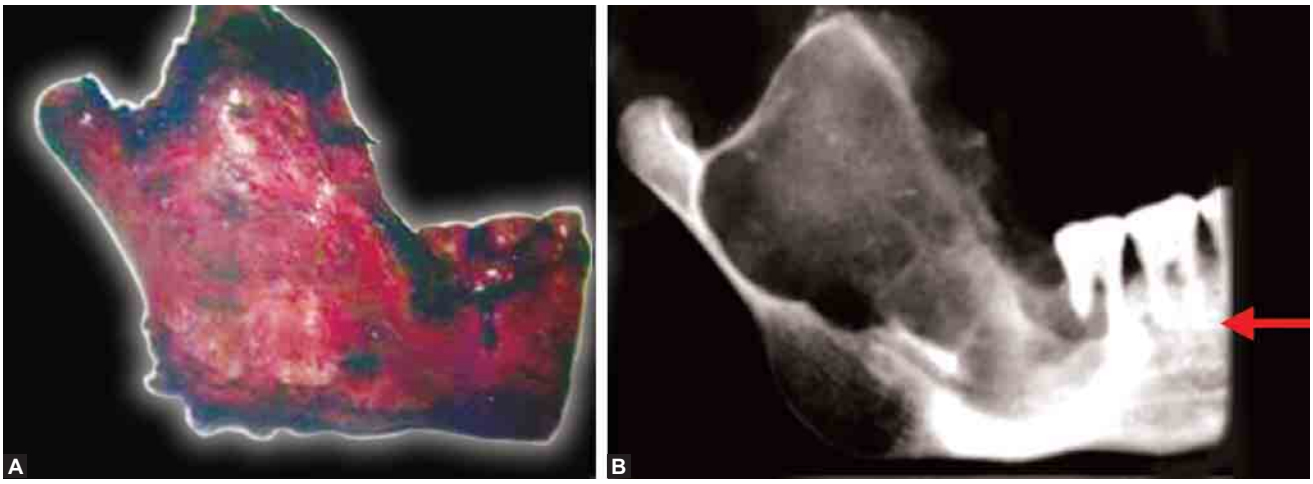
Figs 38.31A to D: Intraoperative pictures of resection of the ameloblastoma in a patient shown in Figure 38.30A.(A) Exposure of the tumor mass through extraoral submandibular incision; (B) Resection of the tumor with hemimandibulectomy with disarticulation of condyle; (C) Reconstruction plate fixation for maintaining the continuity of the mandible; (D) Resected specimen

- Adequate soft tissue coverage should be available, if immediate reconstruction is planned
- Immediate reconstruction can be done by using an autogenous free bone grafts (iliac or rib graft) or bank allogenic bone crib and autogenous bone marrow with a reconstruction plate
- Reconstruction plate with or without condylar prosthesis can be used in very old patients, or in cases where secondary reconstruction is planned or where adequate soft tissue coverage is not available
- If sufficient soft tissue is not available locally, a vascularized composite pedicle graft of bone and myocutaneous tissue can be used
- In maxilla—aggressive resection is carried out **(Figs 38.33A to K)**.

Jackson and Callon Forte (1996) have given guide lines depending upon anatomical extents:

- Tumor confined to maxilla without orbital floor involvement— partial maxillectomy
- Tumors involving the orbital floor, but not the periorbital area—total maxillectomy.
- Tumor involving orbital contents—total maxillectomy with orbital exenteration
- Tumor involving the skull bone—along with skull base resection—neurosurgical procedure.

Behavior: The multicystic ameloblastoma has a recurrence up to 50% during the first 5 years postoperatively. Long-term follow-up is a must.



Figs 38.32A and B: Hemimandibulectomy with disarticulation, tumor resection specimen and its radiograph. Note the safe margin of normal bone in resection



Figs 38.33A to K: A 30-year-old female with recurrent swelling in posterior left maxilla. Patient was operated 5 years back for plexiform ameloblastoma with enucleation. (A and B) Extraoral and intraoral view of the recurrent lesion; (C and D) CT scans— tumor mass involving left maxilla and maxillary sinus and lateral wall of the nose, infraorbital ridge; (E) Three-dimensional CT scan— tumor mass involving left maxilla; (F) Biopsy-photomicrography— plexiform ameloblastoma; (G) Tumor specimen after left maxillectomy and resection of lesion; (H and I) Harvesting of split thickness skin graft to cover maxillectomy defect; (J) Postoperative healing of skin graft after 6 months in intraoral view; (K) Postoperative extraoral view 6 months after surgery

Calcifying Epithelial Odontogenic Tumor (Pindborg Tumor)

First described by Pindborg in 1955.It is a locally aggressive tumor consists of sheets and strands of polyhedral cells in stroma with no inflammatory component and often are concentrically lamellated accompanied by spherical calcifications and amyloid staining hyaline deposits.

- Origin— epithelial elements of the enamel organ
- Incidence—uncommon. One percent of all odontogenic tumors
- No specific sex predilection
- **Age:** Seen in middle age— 30–50 years
- **Site:** Mandible is most commonly involved in the molar region (two-thirds of the tumors). One-third of the tumors are found in the maxilla. Marked predilection for the molar region in both the jaws. Relative distribution of CEOT, in the jaws is as follows– Maxilla– 8 % in anterior and premolars, 21% in posterior region. Mandible– 14% in anterior and premolar, 57% in molar region.
- Fifty percent of the tumors are associated with an unerupted or embedded tooth.
- **Signs and symptoms:** Painless, slow growing mass. If encroached on nasal cavity, then produce nasal symptoms like stuffiness, epistaxis, etc.
- *Variety*—(1) Intraosseous-central—maxillary/mandibular posterior region, (ii) Extraosseous-peripheral—nonspecific, sessile gingival masses commonly seen in anterior gingiva.
- *Radiographic features*— depending on the stage of development, CEOT presents variable radiographic picture.
  - Unilocular or multilocular radiolucency with a well circumscribed border or diffuse lesion.
  - Multilocular honey comb appearance—combined pattern of radiolucency and radiopacity with many small, irregular bony trabeculae traversing the radiolucency in multidirection.
  - Driven snow appearance—scattered flakes of calcification throughout the radiolucency can be seen. Can be seen more concentrated around the crown of the embedded tooth. Tree ring pattern of calcifications can be seen.
  - Fifty percent of lesions (mainly unilocular) may be associated with embedded/unerupted tooth
- **Histopathology:** A locally invasive epithelial tumor characterized by the development of intraepithelial structures, probably of an amyloid like nature, which may become calcified and which may be liberated as the cells breakdown. The areas of calcification form concentric rings termed as *"Liesegang rings"*. These tend to fuse together to form large complex masses.
- CEOT shows some potential for recurrence (15%) and aggressiveness.
- **Management:** Careful excision of the tumor with margin of normal tissue and follow-up.

Squamous Odontogenic Tumor

- A rare benign tumor, first reported by Pullon in 1975
- *Pathogenesis*—presumed to arise from neoplastic transformation of the epithelial cell rests of Malassez within the periodontal ligament of lateral surface of erupted tooth
- Can be mistaken histologically as an acanthamatous ameloblastoma or a well differentiated epidermoid carcinoma
- *Age*— ranges from 11 to 67 years
- No sex predilection
  Site— maxilla and mandible— equal predilection.
  Maxilla— incisor— canine area.
  Mandible — premolar— molar area. Multiple site involvement may be seen. Both jaws may be involved in the same patient.
- Asymptomatic lesions, may experience mild pain, discomfort, tooth mobility
- Radiographic appearance— nondiagnostic
  - It may appear as a semicircular or triangular radiolucency with sclerotic/well-defined borders.
  - It may be seen associated with cervical portion of the tooth (lateral to the tooth root).
- *Histopathology*—varying shaped islands of mature squamous epithelium without a peripheral palisaded or polarized columnar layer
- Conservative local excision is done for this tumor.

Clear Cell Odontogenic Tumor (CCOT)

- Rare jaw tumor, slow growing lesion, central tumor
- First described by Waldron in 1984
- *Age*—above 50 years
- No sex predilection
- *Site*—seventy percent in the mandible— anterior mandible is the site of predilection, followed by the body and the angle region. Twent-five percent in the maxilla.

- *Radiographically*— a radiolucent unilocular or multilocular lesion with poorly defined irregular borders. Evidence of bone destruction and root resorption
- *Histologically*— benign but locally invasive neoplasm, originating from odontogenic epithelium and characterized by sheets and islands of uniform, vacuolated and clear cells
- Strong potential for local aggressiveness and should be therefore treated radically.

Tumors Arising from Odontogenic Epithelium with Odontogenic Ectomesenchyme with or without Dental Hard Tissue Formation/Mixed Odontogenic Tumors

Ameloblastic Fibroma

- Rare biphasic benign neoplasm
- Odontogenic epithelium and odontogenic ectomesenchyme proliferate as a combined soft tissue neoplasm, without the formation of calcified tooth structures
- *Age*—found in first two decades (20 years)
- *Sex*—both males and females are equally affected
- *Site*—occurs in both the jaws, but site of predilection is mandible, especially the third molar area. Relative distribution of ameloblastic fibroma in the jaws is as follows: Maxilla—4% in anterior and premolars, 23 % in posterior region. Mandible—4% in anterior and premolar, 69 % in molar region
- *Radiographically*— well-defined uni- or multilocular radiolucency with sclerotic border. Fifty percent may be associated with unerupted tooth.
  The lesion can be seen from small to large extensive.
  Size ranging from 1 cm to 8 cm
- *The growth pattern* of ameloblastic fibroma occurs usually by smooth expansion within the jaws, producing cortical bone thinning or resorption. (Finger like projections of the tumor extend into the bone)
- *Histopathology* composed of a cell-rich mesenchymal appearing connective tissue in which odontogenic epithelium is predominantly displayed and dispersed throughout the lesion
- Meticulous surgical enucleation with follow-up. Recurrence rate—20%.

Ameloblastic Fibro-odontoma

- Mixed odontogenic tumor, like ameloblastic fibroma, but contains enamel and dentin
- Combination of ameloblastic fibroma and forming complex odontoma. The lesion has expansile growth potential of the former and the inductive capability of the latter
- *Age*—first and second decades (children)
- *Sex*—more common in males, 3:1 ratio
- *Site*—mandible—premolar—molar region. However, can be found in both jaws. Relative distribution of ameloblastic fibroodontoma in the jaws is as follows: Maxilla—14% in anterior and premolars, 21% in posterior region. Mandible—11% in anterior and premolar, 54 % in molar region
- Jaw enlargement without symptoms
- **Radiographically**: Uni- or multilocular radiolucency with well-defined sclerotic border with radiopacity in the center of the lesion (mixed radiolucency-radiopacity). It may be associated with unerupted teeth or can be seen in place of absent teeth
- **Histologically:** Cords and strands of odontogenic epithelium dispersed in a cell-rich mesenchymal tissue, plus areas of odontogenic epithelium and the mesenchymal tissue form dental papillae and enamel organ. Enamel matrix and dentin are produced in bizarre forms. The tumor is well surrounded by a connective tissue capsule
- Conservative management with enucleation.

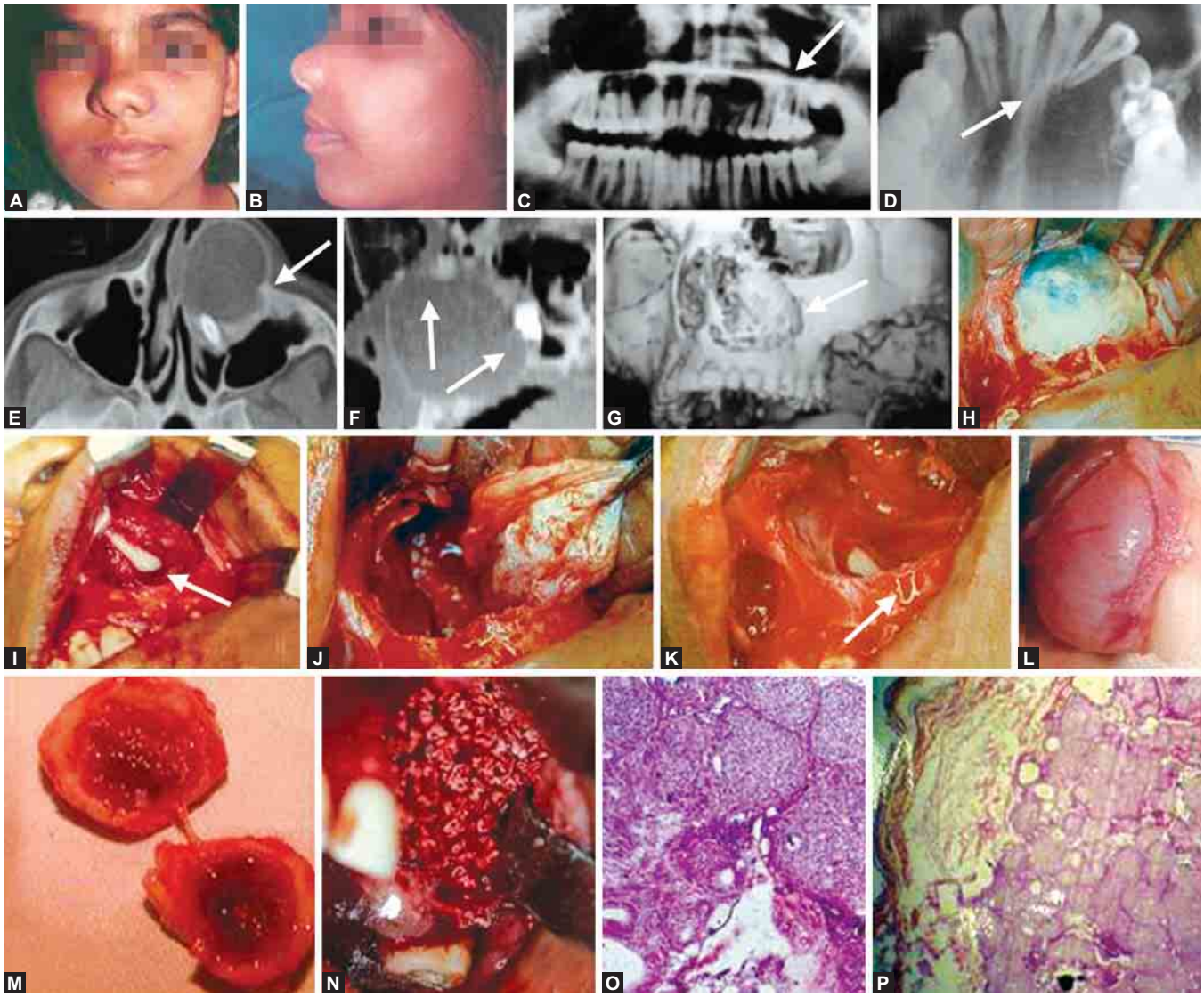
Ameloblastic Fibrodentinoma

- Similar to ameloblastic fibroma, but shows inductive changes that lead to the formation of dentin
- Rare, benign odontogenic mixed tumor
- Considered to be a hamartoma rather than a neoplasm
- *Site*— more common in mandible than maxilla (3:1)
- *Sex*— in males more often than females (2:1)
- *Age*— 4–60 years of age (mostly below 30 years of age)
- *In children* the lesion may be associated with unerupted or missing deciduous teeth and found in the anterior jaw.
- *In adults*— seen more in posterior region involving permanent teeth
- Asymptomatic swelling of the jaws
- *Radiographically*— small or extensive uni- or multilocular with well-defined borders. Radiopacity may be dispersed throughout the lesion. The associated teeth are often seen to be deeply situated in the lesion.
- *Histologically*— several configurations are seen within a basic lesional format of ameloblastic fibroma. Various stages of induction of dentin may

be demonstrated, resulting in lesions that display dentinoid, osteodentin and rarely, tubular dentine. The dentine may be infrequently and poorly mineralized
- Complete excision of the lesion.

Adenomatoid Odontogenic Tumor (Figs 38.34A to P)

- First recognized as separate entity by Stafne
- The term coined by Philipsen and Birn in 1969
- It may be considered as hamartoma. This lesion has an inductive effect on the odontogenic ectomesenchyme with dentinoid frequently being produced. It has got duct like structures
- Incidence—3–7% of odontogenic tumors
- *Age*— Younger age group— 10–20 years (73%) rarely above 30 years
- *Sex*— Predilection to occur in females—65%



Figs 38.34A to P: Adenomatoid odontogenic tumor in a 14-year-old girl in left maxilla. (A and B) Preoperative extraoral view; (C and D) Preoperative X-rays showing well-defined radiolucency in left maxilla with impacted canine, over retained deciduous lateral incisor and canine; (E and F) Preoperative CT scan— displaced nasal septum and teeth, involvement of maxillary sinus; (G) Three-dimensional CT— destruction of anterolateral wall maxilla, orbital floor, deviation of nasal septum; (H) Intraoral exposure of lesion; (I) Upper left lateral incisor on the inferolateral aspect of lesion; (J) Lesion being enucleated; (K) Canine displaced at infraorbital region; (L and M) Excised and cut specimen; (N) Defect filled with hydroxyapatite granules; (O and P) Photomicrograph of AOT— Cuboidal epithelial cells forming rosette like structure. Minimal stromal tissue

- *Site*—More common in maxilla—65% and usually involves the anterior region. Relative distribution of AOT in the jaws is as follows: Maxilla—53% in anterior, 9% in premolars, 2% in posterior region. Mandible—27% in anterior, 7% in premolar, 2% in molar region. Two varients: (1) Central/intraosseous/follicular, associated with unerupted tooth, (2) Extraosseous/peripheral/extrafollicular, associated with erupted tooth and between the roots
- Associated with impacted permanent teeth (invariably canine tooth in about 74%)
- Painless swelling
- *Radiologically*— unilocular radiolucency around the crown of an impacted tooth, resembling a dentigerous cyst. Radiolucency may extend apically along the root crossing CE junction. More often the radiolucency show fine calcification (snowflake). The margins are well defined and sclerotic
- *Differential diagnosis*—Pindborg tumor, calcifying cystic odontogenic tumor (CCOT) or Gorlin cyst, ameloblastoma
- **Histopathology:** The lesion is surrounded by a thick, fibrous capsule.
  Shows epithelial cells either polyhedral or even spindle shaped with scanty stroma of connective tissue. Cells are arranged in sheets, cords or whorled masses, which may form rosette like structure about a central space. Foci of calcification presumed to be abortive enamel formation or dentinoid/cementum like material are seen.
  Calcification in several forms may be observed.
  - Irregular dystrophic bodies
  - Laminated or ring like calcifications
  - Large globular masses.
- **Treatment:** Conservative excision or enucleation, because of the capsule is possible. Recurrence is rare with good prognosis.

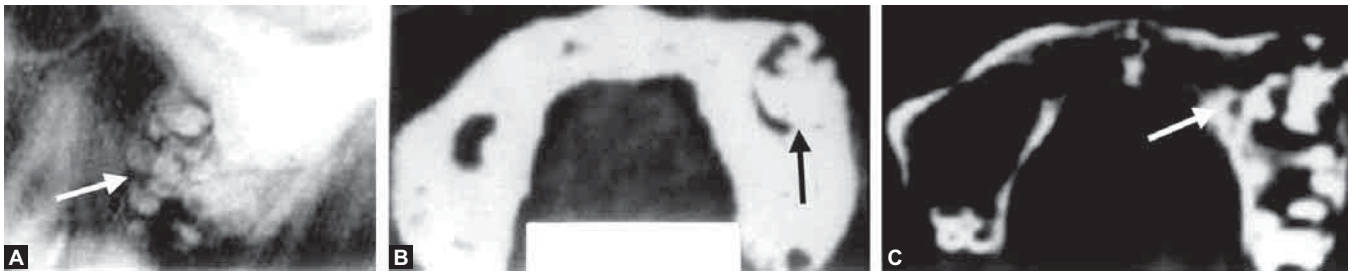
Odontoma

The term refers to any tumor of odontogenic origin in true sense. This is the growth in which both epithelial and ectomesenchymal cells exhibit complete or incomplete differentiation of tooth formation. This is considered more as a developmental anomaly, hamartomatous malformation, also as composite lesion, as it contains more than one tissue. It is not a true neoplasm.

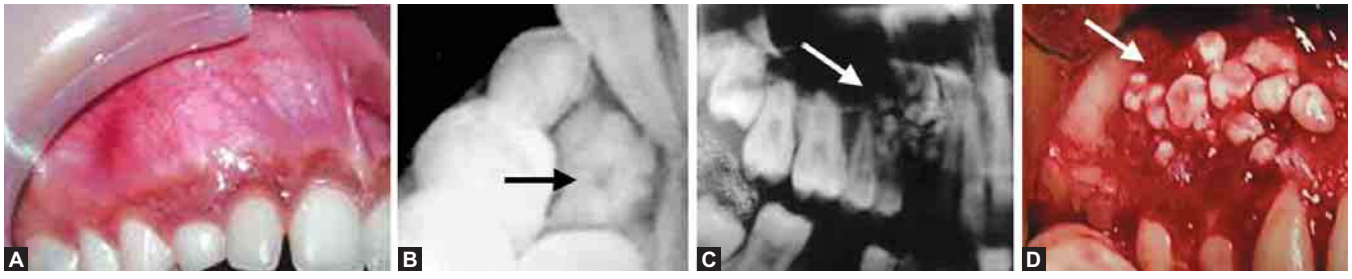
Radiographically and histopathologically, it is recognizable in two forms:

1. Compound odontoma
2. Complex odontoma

Compound composite odontoma: It consists of formed calcified tooth-like structures or miniature dwarfed teeth **(Figs 38.35 and 38.36)**.



Figs 38.35A to C: Radiograph and CT scan: Compound composite odontoma



Figs 38.36A to D: Compound composite odontoma. (A) Intraoral buccal expansion; (B) Occlusal view maxilla X-ray showing radiopaque mass on palatal side; (C) Orthopantomogram (OPG) showing odontoma; (D) Surgical exposure of odontoma

Site: More common in maxilla. Compound odontomas are seen in anterior jaw. Sixty-two percent in canine region.

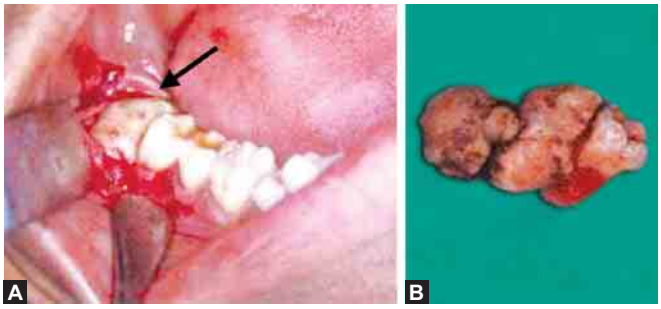
- Generally asymptomatic
- Radiographically:
  - *Compound odontoma*— appears as a radiopaque mass of calcified structures with an anatomic similarity to normal teeth. Seen as a pocket of malformed or dwarfed teeth or tooth like forms surrounded by a narrow radiolucent zone. Sometimes overlying or alongside an unerupted tooth or between the roots of a deciduous tooth. (Multiple small malformed tooth like structures are formed, creating a "bag of marbles" appearance.) It prevents eruption of underlying permanent tooth
  - Asymptomatic, shows no expansion of the bone and facial asymmetry
- Commonly detected on radiographs, searching for missing teeth in the arch
- May show associated unerupted or impacted teeth, associated swelling and infection
- *Histologically*, the compound odontoma shows a connective tissue capsule. The lesion is composed of anatomically distinct, small, well-formed or distorted teeth with enamel, dentine, pulp and cementum.
- **Management:** Completely calcified compound odontoma is biologically inert and can be left alone. If infected, then excision is carried out.

Complex composite odontoma: It is a malformation in which all the dental tissues are represented, with the individual tissues being well formed but occurring in a disorderly pattern. It is composed of conglomerate mass of enamel and dentin, which bears no resemblance to a tooth. Here the calcified dental tissues are simply found as an irregular mass bearing no morphological similarity to the rudimentary teeth. (Disorderly and haphazard arrangement of calcified dental structure) **(Figs 38.37 to 38.40)**.

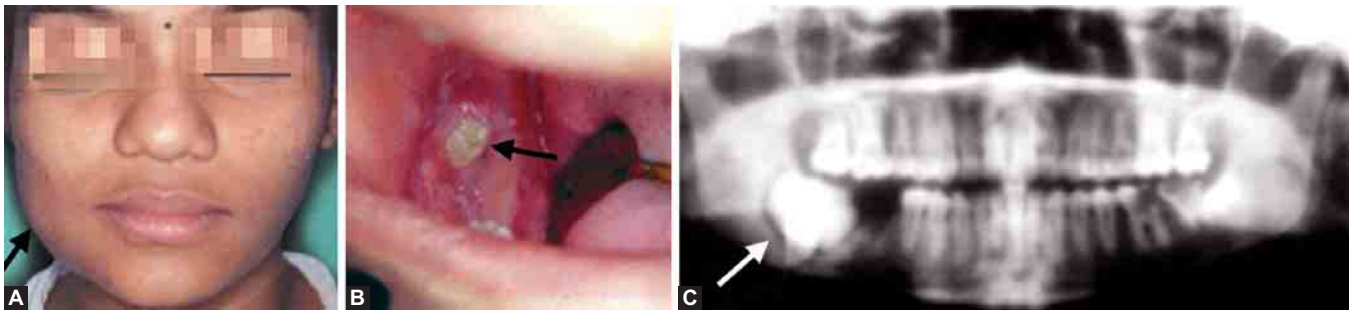
- Most common type of odontogenic lesion (<30%)
- *Age*— first and second decades (10–70 years)
- *Sex*— equal predilection in both sexes
- *Site*— occurs in both the jaws. Complex odontomas are seen in posterior jaw, especially in third molar region. Seventy percent seen in mandibular first and second molar region.

The radiological picture is variable, depending on the stage of formation at the time of incidental discovery. It will range from complete radiolucency in the initial stage to the stage of "maturation", i.e. complete calcified structure. Mixed radiolucency and radiopacity can be seen in one lesion also. *Complex odontoma* may be small, large or occasionally huge, irregular or ovoid smooth, densely radiopaque mass, often surrounded by a thin radiolucent zone. It is frequently overlying a displaced unerupted tooth.

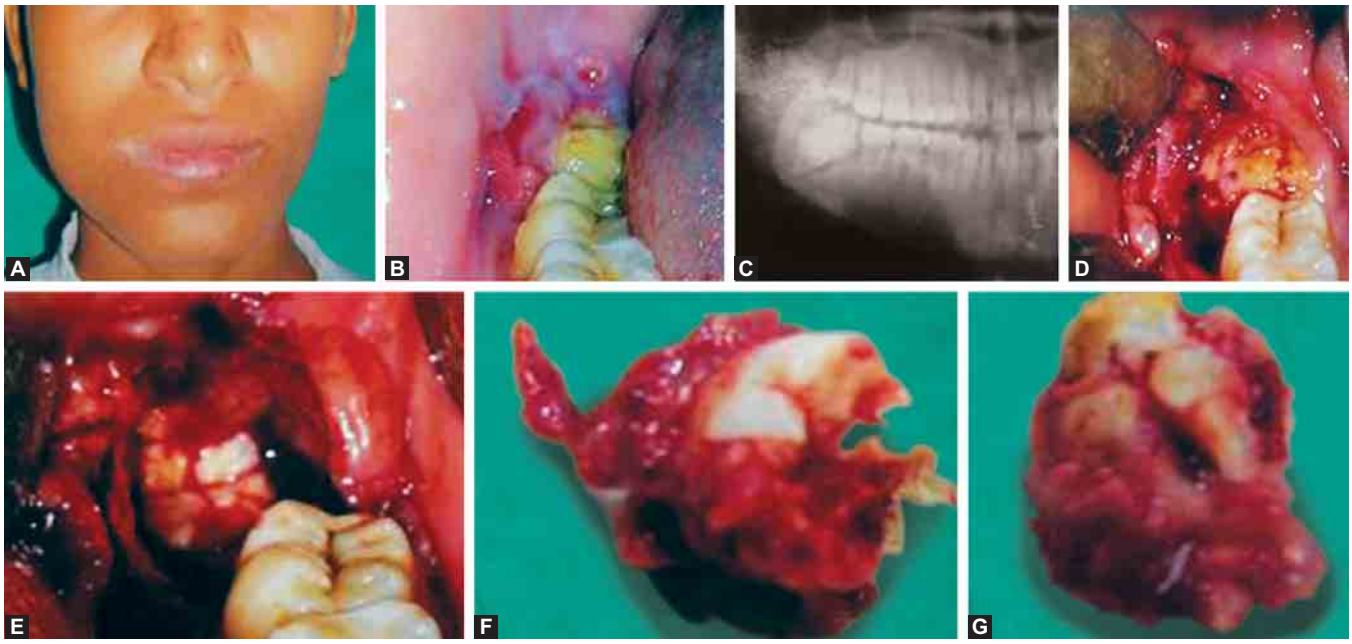
Histologically, the complex odontoma lacks anatomical organization and consists of calcified dental tissue in a haphazard manner, bound together in a mass



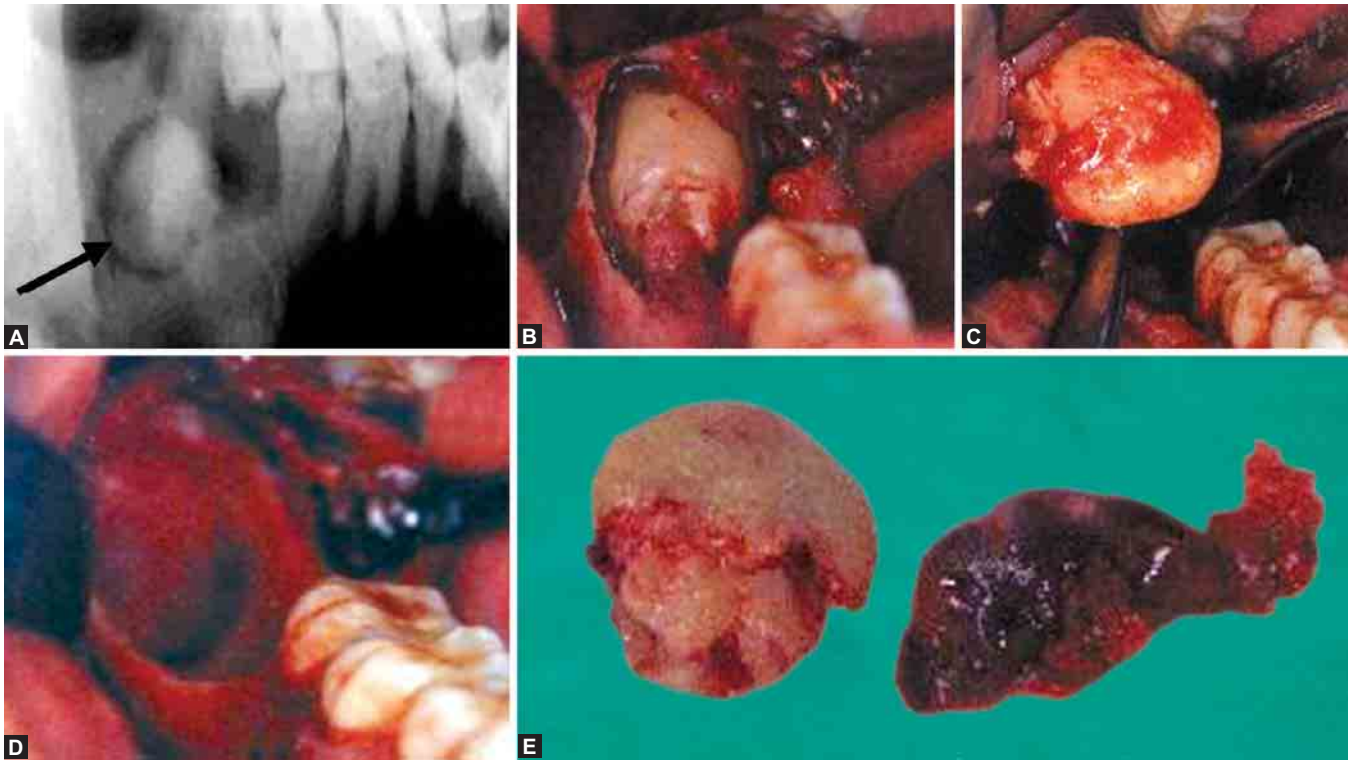
Figs 38.38A and B: Complex odontoma removed from right third molar region



Figs 38.37A to C: Complex odontoma. (A) Extraoral swelling at right angle area; (B) Intraoral swelling in second and third molar area, with small exposed part of complex odontoma; (C) Orthopantomogram (OPG) showing dense radiopaque mass with displaced lower third molar, surrounded by thin radiolucent zone. Second molar is missing. First molar was extracted



Figs 38.39A to G: Complex composite odontoma: Clinical, radiological, surgical presentation



Figs 38.40A to E: Complex odontoma. (A) Lateral oblique view X-ray showing well encapsulated radiopaque mass at angle of the ascending ramus; (B) Surgical exposure of the mass, in a 50-year-old lady, who came with the C/O intraoral pus discharge from right angle region, since 4 months; (C) Surgical removal of the mass; (D) Surgical defect; (E) Complex odontoma and its capsule

of cementum and often surrounded by a thin connective tissue capsule.

Management: Completely calcified complex odontoma is biologically inert and can be left alone. But, in case of pressure or pain symptoms or facial asymmetry, excision can be planned. Care is taken to avoid pathological fracture during excision.

Reasons for Excision

- Once detected, patient may be psychologically affected about the diagnosis of the lesion
- To remove the blockade of the favorably placed unerupted tooth underneath or nearby
- To obtain definite diagnosis between the complex odontoma and cementoblastoma or ossifying fibroma or CEOT, etc.
  - **Surgical treatment (intraoral approach):** Adequate amount of overlying bone removal should be done to access the lesion. Compound odontoma is enucleated if the capsule is intact. If the capsule is disrupted, then the individual teeth forms are removed carefully. Small complex odontoma can be enucleated. Large complex odontomas may be fused to the surrounding bone and is very hard. It should be cut into pieces for removal. If excessive force is used to elevate the lesion, the jaw fracture can occur.
  - Recurrence is not seen.

TUMORS ARISING FROM ODONTOGENIC ECTOMESENCHYME WITH OR WITHOUT INCLUSION OF ODONTOGENIC EPITHELIUM

Odontogenic Fibroma

- An uncommon, hence poorly understood entity
- Central benign odontogenic tumor, which contains a moderately cellular fibrous connective tissue stroma with variable amount of inactive odontogenic epithelium.

  The odontogenic fibroma is found:
  - Intraosseously— central odontogenic fibroma
  - Extraosseously— on the gingiva— peripheral odontogenic fibroma.

Central Odontogenic Fibroma

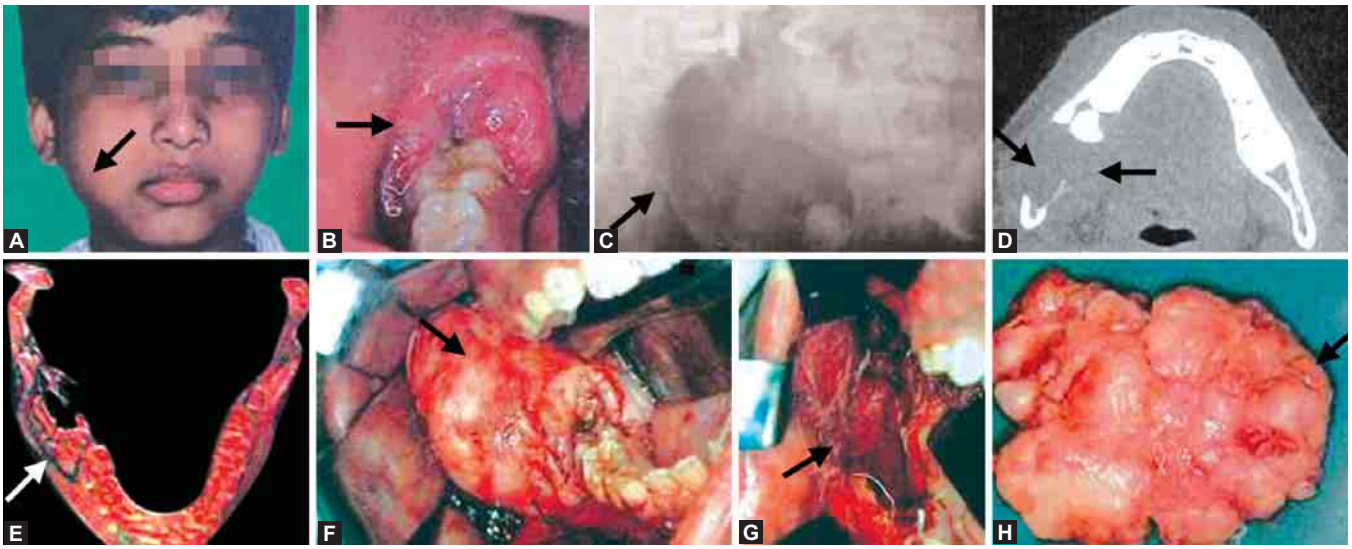
- Slow, persistent growth and asymptomatic cortical expansion (mainly detected on radiographs).
- *Site*—more commonly seen in mandible. If seen in maxilla—anterior to the first molar. Relative distribution of odontogenic fibroma in the jaws is as follows: Maxilla—29% in anterior, 6% in premolars, 10% in posterior region. Mandible—8% in anterior, 18% in premolar, 29 % in molar region
- *Sex*—males are more affected
- *Age*—mean age 37 years
- **Radiologically:** Multiloculated radiolucency with well-defined sclerotic margin or an ill-defined nonsclerotic border that merges into surrounding bone. May show extensive root resorption or root divergence. May be associated with unerupted third molars
- **Histologically:** The connective tissue stroma shows a whorling or interlacing dense collagen matrix with fairly cellular uniform fibroblasts. The odontogenic epithelial component is seen as narrow islands, strands or cords of cuboidal cells. Occasionally some hyalinization or cementum/bone like or dentinoid like calcification can be seen around some of epithelial islands. It is not a capsulated lesion
- **Differential diagnosis:** Desmoplastic fibroma, myxoma
- **Management:** Enucleation and curettage.

Peripheral Odontogenic Fibroma

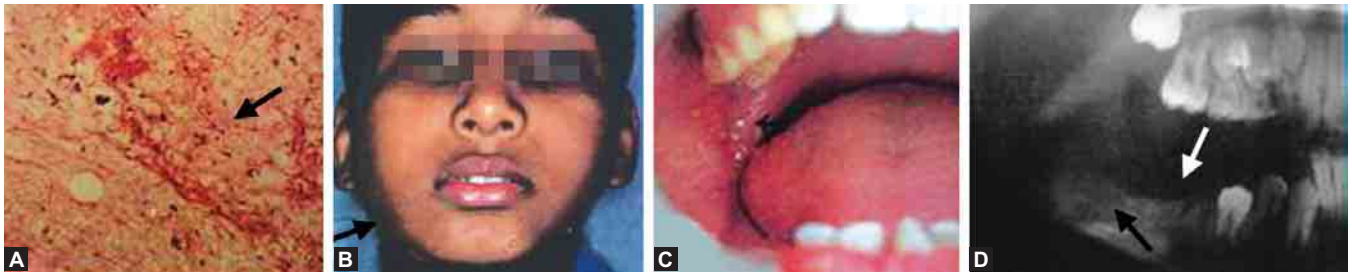
- *Site*— seen more frequently in the mandible. Most lesions are found anterior to the second premolar
- Size— 1–3 cm
- The lesions are attached on the gingiva— pedunculated or sessile and have normal gingival color
- *Sex*— seen equally in males and females
- *Age*— 1st to 8th decade
- *Treatment*— excision with a margin of uninvolved tissue.

Myxoma (Odontogenic Myxoma or Myxofibroma)

- Central benign, slowly growing, locally infiltrative tumor of the jaws, which expands the bone and causes destruction of the cortex, with a relatively rare occurrence (9.2% of all the odontogenic tumors).
- Mostly found in tooth bearing areas of the jaws.
- Occurs both in maxilla and the mandible with a slight predilection for mandible. Relative distribution of odontogenic myxoma in the jaws is as follows: Maxilla—9% in anterior, 9% in premolars, 16% in posterior region. Mandible—18% in anterior, 20% in premolar, 28% in molar region **(Figs. 38.41 and 38.42)**.



Figs 38.41A to H: Odontogenic myxoma of right mandible in a 10-year-old male patient. (A and B) Preoperative extraoral and intraoral view of the lesion; (C) Preoperative X-ray showing the lesion involving ramus and angle region; (D) CT scan showing expansion of buccal and lingual cortices with areas of expansion; (E) Three-dimensional CT scan; (F) Exposure of tumor mass by intraoral approach; (G) Surgical defect after excision of tumor mass; (H) Soft gelatinous mass with slimy appearance



Figs 38.42A to D: (A) Histopathology of odontogenic myxoma; (B and C) Postoperative extraoral and intraoral views; (D) Six months postoperative orthopantomogram (OPG) showing regeneration of bone same patient in Fig. 38.41

- Usually unilateral lesions, but some may cross the midline. Facial asymmetry may be prominent
- Females are affected more than males— 1.5:1 ratio
- Wide age range— 11 months–70 years. More at 20–40 years of age
- The occurrence in children is higher (not below 10 years of age)
- **Pathogenesis:** It is derived from the mesenchymal portion of the tooth germ, either the dental papilla or the follicle, or the periodontal ligament. Apart from its origin being from the mesenchyme or ectomesenchyme of a developing tooth germ. It has also been associated with a myxomatous change of an odontogenic fibroma or residual foci of embryonic tissue.

A debate still persists whether odontogenic myxoma is truly an odontogenic neoplasm? But its histological similarity to the stellate reticulum of developing tooth, its exclusive occurrence in close proximity and vicinity to the tooth-bearing parts of the jaws, occasional association with a missing or unerupted tooth, the presence of odontogenic epithelium, and its rare appearance in any other part of the skeleton establishes its odontogenic origin.

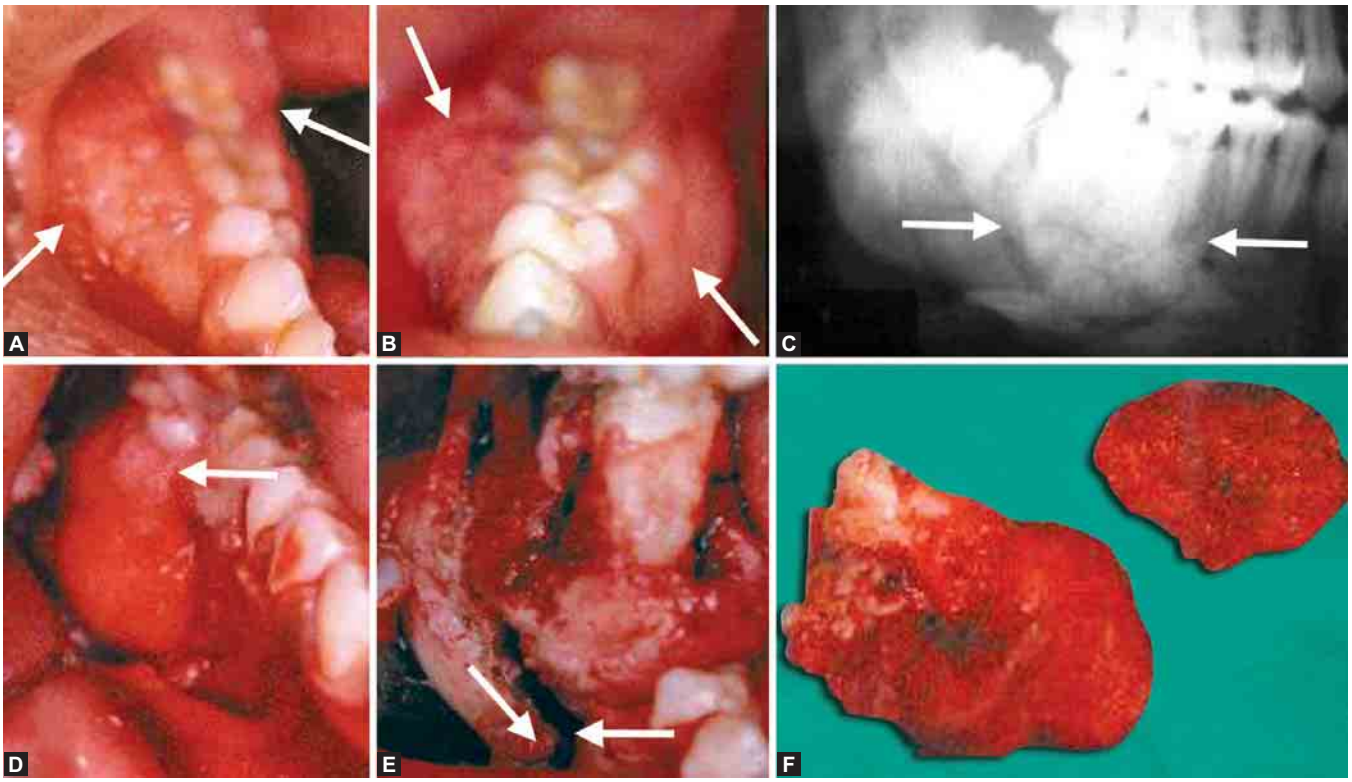
- *Radiologically*— multilocular, small or extensive lesion. May be completely radiolucent or "soap bubble" or "honey comb" or "tennis racket" appearance with irregular, scalloped margins. Teeth may be displaced or resorbed.

- *Differential diagnosis:* Ameloblastoma, hemangioma, etc.
- *Histologically* characterized by stellate-shaped, angular or rounded mesenchymal cells in a homogenous mucoid stroma, may contain few collagen fibrils. Large and small lesions can resorb cortical bone and penetrate periosteum.

  Based on ultrastructural three principal histological variants of odontogenic myxoma can be distinguished:
  1. Well differentiated fibroblast (30–40%), which appears spindle like on longitudinal section and stellate on cross section.
  2. Myxoblastic cell (10%), an immature cell with numerous ribosomes, located within an amorphous tumor matrix consisting of acid mucopolysaccharides.
  3. An intermediate cell having morphological characteristics of both main tumor cell type (40–50%)
- *Macroscopically* gelatinous texture and shiny appearance.
- **Treatment:** As it is infiltrative in nature and absence of encapsulation, recurrence rate is high 25%.
  Extensive lesions— excision by RsCD or RcwCD—including a perimeter margin of tumor-free bone. The neurovascular bundle should not be sacrificed routinely. The immediate or delayed reconstruction is dependent upon the clinical and/or histological certainty of complete excision of the tumor
- Recurrence rate is 33%
- Long-term follow-up.

Benign Cementoblastoma (Cementoblastoma, True Cementoma) (Figs 38.43A to F)

- True neoplasm of cemental origin
- True cementoma: It is defined by WHO as a neoplasm characterized by the formation of sheets of cementum-like tissue containing a large number



Figs 38.43A to F: Cementoblastoma. (A) Intraoral view of slow growing swelling. Duration 3 years; (B) Buccal and lingual expansion seen; (C) Orthopantomogram (OPG) showing well-defined, oval radiopaque mass with a radiolucent periphery. The mass is fused to the roots of lower right first and second molars; (D) Surgical exposure of the mass; (E) Thinning out of buccal cortical plate and pathological fracture (arrows) during excision of the mass; (F) Cementoblastoma—excised specimen

of reversal lines and being unmineralized at the periphery of the mass or in the more active growth areas.

- It is a rare tumor of connective tissue, forming cementum like calcification, fused to a tooth root
- *Age*— 10–20 years
- No sex predilection
- Almost equal frequency in mandible and the maxilla. Always in the premolar or molar region
- Mandibular lesions are found to be attached to a single tooth, while in maxillary lesions they are found to be fused to two or more teeth
- Slow growing lesion with clinical expansion of the jaw, producing facial asymmetry. Sometimes resorption of the cortical bone is seen. No discomfort or pain. The affected tooth is frequently vital
- **Radiographically:** A well-defined, round, oval radiopaque mass with a radiolucent periphery, which is fused to a single or multiple roots of a vital tooth. The affected roots usually show partial resorption
- **Differential diagnosis:** Condensing osteitis, cementifying fibroma, osteoblastoma, odontoma, etc
- Histologically
  - Main bulk consists of a dense cementum or osteocemental mass
  - Numerous reversal lines forming a calcified mosaic pattern is seen occupying the central area of the lesion

  At periphery, trabeculae are almost arranged at right angles. Peripheral active fibrous stroma shows unmineralized fine cemental trabeculae bordered by cementoblasts and cementoclasts farther away from it.
- **Management:** As the size of the lesion usually varies between 1 and 3 cm in diameter and the lesion is separated from the surrounding bone by capsular like connective tissue— it can be easily enucleated. Large lesions can be cut into segments for enucleation. Tooth attached to the lesion is extracted with the lesion.

NONODONTOGENIC LESIONS OF THE JAWS

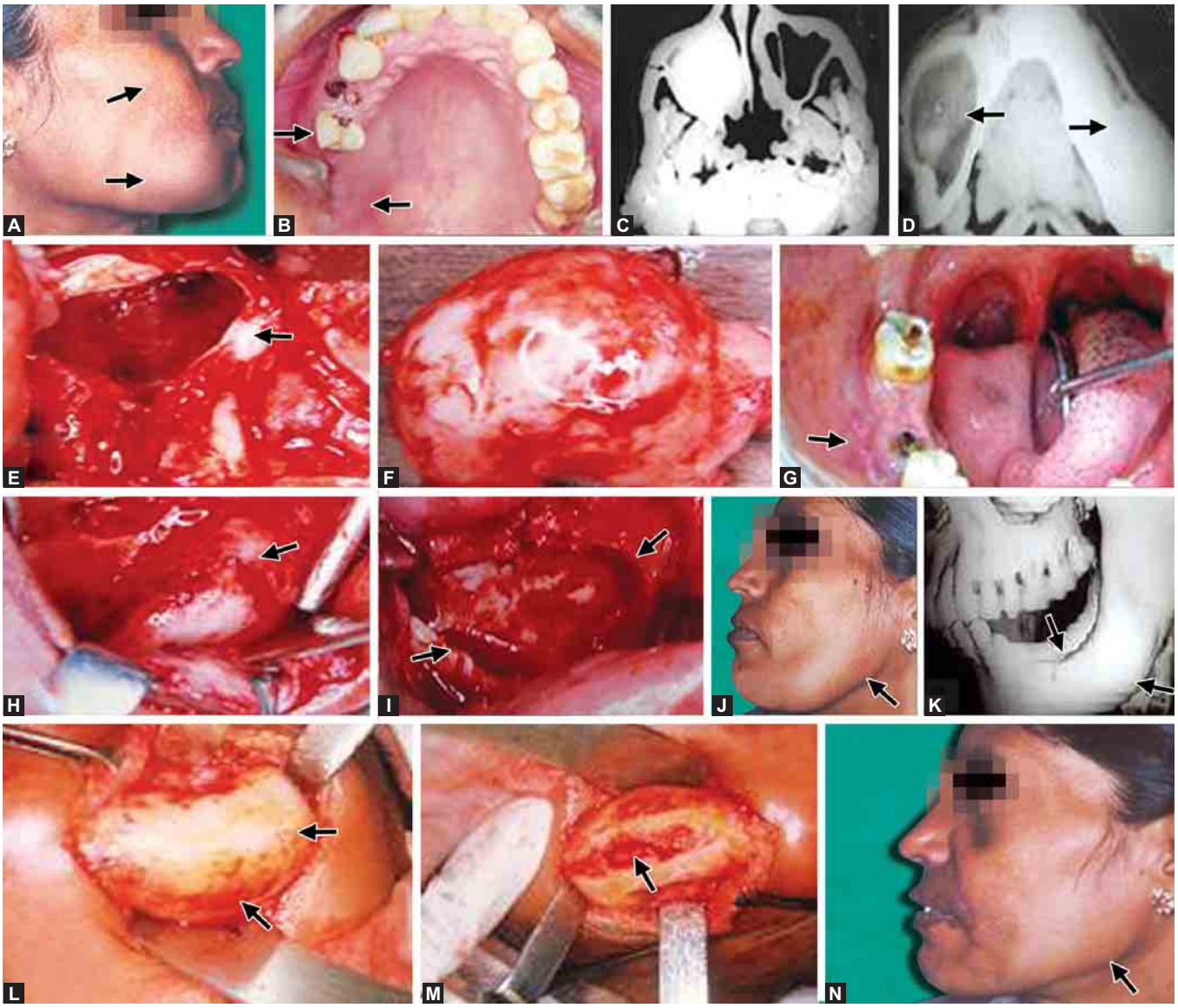
Osteogenic Neoplasm

Cemento-ossifying fibroma (COF), Cementifying fibroma.

Ossifying Fibroma (Figs 38.44 to 38.46)

The lesion previously termed as cementifying fibroma was considered as odontogenic tumor. But today it is agreed that these lesions are best classified as *osteogenic neoplasms.*

- **Origin:** Ossifying fibroma is a benign lesion arising from undifferentiated cells of the periodontal ligament
- **Age:** Third and fourth decades of life
- **Sex:** A definite female predominance with female to male ratio—5:1
- **Site:** Mandible is the most common site—premolar molar area. Maxilla— common site— posterior maxilla
- **Signs and symptoms:** Small lesions are symptomless and detected on radiological examination. Larger lesions are painless, slow, but persistently growing swelling of the involved bone, often causing facial asymmetry. Pain and paresthesia are not associated. Gradual expansion and thinning of the buccal and lingual cortical plates is seen
- **Radiologically:** Well circumscribed lesion with sharply defined border between the lesion and adjacent normal bone. Most often it shows unilocular radiolucency, but varying degrees of radiopacity can be seen. After maturation and mineralization of long-standing, the lesion appears as a dense, radiopaque mass surrounded by a thin, well-defined regular radiolucent rim. As the lesion enlarges, it may displace the adjacent teeth and less commonly, cause resorption of the roots. Large ossifying fibroma of the mandible, often may demonstrate a typical downwards bowing of the inferior cortex of the mandible
- **Histopathology:** It may show a fibrous capsule surrounding a tumor or it is well demarcated neoplasm composed of fibrous tissue that contains varying amounts of calcified tissue resembling bone, cementum or both. The tumor consists of a collagenous stroma, containing variable numbers of uniform spindled on stellate cells. The feature which distinguishes ossifying fibroma from fibrous dysplasia is the focal presence of osteoblasts along the surface of the bone deposits. Two types of calcifications are commonly seen— (1) in the form of trabeculae of osteoid and bone, (2) basophilic ovoid calcifications that resemble cementum like material
- **Management:** As the lesion is well demarcated from the surrounding bone, it permits relatively easy separation in one piece or in several large pieces. Intraoral approach by enucleation is the preferred method. Adjacent teeth, neurovascular bundle and bone should be preserved, whenever possible. More extensive lesion may require resection and bone grafting. Recurrence is not seen **(Figs 38.44 to 38.46)**.



Figs 38.44 A to N: Multiple lesions of the jaw bones in a 36-year-old female. (A) (Right) maxilla—ossifying fibroma, (right) mandible—radicular cyst; (B) Buccal and palatal expansion; (C) CT scan (right) maxilla; (D) CT scan showing right mandibular radicular cyst and left mandible fibrous dysplasia; (E) Tumor mass excision; (F) Tumor specimen; (G) Radicular cyst location; (H) Radicular cyst—surgical exposure in right mandible; (I) Cyst enucleation done; (J) Bowing of inferior border mandible; (K) CT scan of left mandible-fibrous dysplasia; (L and M) shave down recountouring surgery for left mandible inferior border (N) Postoperative left profile after recountouring procedure

Juvenile Aggressive Ossifying Fibroma

This is the uncommon, controversial lesion. It is described in the literature under various terms as *juvenile active ossifying fibroma, aggressive psammomatoid ossifying fibroma*. It is distinguished from the standard ossifying fibroma on the basis of occurrence in a younger age group, tendency to occur in different anatomic sites and aggressive clinical behavior **(Fig. 38.47)**.

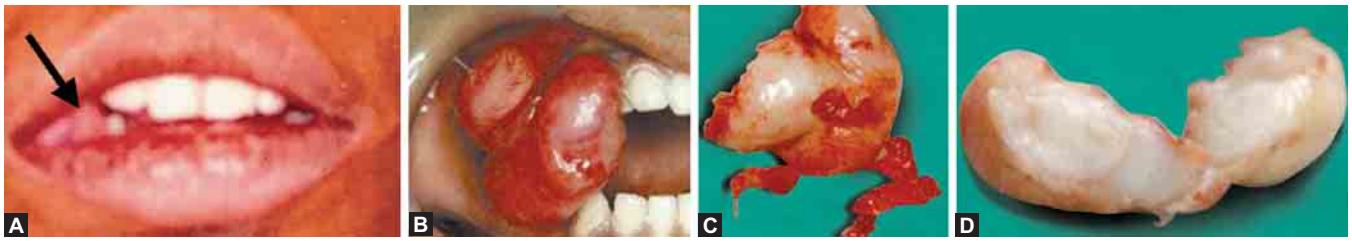
- **Age:** Most commonly seen below the age of 15 years in younger children
- **Site:** Orbital, frontal and ethmoid bones are most frequently involved. The maxilla, paranasal sinuses are more frequently involved than mandible
- **Signs and symptoms:** Some tumors show rapid progressive growth and enlargement with expansion and thinning of the adjacent cortical bone and invasion of adjacent tissue. Common clinical symptoms include



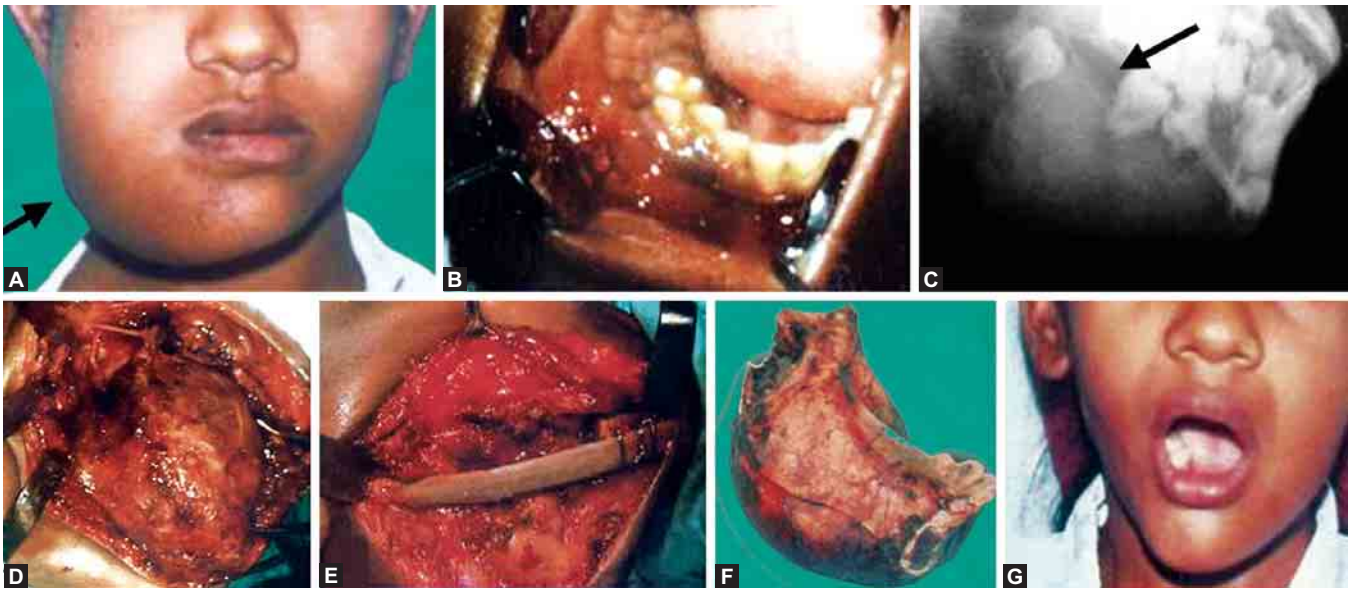
Figs 38.45A to O: Ossifying fibroma, segmental resection, reconstruction with fibular graft. (A and B) Extraoral views of swelling involving (right) ramus and body mandible. Note the bowing and expansion of the inferior border; (C) Intraoral view of the lesion history of exfoliation of first, second premolars and second molar. Expansion of the cortices is seen; (D) Radiograph; (E) CT scan showing well-circumscribed lesion with sharply-defined borders. Mixed radiopaque/radiolucent lesion; (F) Surgical exposure of tumor via submandibular extraoral incision; (G) Occlusal view of the resected specimen showing expansion and fibrous tissue capsule; (H) Segmental resection; (I) Intraoral watertight closure, prior to immediate reconstruction with fibular grafting; (J) Preparation of fibula; (K) Harvesting of fibular graft; (L) Graft fixation with bone plates and screws; (M) Postoperative facial view; (N) Photomicrograph—calcified bodies and cementicles seen in firbous stoma; (O) Cut surface of specimen— pink white gritty surface with fibrous and calcified tissue

proptosis, exophthalmos, visual disturbances, nasal obstruction and facial asymmetry

- **Radiographically:** Variable features, depending on the location and the amount of calcified tissue. A destructive, expansile lesion often with well-demarcated borders, but it may demonstrate invasion and erosion of the surrounding bone. Varying degrees of radiolucency and opacity may be seen depending on the degree of mineralization.
- **Histopathology:** The stroma consists of a highly cellular proliferation of spindled to stellate cells with minimum intervening collagen. Small strands of immature



Figs 38.46A to D: Peripheral ossifying fibroma: A 28-year-old female with painless mass of 1-year duration. Excision of the mass associated with right upper first and second premolars done



Figs 38.47A to G: Juvenile ossifying fibroma. (A) A 14-year-old girl with large, bony swelling of (Right) mandible; (B) Intraoral swelling from (Right) canine to retromolar region; (C) X-ray; (D) Surgical exposure of the lesion; (E) Reconstruction with rib graft; (F) Resected specimen; (G) Postoperative facial view and near normal mandibular movement

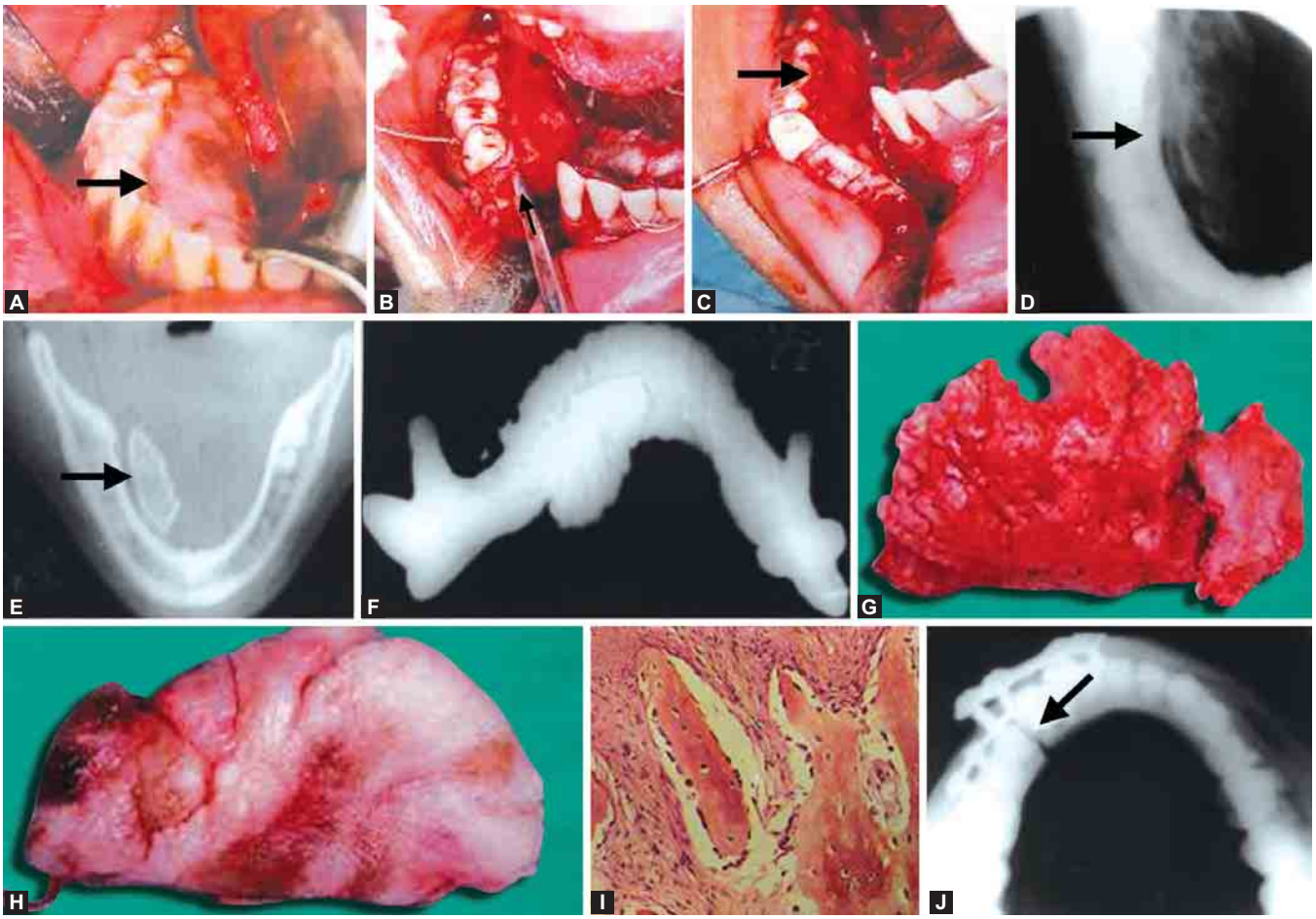
cellular osteoid forms within the lesion. Some lesions contain numerous uniform, often laminated structures described as ossicles or psammoma like bodies surrounded by osteoid rims. Some investigators believe that this is the characteristic microscopic feature of this neoplasm.

- **Treatment and prognosis:** Uncertain to state. Recurrence rate is reported as 30–58%. Complete surgical excision is mandatory. Small accessible lesions are treated with enucleation or peripheral osteotomy. Large lesions require en bloc resection.

Osteoma

Osteomas are benign tumors, which consist of mature, compact or cancellous bone. Osteomas are found only in the craniofacial skeleton and rarely found in other bones like clavicles and long bones **(Figs 38.48 and 38.49)**.

- **Etiology is unclear:** Some appear as true neoplasm of the bone, while other show response to trauma or infection
- Variety (1) Peripheral osteoma or periosteal osteoma, which arise on the surface of the jaw bone as a polypoid or sessile mass, (2) Endosteal osteoma or enostoses—those which develop centrally within medullary bone
- **Age:** Detected in young adults. 2nd to 5th decades
- **Sex:** Predilection not known
- **Signs and symptoms:** Periosteal osteoma presents as a slow growing, asymptomatic bony hard masses.

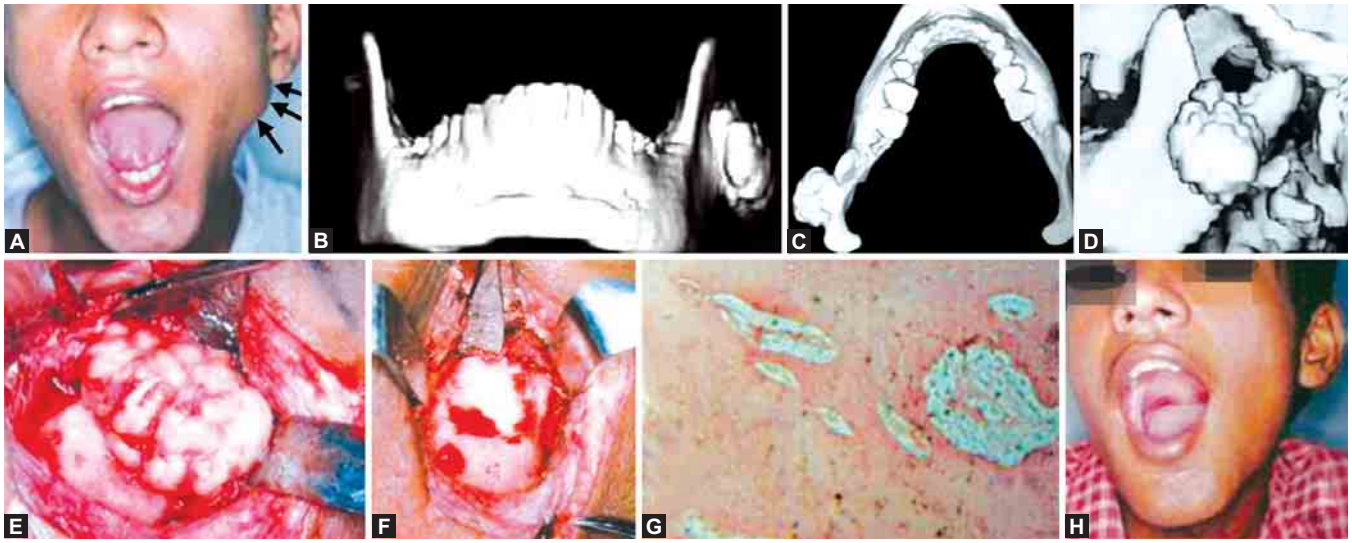


Figs 38.48A to J: Peripheral osteoma of the (right) mandibular body, on the lingual aspect, extending from (right) central incisor to (Right) third molar region. (A) Firm, nontender growth in 20-year-old male, duration—2 years; (B) Access osteotomy performed in lower (right) canine and premolar region to approach the mass. Excision with the osteotome; (C) Excision complete; (D) Preoperative occlusal X-ray suggestive of osteogenic tumor; (E) CT scan— over hanging lesion on the medial surface of the mandible; (F) Three-dimensional scan showing the extension of the mass from (right) central incisor to third molar region. The mass is hanging below the level of the inferior border; (G) Gross specimen—hard tissue mass; (H) Tough, fibrous tissue covering the lesion; (I) Histology of osteoma; (J) Postoperative occlusal view showing fixation of access osteotomy and complete excision of the lesion

Asymmetry of the affected bone may be evident, when lesion enlarges to sufficient proportion. The lesion may arise in the maxilla or mandible, especially at the angle of the mandible and lingual aspect of the mandible in premolar/molar area. An osteoma involving the mandibular condyle may cause a slow progressive shift in the patient's occlusion with deviation of the midline of the chin towards the unaffected side.

Small endosteal osteomas are asymptomatic, but large lesions cause progressive enlargement of the affected area. Lesions within the paranasal sinuses may develop symptoms like sinusitis, headaches, ophthalmological problems

- *Radiographically* well circumscribed, densely sclerotic, radiopaque masses. Periosteal osteoma may show a uniform sclerotic pattern at the periphery with a central trabecular pattern
- **Histopathologically:** Two varieties are seen. (1) Compact osteoma— composed of dense, compact bone with sparse marrow tissue. The bone is mature and lamellar with osteomas and haversian canals; (2) Cancellous osteomas— composed of lamellar trabeculae of cancellous bone and fibro fatty marrow. Osteoblastic activity may be fairly prominent
- **Treatment:** Conservative surgical excision is done. Osteotome may be used to separate the periosteal osteoma from the attachment of the underlying bone.



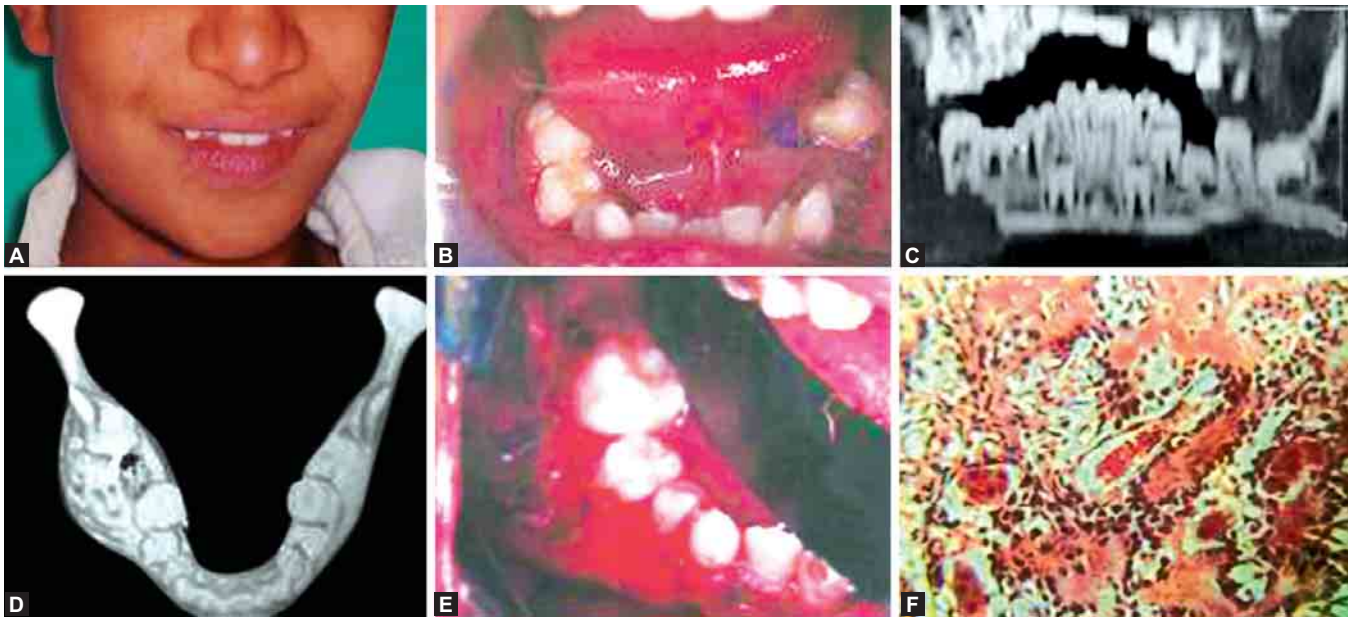
Figs 38.49A to H: Peripheral osteoma on the ascending ramus. (A) In a 16-year-old male, hard, nontender growth below (Left) preauricular area. Duration 1 year; (B to D) Three-dimensional CT scan revealed a well-defined radiopaque, cauliflower like growth on the external area of ramus, extending till sigmoid notch; (E) Postramal Irby's incision to expose mushroom like bony growth; (F) Excision with osteotome complete; (G) Mature lamellar bone picture; (H) Postoperative view after 6 months follow-up. No recurrence

Gardner syndrome: It is inherited as an autosomal dominant disorder. The clinical expression of this genetic disorder is variable. But, the most common manifestations are— multiple adenomatous polyps of the colon and rectum, multiple osteomas, dermal and mesenteric fibrous tumors (fibroma), multiple odontomas, epidermal and trichilemmal cysts, dermoid fibrous tumors of skin. *The presence of mutiple osteomas of the facial bones is an important early marker for this syndrome.* Such patients and other family members should be evaluated for other clinical manifestations. Some patients may exhibit distinct hyperplastic alterations of retinal pigmented epithelium, which may precede the colonic or osseous lesions. Dental abnormalities such as impacted permanent and supernumerary teeth and odontomas may be present in addition to osteomas. Prophylactic colectomy is performed in these patients to prevent transformation of the adenomatous polyps to adenosarcoma or adenocarcinoma.

Benign Osteoblastoma

First described under the name "giant osteoid osteoma" by Dahlin and Johnson (1954). Presently accepted term "benign osteoblastoma" is suggested by Jaffe and Lichtenstein [1956 **(Figs 38.50A to F)**].

- The lesion is rather uncommon in jaws, seen in long bones and vertebrae
- *Size*— greater than 2 cm in diameter
- Vascular osteoid and bone forming benign tumor of bone, characterized cytologically by the abundant presence of actively proliferating osteoblasts and moderate number of multinucleated giant cells in the osteoid tissue
- It is a central bone tumor
- Most frequently seen in young patients below 25 years
- Definite predilection for occurrence in males
- Clinically swelling with or without cortical expansion is noticed, may be of few weeks duration or few years duration. Associated teeth may be mobile
- Seen in both maxilla and mandible (more) posterior aspect of the jaws
- It was always misinterpreted as giant cell tumor, but because of ultrastructure histopathological examination demarcation is possible. With few exceptions, tumor osteoblasts resemble normal osteoblasts.
- Radiographic picture— variable. But relatively well-defined, mixed radiolucent— radiopaque lesions are seen. When the calcification of the lesion is more, then it appears as a central opacity with a thin radiolucent rim around
- Intramedullary lesion. A "sun-ray" appearance of new bone formation may be evident in some lesions misleading to the diagnosis of sarcoma
- Treatment and prognosis—Complete surgical excision—intraoral approach. Conservative treatment—



Figs 38.50A to F: Benign osteoblastoma of the right mandibular ramus. (A) Eight-year-old male, with slow growing swelling in (right) side of the lower jaw, since four months; (B) Intraoral bony expansion seen in premolar, molar area with mobility of the teeth; (C and D) Orthopantomogram (OPG) and three-dimensional CT scan revealed well-defined radiolucent lesion with buccal and lingual cortical plates expansion in (right) premolar, molar region in the mandible; (E) Intraoral excision of the bluish, gray, firm, gritty mass with multiple lobules was done; (F) Histology: Benign osteoblastoma with moderate number of multinucleated giant cells scattered in osteoid tissue and actively proliferating osteoblasts

curettage or local excision also can be done. But follow-up should be done for recurrence after conservative treatment.

Osteochondroma

Also known as osteocartilagenous exostosis regarded as the most common benign tumor of bones in the body (one-third of benign bony tumors). But its occurrence in jaw bone is rare **(Figs 38.51 to 38.53)**.

It is not a true neoplasm, but thought to represent a developmental or hamartomatous process of bone. It forms as an exophytic growth from the surface of the affected bone. In the jaw bone mandibular condyle, coronoid process, symphysis, zygomatic arch, posterior maxilla may be involved.

Asymptomatic, bony-hard swelling. Involvement of the mandibular condyle may produce unilateral posterior open bite, chin deviation away from the affected side with facial asymmetry or bowing of the mandibular ramus.

Radiographs: Show a sessile or pedunculated lesion that is continuous with the adjacent cortex and underlying medullary bone. The bony portion of the lesion shows a central trabecular pattern with well-defined radiopacity. The cartilaginous superficial aspect is less well mineralized.

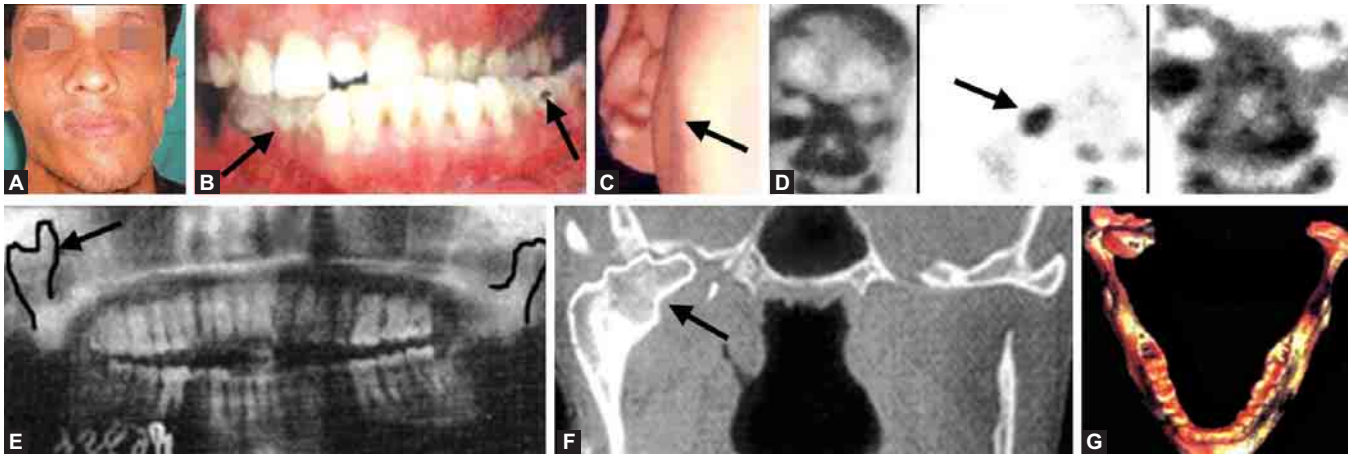
Histopathology: The surface is composed of a moderately cellular, hyaline cartilage cap covered by a thin, fibrous perichondrium. The deep layer of cartilage exhibits endochondral ossification with deposition of woven bone on mineralized cartilage.

Treatment: Complete conservative surgical excision is done. Recurrence is not reported.

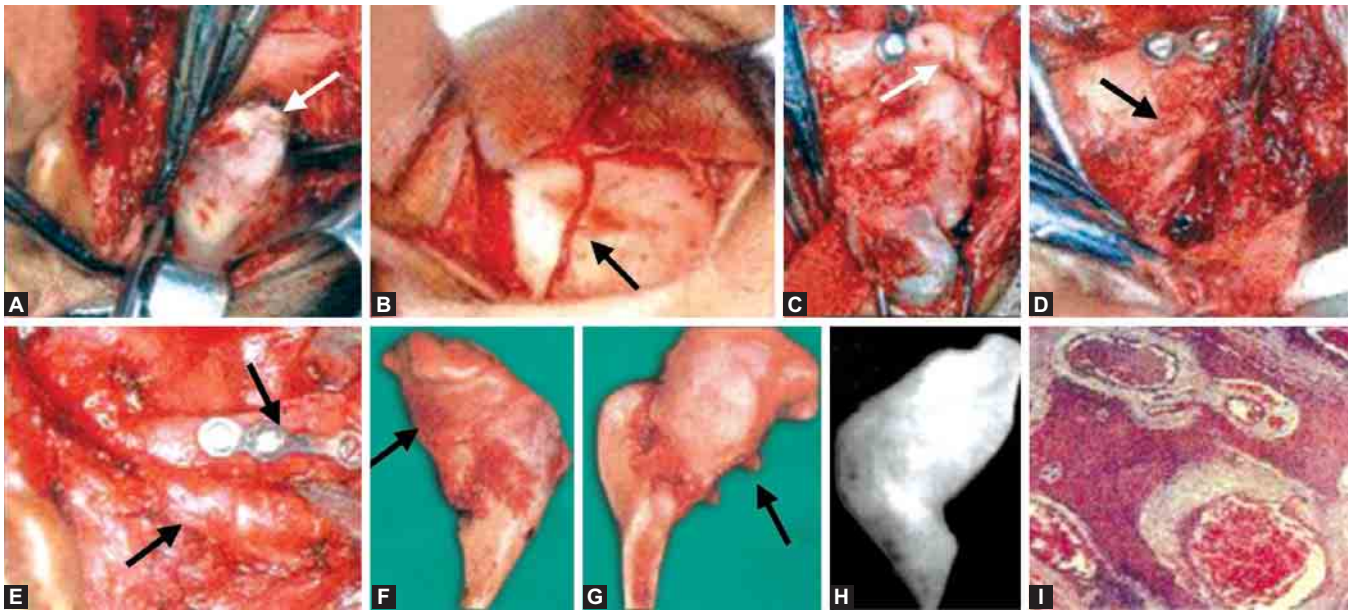
NONNEOPLASTIC BONE LESIONS

Fibro-osseous Lesions of the Jaws

These lesions of the jaw represent a diverse group of lesions that are characterized by replacement of normal bone by a fibrous tissue matrix containing trabeculae of newly formed mineralized bone. This terminology "fibro-osseous lesion" is not a specific diagnosis, but describes only a process. Fibro-osseous lesions of the jaw include developmental (hamartomatous) lesions, reactive or dysplastic processes. The histopathological picture of these lesions may be remarkably similar. The final diagnosis of these disorders



Figs 38.51A to G: Osteochondroma of condyle. (A) A 23-year-old male c/o bony prominence in (right) preauricular area, clicking and inability to carry-out lateral excursion of (right) jaw. Slow growing swelling with deviation of the chin to the left side, causing facial asymmetry; (B) Occlusal derangement with lower midline shift to left side; (C) Visible prominence in (right) preauricular area; (D) Bone scan showing the increased uptake in (right) condylar region; (E to G) Orthopantomogram (OPG), CT scan and three-dimensional scan— well-defined radiopaque/radiolucent mass on the medial aspect of the head of the (right) condyle. Complete excision of the tumor through Al Kayat and Bramley incision was planned

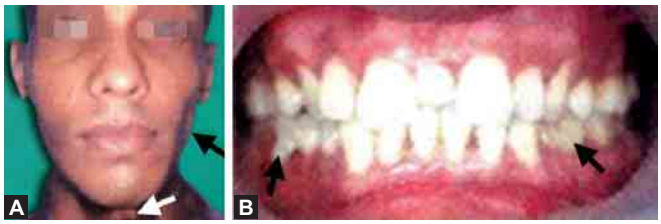


Figs 38.52A to I: Osteochondroma (right) condyle surgery. (A) (right) condyle shifted out of fossa; (B) Risdon's incision condylectomy cut given; (C) Zygomatic arch access osteotomy; (D) Surgical defect after (right) condylectomy along with complete excision of tumor; (E) Temporalis myofacial flap interpositioning, fixation of zygomatic arch by bone plate system; (F and G) Gross specimen—tumor attached to the anteromedial surface of condylar head; (H) Radiograph of specimen—tumor mass is continuous with the parent bone; (I) Photomicrograph of osteochondroma

will depend on clinical, radiographic, operative and microscopic features all considered together.

The common fibro-osseous lesions of the jaws are:

- Fibrous dysplasia of the jaws
- Cemento-osseous dysplasia
  - Periapical cemento-osseous dysplasia
  - Focal cemento-osseous dysplasia
  - Florid cemento-osseous dysplasia.



Figs 38.53A and B: Postoperative front face and satisfactory occlusion of the patient seen in Figure 38.51A

Fibrous Dysplasia of the Jaws (Figs 38.54 to 38.58)

Fibrous dysplasia was first described by von Recklinghausen in 1891. In 1938, Lichtenstein introduced the term "fibrous dysplasia". The pathogenesis is not understood completely, but trauma and endocrine disturbances were labeled as culprits. More recently molecular basis has been identified.

It is a self-limiting condition, in which normal medullary bone is gradually replaced by an abnormal fibrous connective tissue proliferation. The mesenchymal tissue contains variable amounts of an osseous matrix that presumably arises through metaplasia and consists only of woven bone.

Types

- Solitary or monostotic lesion 80–85% more common (involving a single bone)
- Multifocal or polyostotic lesion (involving several bones) relatively uncommon.
  - *In Jaffe type*— three-fourths of the entire skeleton may be involved.
  - *In Lichtenstein syndrome*—the entire skeleton may be involved, along with cutaneous melanotic pigmentation.
  - *Mazabrand syndrome*—fibrous dysplasia associated with soft tissue myxomas, usually intramuscular (Adjacent to the FD lesion).
  - *McCune-Albright syndrome*—Polyostotic with endocrinopathy—more severe form. Occurs commonly in females. Three percent of the patients with polyostotic fibrous dysplasia have multiple areas of cutaneous melanotic pigmentation (Café au lait macules) and autonomous hyperfunction of one or more of the endocrine glands. (Precocious sexual development and onset of puberty).

The skull and jaws are commonly associated in all above forms.

Etiology unknown: Many hypotheses have been proposed.

- A non-neoplastic, hamartomatous growth resulting from altered mesenchymal cell activity or a defect in the control of bone cell activity
- Focal bone expression of a complicated endocrine disturbance (finding of estrogen receptors in osteogenic cells of a patient)
- Inherited basis.

Monostotic Fibrous Dysplasia of the Jaws

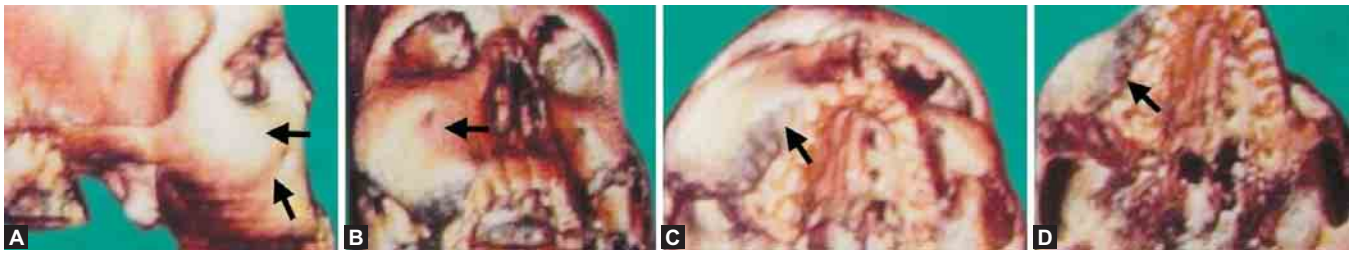
- **Onset:** It occurs during the first or second decade of life. Insidious, asymptomatic, painless, slow growing lesion.
- **Sex:** Both males and females are affected equally.
- **Site:** Maxilla is more commonly affected than mandible. Maxillary lesion may extend to include zygoma, sphenoid bone, maxillary sinus and floor of the orbit and are not strictly monostotic. Therefore are termed *craniofacial fibrous dysplasia*. In the mandible, mandibular body is most frequently involved.
- *Swelling* is unilateral, slow growing with progressive enlargement. As the lesion grows, facial asymmetry becomes more evident and it may be the patient's chief complaint.

  The fusiform oval (low plateau) firm and smoothly contouring swelling of the affected jaw. Most commonly results from the expansion of the buccal cortical plate. The lingual cortex is rarely involved. In mandible, it may cause a protuberance excrescence of the inferior border. As a rule, the growth of the lesion ceases with skeletal growth.

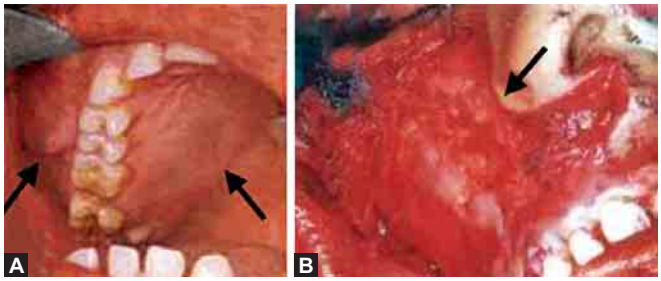
  Teeth involved in the lesion are usually firm, but may be displaced by the bony mass or occlusal level can be changed. The more aggressive clinical form may produce rapid growth, pain, nasal obstruction or exophthalmos.
- *Radiological features* variable. Ranges from radiolucent to a densely radiopaque mass. Four different pictures can be seen radiologically. (1) The characteristic feature is "*ground glass*" appearance in mature stage, i.e. a homogenous radiopacity with the numerous trabeculae of woven bone or '*orange peel appearance*'. (2) In early stage, some lesions may be seen as unilocular or multilocular radiolucencies. (3) In intermediate stage radiolucent lesion with patchy, irregular opacities similar to Paget's disease can be seen. (4) A fingerprint bone pattern and superior displacement of mandibular canal can be seen.



Figs 38.54A to D: A 20-year-old male with fibrous dysplasia of (right) maxilla, zygomatic bone, sphenoid, maxillary sinus, orbital rim. (A and B) Preoperative view showing marked facial asymmetry; (C and D) Postoperative view after debulking



Figs 38.55A to D: Three-dimensional CT imaging showing marked expansion of (right) maxilla, zygoma due to fibrous dysplasia. Right orbital volume is reduced, right nasal bones are also involved



Figs 38.56A to B: (A) Intraoral view showing involvement of right maxilla with buccal and palatal expansion of bone due to fibrous dysplasia; (B) Weber-Fergusson incision to expose the lesion for debulking and recontouring surgical procedure

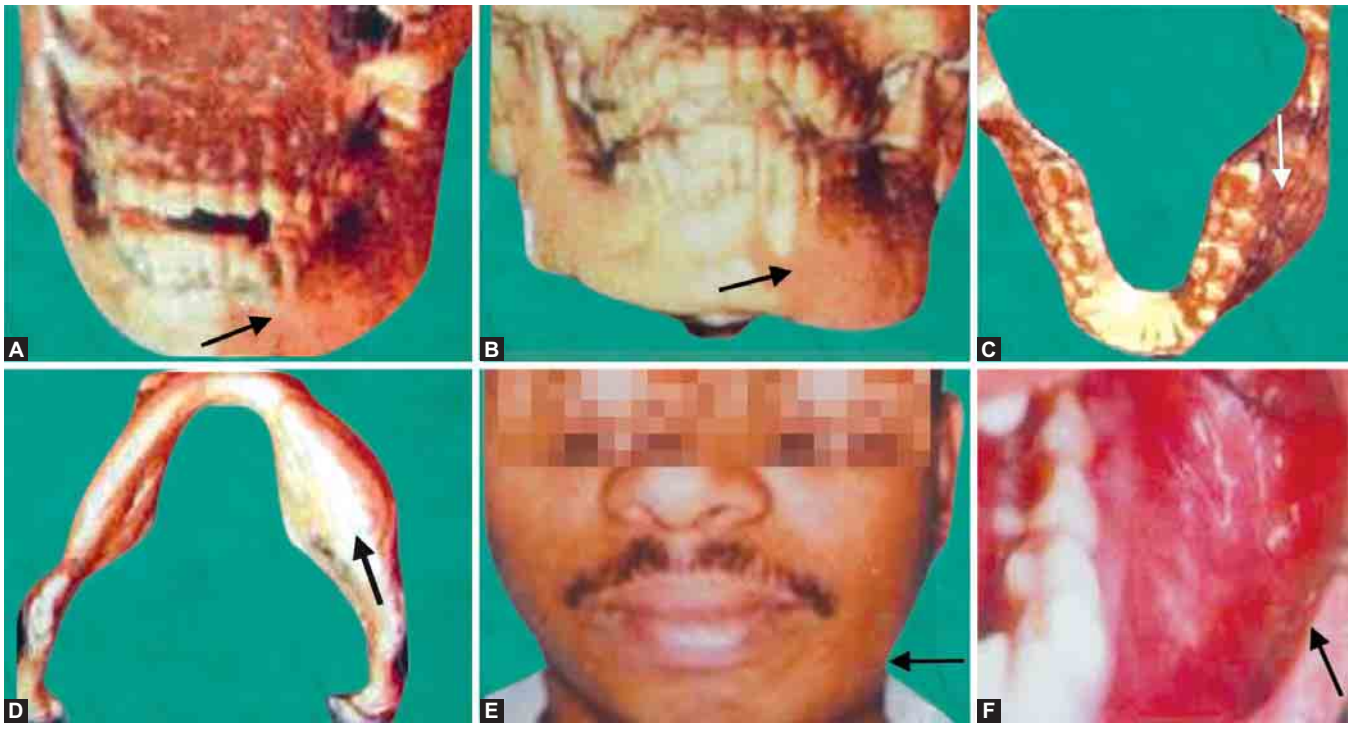
In maxilla: There is obliteration of the maxillary sinus by the lesional tissue. Shows increased bone density of base of the skull involving the occipital, sphenoid, roof of the orbit and frontal bones.

The most important characteristic feature of fibrous dysplasia is the poorly defined clinical and radiological demarcating margins of the lesion. The lesion appears to blend into the surrounding normal bone without any evidence of a circumscribed border.

- *Serum chemistry levels* serum calcium, phosphorus and alkaline phosphatase, are within normal ranges because of the slow growth rate.
- **Histologically:** The lesion is essentially a fibrous one, made up of proliferating fibroblasts in a compact stroma of interlacing collagen fibers. Irregular bony trabeculae may be scattered haphazardly or "c" shaped trabeculae may occur, giving "*Chinese*" *character appearance*. Bony trabeculae may be coarse woven bone or lamellar. As the lesion matures, spicules of lamellar bone with osteoblastic rimming may be seen.
- *Differential diagnosis* from ossifying fibroma, cementifying fibroma, Paget's disease, osteosarcoma, etc. The usual course of fibrous dysplasia is slow growth for a decade or so, stabilization and slow return to normal. Occlusion and tooth-jaw relation should be carefully monitored during the period of skeletal growth.

Polyostotic Fibrous Dysplasia (McCune-Albright Syndrome)

- The skull and jaws affliction with resultant facial asymmetry
- Simultaneous involvement of both the jaws along with long bones is seen
- "Hockey stick" deformity of the femur is seen with leg length discrepancy
- Well defined, generally unilateral tan macules on the trunk, thighs, oral mucosa, known as Café au lait



Figs 38.57A to F: A 22-year-old male patient with fibrous dysplasia. (A to D) Three-dimensional reconstruction CT scan showing bowing of the inferior border of the mandible and expansion of buccal and lingual cortical plates; (E) Facial asymmetry; (F) Intraoral view showing expansion of buccal cortex and tilting of posterior teeth lingually. Recontouring was carried out

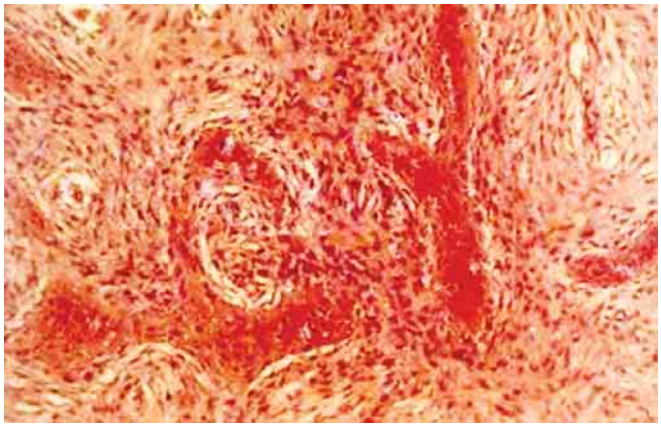


Fig. 38.58: Fibrous dysplasia: Histopathological picture

(coffee with milk) pigmentations. The margins of these spots are very irregular in contrast to the spots of neurofibromatosis which have smooth borders

- Sexual precocity, most commonly seen in females is the common endocrine manifestation
  (Breast development, pubic hair, menstrual bleeding may be seen to occur within first few years of life in affected girls).

Management: The management of the fibrous dysplasia can be difficult at times. The treatment plan depends on the extent of involvement, functional disability, danger to function, neurologic symptoms and esthetic consideration. Differentiation should be made between monostotic and polyostotic form of the lesion. Complete bone scintigraphy can suggest multiple involvements.

The treatment ranges from observation for minor lesions to radical resection.

Small lesions: Biopsy for confirmation and follow-up.

Lesions with functional or esthetic problems: Osseous recontouring via a transoral approach. Resection with bony reconstruction is often not advisable as complete excision is not possible and unnecessary, as the large lesions have poorly defined borders and the disorder is nonneoplastic in nature. The recontouring is done with the contouring round bur or osteotome, while softer lesions can be contoured with a scalpel.

The recontouring is generally undertaken after the active growth stage and during the phase of stabilization. This procedure entails surgical reduction of the lesion to an acceptable contour without any attempts to remove the entire lesion. This is also known as "*surgical shave*

down procedure". 25 to 50 percent of the patients may show variable regrowth of the lesion after recontouring procedure. Radiation therapy is contraindicated, as it carries risk for developing bone sarcoma.

Cemento-osseous Dysplasias

- Most common types of fibro-osseous lesions occurring in the tooth-bearing areas of the jaws.
- Precise etiology is not known. May be the result of disorders in the metabolism of cells normally involved in the production of bone and cementum matrices.
- Microscopically, they consist of fibrous tissue, bone and cementum-like calcification.
- On the basis of clinical and radiological features, three disease processes can be seen. (1) Periapical, (2) Focal, (3) Florid cemento-osseous dysplasias. All these forms represent only variants of the same pathological process.

Periapical Cemental Dysplasia, (Periapical Cementoma), Periapical Cemento-osseous Dysplasia (Figs 38.59 and 38.60) (Table 38.6)

Differentiation with hypercementosis is done by examining for periodontal ligament space which is present in periapical cemental dysplasia. In multiple radiolucencies, distinction between this condition and a radicular cyst can be made on the basis of lack of widening of periodontal ligament space.

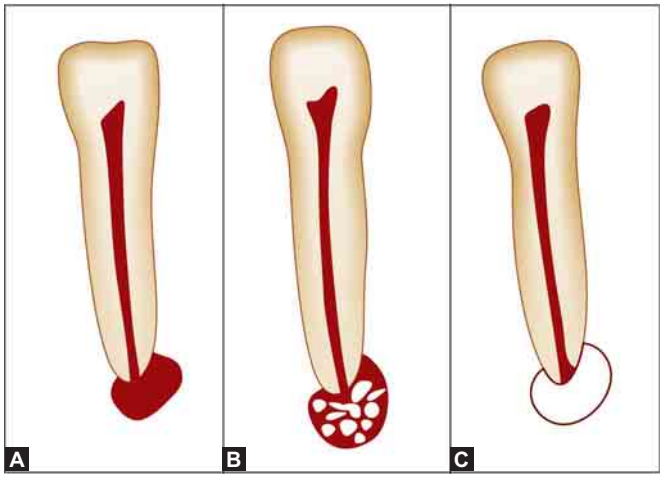
Treatment—requires no definitive treatment following diagnosis. Vitality test should be carried out.

Focal Cemento-osseous Dysplasia

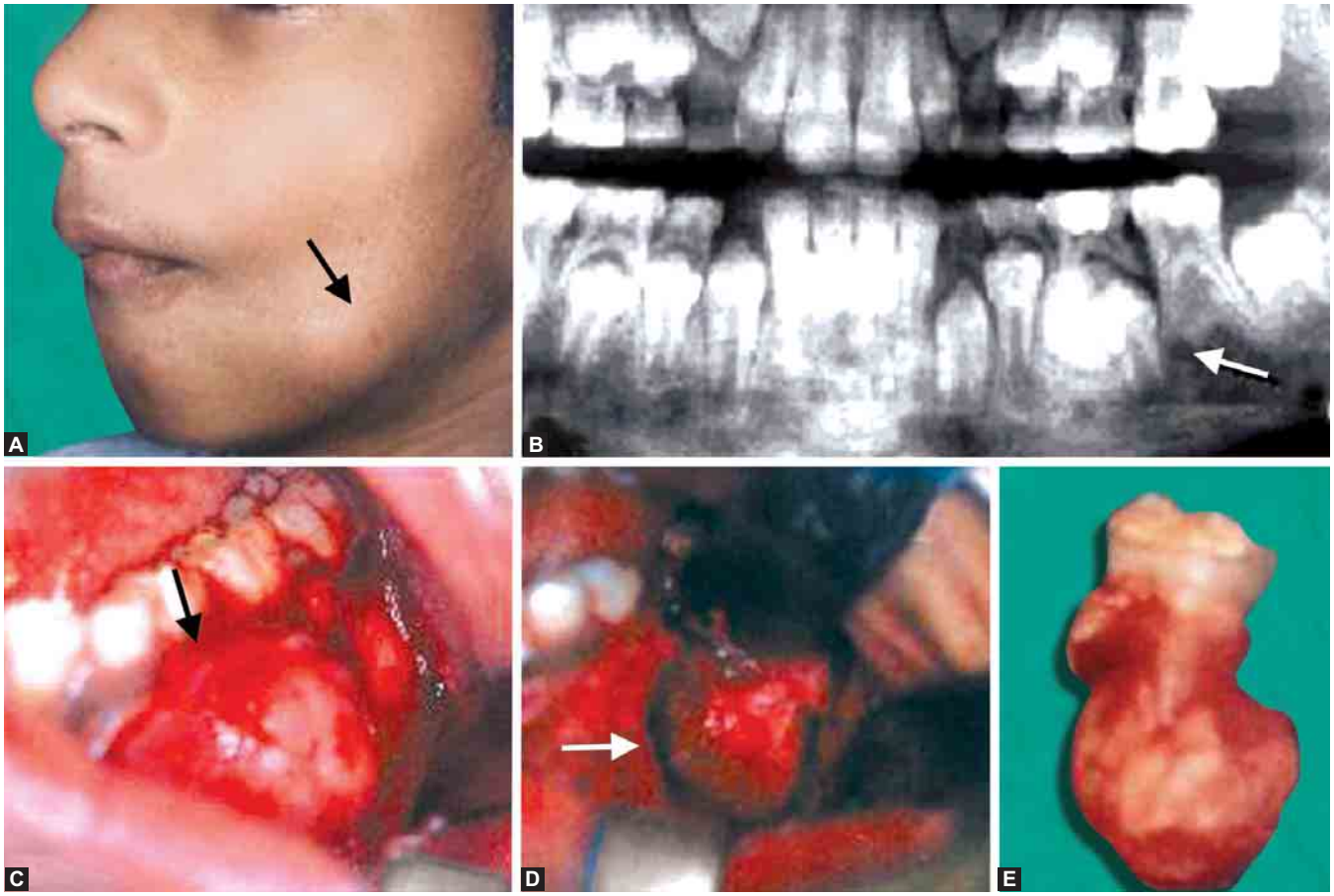
- Seen more in white females
- Forty to fifty years of age
- Posterior mandible is more common site
- Recently described entity that is thought to fall between periapical and florid osseous dysplasia
- More common than the other forms of fibro-osseous diseases of the jaws
- Asymptomatic and usually discovered during routine radiographic examination
- Radiographic appearance may vary from well-defined radiolucent lesion to a densely radiopaque mass
- Many cases involve bone adjacent to the roots of asymptomatic vital teeth or it can be seen in edentulous areas of the jaws
- Some of these lesions may be associated with the development of idiopathic bone cavities (traumatic bone cyst)
- Differentiation should be made from ossifying fibroma, which tends to separate clearly from bone during surgery in one or many fragments, while focal cemento-osseous dysplasia cannot be separated from the bone easily and is removed by curettage
- Requires no treatment following the biopsy.

Florid cemento-osseous dysplasia (FOD) gigantiform cementoma: A rare familial form of disease— also known as familial gigantiform cementoma. WHO in 1992, has used this term as a synonym for florid cemento-osseous dysplasia.

- Shows a striking predilection in adult black women
- Hereditary, seen only in jaw bones
- Marked tendency for bilateral, often symmetric involvement. Many times all four posterior quadrants can be involved. Mandible more than maxilla
- Mostly discovered in routine radiographs
- In some cases, it may be asymptomatic and in others dull pain and an alveolar mucosal fistula may be present
- Both dentulous and edentulous area may be affected
- *Radiologially*— typically mottled, mixed radiolucent— radiopaque lesions adjacent to the teeth throughout the affected portions of the jaws can be seen. Cotton-wool appearance similar to Paget's disease. Difference in FOD is limited to jaw bones only
- Uncomplicated lesions may produce bilateral mild cortical expansion. However, there can be development of osteomyelitis following traumatic episodes like extractions or biopsy or ill-fitting denture trauma, etc. The presence of osteomyelitis with its symptoms



Figs 38.59A to C: Peripheral cementoma. (A) (Stage 1) adiolucent; (B) (Stage 2) mixed; (C) (Stage 3) radiopaque



Figs 38.60A to E: Periapical cementoma. (A) Extraoral profile view of a 9-year-old boy showing swelling at the lower left body mandible of 6 months duration; (B) Orthopantomogram (OPG) showing well-circumscribed radioopaque mass in relation to lower left deciduous second molar mesial root; (C) Surgical exposure of the mass; (D) Defect after excision of the mass, along with the extraction of lower left deciduous second molar; (E) Specimen-biopsy report-periapical cementoma

Table 38.6: Features of periapical cemental dysplasia

Lesion	*Location*	*Features*	*Radiographic features*
• Stage I Osteolytic stage Radiolucent	• Lower anterior and premolar regions • Involves the periapical bone at the apices of the teeth • Often detected in routine radiographs	• Mainly seen in postmenopausal females, 30–50 years of age • Common in black females • Multiple teeth may be involved • Associated with vital noninflamed pulps • Asymptomatic self-limiting lesions	• Multiple, round to ovoid radiolucent (within 2 cm) lesions at the apices of vital teeth with no sclerotic border • Differential diagnosis with periapical granuloma difficult
• Stage II Mixed stage	• Same as above	• Same as above	• Cyst like radiolucency with internal calcific radiopacities. Patchy mottled appearance
• Stage III Radiopaque stage	• Same as above	• Same as above	• Well-defined circular radiopacity bordered by a thin radiolucent band

like pain, swelling, pus discharge and sequestrum formation can be seen.

- *Histopathology* is similar to the periapical variety. FOD is a reactive type of fibro-osseous bone lesion, originating from the periodontal ligament cells and is characterized by its infiltrative nature into nearby bones resulting in indistinct margins.
- **Treatment:** Florid osseous dysplasia is a non-neoplatic, self-limiting process, which requires no treatment following diagnosis. Any form of trauma or extractions or biopsy should be avoided. Once the lesion becomes complicated and osteomyelitis sets in, then standard treatment like debridement, sequestrectomy, wound care and antibiotics, etc. should be offered.

Familial gigantiform cementoma may show relatively rapid growth resulting in facial deformity. Shave down procedure may not work as the tissue rapidly regrows.

Other Cemento-osseous Dysplasias (Giant Cell Lesions of the Jaw Bones)

A variety of pathological conditions of the jaw bones show the presence of multinucleated giant cells. Of these, the benign, intraosseous, giant cell lesions, though rare in their occurrence in the jaws, have been a source of debate. This group of benign, intraosseous, giant cell lesions comprise of:

- *Cherubism* is a rare inherited condition affecting the jaws characterized by the replacement of normal bone by a proliferation of fibrovascular tissue containing multinucleated giant cells **(Figs 38.61A and B)**.
- *The central giant cell granuloma* is, defined by the WHO, as "an intraosseous lesion" consisting of cellular fibrous tissue that contains multiple foci of hemorrhage, aggregations of multinucleated giant cells, and trabaculae of woven bone (Pindborg 1991).

Cherubism: In 1933, Jones first reported three cases of cherubism in jewish siblings. It was the upward "looking towards heaven" upturn of the eyes, combined with the characteristic facial chubbiness of these children that prompted Jones to coin the term "cherubism" (The term cherubism meaning "angle face" was coined as such, since the bilaterally swollen mandible creates a resemblance with the cherubs of Renaissance paintings. Cherubs-plump-cheeked little angles) **(Figs 38.62A to H)**.

- It is an inherited autosomal dominant non-neoplastic disorder
- Pedigrees of families have demonstrated involvement of three or more generations
- Some cases of cherubism are seen without any family history of disorder. These represent spontaneous mutation
- It is a rare inherited disorder affecting the jaws and the key feature is replacement of normal bone by a proliferation of fibrovascular tissue containing multinucleated giant cells
- It manifests during childhood as early as one year of age. Milder cases may be detected at the age of 7–12 years. Age range for most cases— 2–7 years
- Sex—male to female ratio— 2:1— male predominance
- Site—most common sites: mandibular angle and ascending rami. The mandible may be first and only bone to be affected. In severe cases, maxilla is also involved.

Clinical presentation: Fordyce in 1976, described the grades of this disorder.

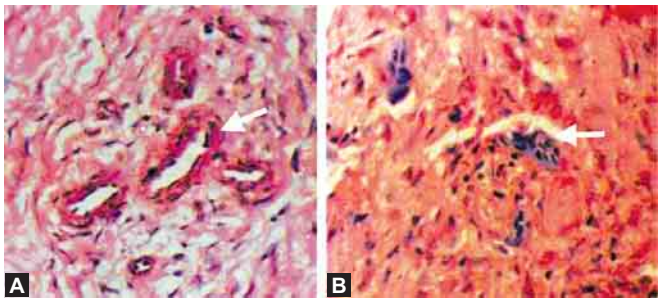
Grade I: Mild, bilateral, symmetrical, posterior mandibular expansion imparting "chubby" appearance to the face.

Grade II: In addition to mandibular involvement, bilateral maxillary tuberosity involvement will be seen.

Grade III: More extensive, generalized involvement of posterior and anterior regions of the mandible and maxilla. Extensive maxillary involvement causes stretching of the skin of the upper face to expose the sclerae "eyes upturned to heaven gaze".

Grade IV: Normally coronoid and condylar processes are spared in cherubism. But in extreme cases of grade IV, there will be involvement of both these processes.

- Bilateral, painless, slow expansion of the affected areas of the jaw (depending on the grade)
- The facial disfigurement will range from mild to extensive



Figs 38.61A and B: Photomicrograph. Multinucleated giant cells in a fibrous stoma. Perivascular cuffing (arrow) with eosinophilic coagulum. Along with clinical picture, shown in Fig. 38.62A to H suggestive of cherubism

- In extensive involvement, there is enlargement and widening of alveolar bone. Developing teeth are often displaced or fail to erupt, malformed or absent
- The bony expansion is firm and nontender on intraoral palpation
- The palatal vault may be considerably reduced or obliterated as a result of maxillary expansion

Extreme tumorous swellings ultimately cause a grotesque appearance with functional problems involving speech, respiration, deglutition, limited range of jaw motion and mastication. There can be complete obliteration of maxillary sinuses. Visual disturbances can be seen due to unequal globe displacement.

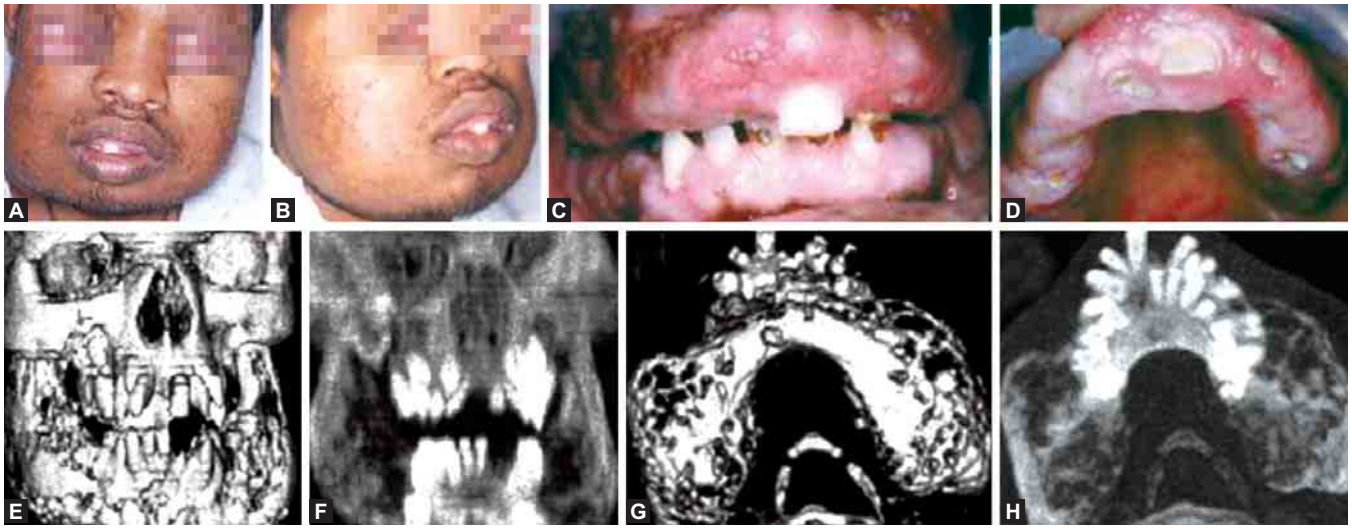
- Regional lymphadenopathy is a common finding in these patients.
- Radiographically— virtually diagnostic picture. Bilateral involvement of the jaws with typically multiloculated, expansile radiolucencies. Expansion and thinning of the cortices is seen. The coronoid process may be involved with flattening of the sigmoid notch. The condyles are most often spared. Teeth may be displaced, unerupted and appear to be floating in the cyst-like spaces. Areas of cortical perforations are commonly seen
- Computed tomographic scans usually reveal replacement of the affected bone by a soft tissue density. Cortical disruption of the buccal and lingual/palatal sides are easily appreciated as is the superomedial extension of the lesion.

Biologic Behavior

- The disorder manifests usually between the age of 2 and 4 years and progresses till the age of 7, where it plateaus or progresses very slowly
- The earlier the condition manifests, the more aggressive is its course
- At puberty, the facial deformity remains static and tends to improve during late teens, when the disorder tends to undergo spontaneous involution. The maxillary lesion usually regresses before the mandibular one
- Facial appearance may return to almost normal by the fourth or fifth decade of life.

Treatment modalities: Difficult to standardize. The treatment is usually based on the rate of progression of the lesion, the extent of involvement and the emotional status of the patient.

- For aggressive lesion with associated functional problems and psychological problems, prompt surgical intervention is needed. Local curettage is the treatment of choice. Packing the defects with allogenic bone powder may aid in rapid osseous healing.
- Other lesions can be kept under observation.
- When functional or esthetic problems persist into adult life, surgical intervention, consisting of conservative



Figs 38.62A to H: Cherubism Grade IV. (A and B) A 17-year-old male, with bilateral symmetrical swellings of the jaws including mandible as well as maxilla. Duration—10 years; (C and D) Intraoral examination showed generalized gingival enlargement, covering almost all the teeth, except anteriors. The gingiva appeared to be firm, hard and leathery, with pebbled surface; (E to H) CT scan— bilateral mandibular, expansile lesions with trabeculated margins associated with enhancing soft tissue within focal areas of erosion are seen in lingual and buccal cortices. Maxilla also shows focal areas of erosion. An osteoid matrix is seen within all these focal areas. Presence of multiple missing and displaced teeth noted

curettage to debulking of lesions with surgical recontouring is the treatment of choice.

Central giant cell granuloma (giant cell lesion, giant cell tumor): Waldron and Shafer termed it "central giant cell granuloma" in 1966 **(Figs 38.63 and 38.64)**.

- **Incidence:** Central giant cell granuloma of the jaws is a relatively uncommon lesion
- **Age:** Occurs predominantly in children, teens and young adults
- **Sex:** Females are more commonly affected 2:1 ratio to male/female
- **Site:** Seventy-two percent of the lesions are located in the mandible. Twenty-eight percent in the maxilla. Anterior region is more commonly involved in both the jaws. Multiple giant cell lesions can be seen in one individual involving maxilla and mandible.

Clinical presentation: Giant cell lesions of the maxillofacial skeleton range clinically from slowly growing asymptomatic swellings of the affected jaws, which fail to demonstrate cortical perforation or root resorption to rapidly expanding aggressive tumors characterized by pain, root resorption and a high recurrence rate.

On the basis of the clinical and radiological features they have been divided into two groups:

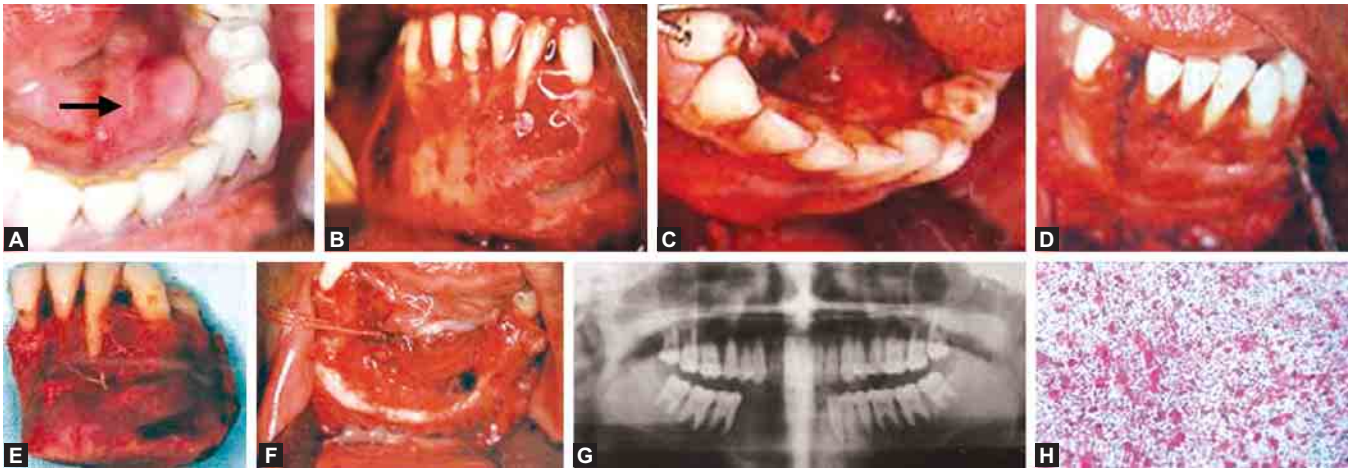
1. Nonaggressive lesions
2. Aggressive lesions

Radiologically: Central giant cell lesions present with a range of radiographic features, from incidental findings on routine radiographic examination to large destructive multilocular radiolucencies. The growth pattern of the giant cell granuloma is characterized by outpocketings, with irregular resorption of the cortex. These features are reflected in the radiographs, which gives an impression of septate multilocularity and ill-defined border. Honey comb or "soap bubble" appearances may be seen. Expansion of buccal and lingual cortices may be evident, with occasional cases of cortical perforation.

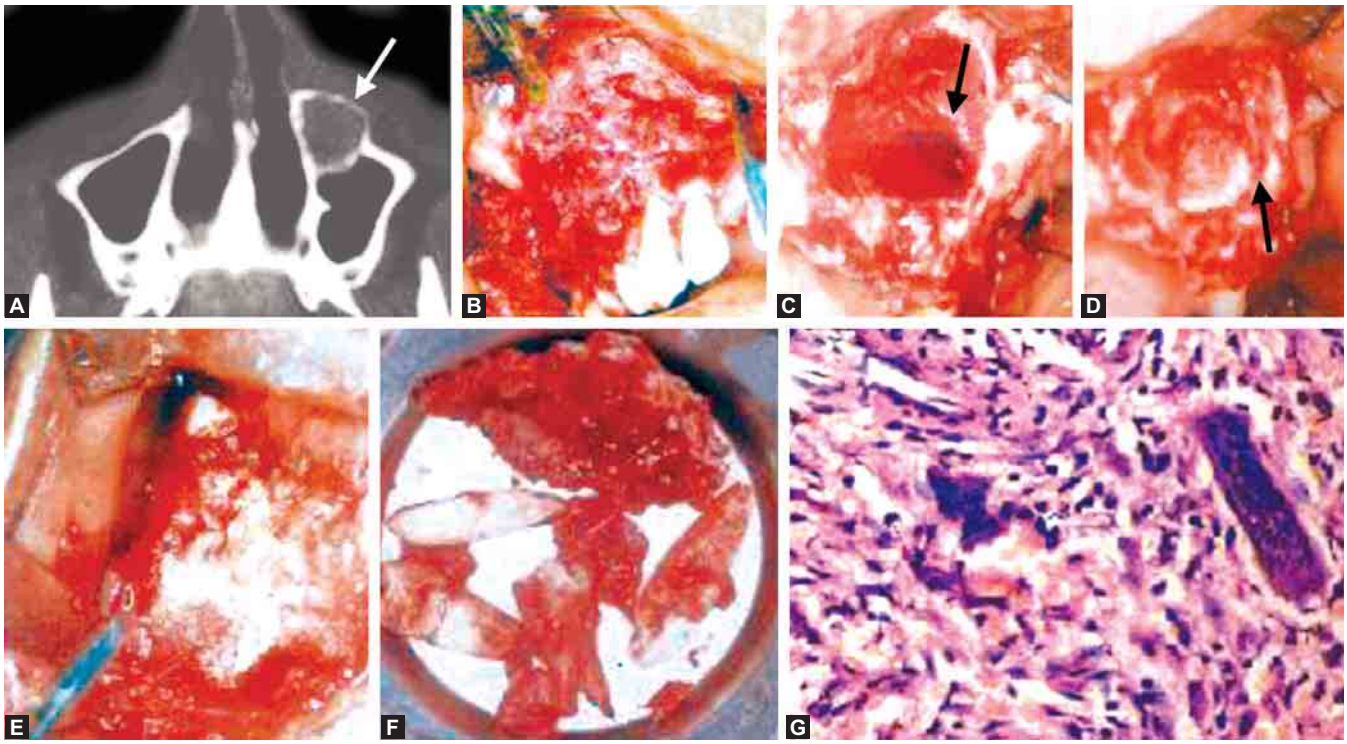
Histopathology: It is composed of a proliferation of spindled fibroblasts in a variable collagenous stroma. Numerous small vascular channels are evident throughout the lesion.

Multinucleated giant cells are present throughout the connective tissue stroma. The giant cells show variability—small, irregular with 5–10 nuclei per cell or large cells with rounded contours and containing more than 20 nuclei. The giant cells are seen around vascular channels aggregated in clusters. In clinically more aggressive lesions, there can be more dense distribution of more nuclear giant cells with less fibrovascular tissue.

Treatment and prognosis: Aggressive curettage of the tumor mass followed by removal of the peripheral bony margins is recommended treatment modality, which results in a low recurrence rate and good prognosis. Aggressive lesions require extensive surgery like resection. Because, the histological features of central giant cell



Figs 38.63A to H: Central giant cell granuloma: A 30-year-old female came with the recurrent swelling in (left) parasymphysis region with displacement of associated teeth. History of earlier curettage 1 year back. (A) Intraorally, a firm, smooth, tender swelling, extending from 31–35. Marked buccal and lingual expansion was seen; (B and C) Surgical exposure— note buccal and lingual cortical expansion; (D) Intraoral peripheral osteotomy done; (E) Resected specimen; (F) Resection with continuity; (G) Postoperative, orthopantomogram (OPG); (H) Giant cells irregularly distributed in a hemorrhagic fibrous stroma



Figs 38.64A to G: Central giant cell granuloma. (A) CT scan showing well-defined radiolucency involving left maxillary region from lateral incisor to second premolar. Expansion of the buccal cortex seen. Anterior involvement of maxillary sinus; (B) Intraoral buccal vestibular incision to expose the tumor; (C) Communication with the max sinus, but no involvement; (D) Use of symphyseal bone graft to seal the communication; (E) Rest of the defect packed with allogenic bone powder; (F) Excised tumor tissue with extraction of teeth; (G) Histopathological picture of central giant cell granuloma— multinucleated giant cells in a spindle cell stroma

granuloma are similar to those of brown tumor of hyperparathyroidism— investigations like serum calcium, phosphate and parathyroid hormone levels should be done. Recurrence rate is 10–50% or greater is seen. Long-term follow-up is necessary.

KERATOCYSTIC ODONTOGENIC TUMOR

Reclassification of the odontogenic keratocyst, from cyst to tumor– KCOT.

Historical Background

Mikulicz in 1876, first described the odontogenic keratocyst as a part of a familial condition affecting the jaws and as a separate entity. He termed it as a "Dermoid Cyst". In 1926, Hauer introduced the term "cholesteatoma" for it. Robinson (1945) first, popularized the term, *primordial cyst* for cysts arising from primordial odontogenic epithelium. He stated that these cysts can arise from dental lamina or its remnants, odontogenic basal cell hamartias or enamel organ, prior to the formation of calcified structures, thus, this cyst is found in place of a tooth (from the normal series or supernumerary) instead of being associated with one. (Tooth is absent in the arch). Later on, the term "keratocyst" was coined by Philipsen (1956), and was based on the histologic appearance of the cystic lining. This designation, was then widely used and two variants, i.e. orthokeratinized and parakeratinized OKCs were identified.

Pindborg and Hansen in 1963, reported their series of 30 cases of OKC and described the essential features of this type of cyst. It is called keratocyst because the cyst epithelium produces a large amount of keratin which fills the cyst lumen. It also shows distinctive histological features such as flattening of basement membrane, and palisading of the basal epithelial cells, which are characteristics of OKC.

The OKC is regarded as a distinctive entity, because of its characteristic histological picture, proliferation kinetics, and aggressive behavior. Therefore, although keratinization

may be present in many other types of cysts, the specific histologic pattern of the OKC separates it from others.

Differences in cytokeratin, epithelial membrane antigen (EMA) and carcinoembryonic antigen (CEA) immunoreactivity between the parakeratinized (OKC)–KCOT and the orthokeratinized variety have been demonstrated and the suggestion made that the latter having a considerably less aggressive behavior is different entity and should bear a different name "orthokeratinized odontogenic cyst (Shear M, 2002)-OOC **(Table 38.7)**.

Toller (1967) had suggested that OKCs might be regarded as benign cystic neoplasms.

However, in 2005, The WHO reclassified "the odontogenic keratocyst" as "the keratocystic odontogenic tumor" and added it in its Histological Classification for Benign Odontogenic Tumors Category **(Table 38.8)**. KCOT behaves like a tumor in many ways, such as: involvement of large areas of bone, high recurrence rate, distinctive histopathological features, disregulation of patched (PTCH) gene in both nevoid basal cell carcinoma syndrome (NBCCS) and association with other abnormalities (most notably the Bifid Rib Basal Cell Nevoid Syndrome). Cases of carcinoma arising in KCOT have also been reported.

Definition: Benign uni or multicystic intraosseous tumor of odontogenic origin with characteristic lining of parakeratinized stratified squamous epithelium and potential for aggressive infiltrative behavior. WHO recommends KCOT is better term over OKC as it reflects its neoplastic nature.

This redesignation of the OKC as the KCOT by WHO is based on the well-known aggressive behavior of this lesion, its histology and new information regarding its genetics.

According to Madras and Lapointe-2008:

- Behavior—KCOT is locally destructive and exhibits highly recurrent infiltrative pattern in surrounding tissues. Tendency to recur—"aggressive" growth potential.

  Histopathology—potential for epithelial budding of the basal layer of KCOT into connective tissues and abundant mitotic activity seen in suprabasal layers, the presence of satellite cysts attached to the side walls of the pericystic cavity, the predilection to proliferate. (Mural growth with proliferation of the lining into the cancellous bone.)

Etiology and Pathogenesis

Keratocystic odontogenic tumor that occurs in dentate areas of both the maxilla and mandible is probably derived from odontogenic remnants. Whether it is developmental or neoplastic in origin is still debated.

Table 38.7: Differences between keratocystic odontogenic tumor (KCOT) and odontogenic orthokeratinized cyst (OOC)

keratocystic Odontogenic Tumor (KCOT)
• Uni- or Multilocular radiolucencies • Associated with impacted teeth (7–47%) • Higher proliferative potential • High recurrence-12–60% • Multiplicity and association with nevoid basal cell carcinoma syndrome present
Orthokeratinized Cyst (OOC)
• Unilocular radiolucencies • Associated with Impacted teeth (50–61%) • Lower proliferative potential • Lower recurrence– 2% • Multiplicity and association with nevoid basal cell carcinoma syndrome not observed

Mikulicz in 1876, had first described KCOT as a part of a familial condition affecting the jaws.

Keratocystic odontogenic tumor is generally considered to be a developmental anomaly, which arises from odontogenic epithelium, the main sources being:

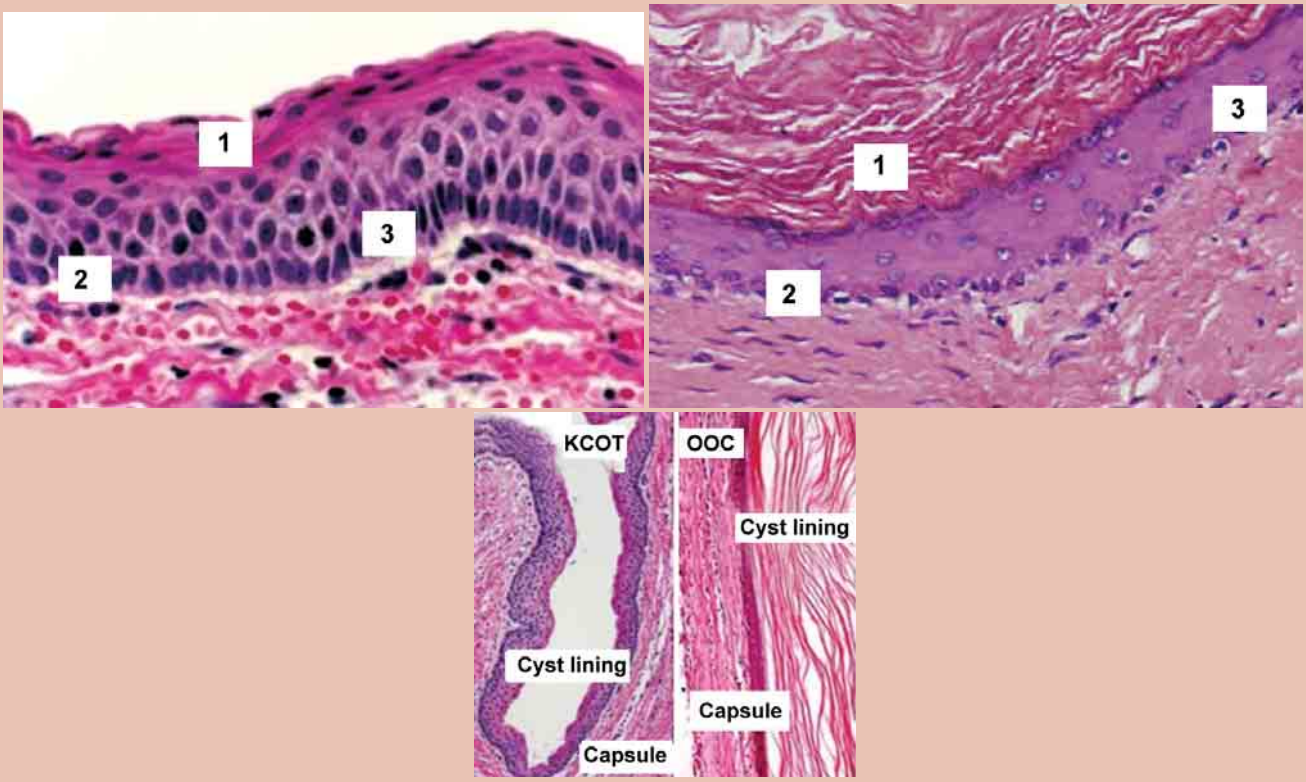
- Dental lamina or its remnants (after this organ has served its purpose)
- Basal cells from the overlying oral mucosa
- Enamel organ— by degeneration of the stellate reticulum.

Incidence: Keratocystic odontogenic tumor comprise approximately about 5–11% of odontogenic lesions of the jaws and is seen predominantly in the second, third and fourth decades of life, though they can occur in any age group. It has a slight predilection for the males than females in ratio of 2:1.

In approximately 10%, the patients with KCOT, the lesions represent a manifestation of the basal cell nevus syndrome (BCNS) or NBCCS.

Site: The KCOT have a strong predilection of occurrence in the mandible than the maxilla, about 49% of the lesions are seen to involve the angle of the mandible with extension for varying distances into the ascending ramus and body mandible. However, they can occur anywhere in the jaws, including the midline, though majority of the cysts are seen posterior to the first bicuspids. Cases in maxillary anterior, third molar and antrum region have also been reported.

Table 38.8: Differences in histopathology of keratocystic odontogenic tumor (KCOT) and odontogenic orthokeratinized cyst (OOC)



Histopathology of KCOT
1. Parakeratinized, corrugated surface
2. Well-defined, palisaded, basal layer of columnar cells
3. Basal cells oriented away from the basement membrane and are often intensely basophilic
Histopathology of OOC
1. Orthokeratinized surface with stratum granulosum
2. Cuboidal or flattened basal cells with absence of characteristic palisading
3. No particular orientation of the basal cells

Clinical Features

The physical signs and symptoms of a KCOT will depend to a certain extent on the dimensions of the lesion. A small lesion is unlikely to be diagnosed on routine examination of the mouth, and is generally detected accidentally on a radiographic examination. In case of the KCOT, patients are remarkably free of symptoms, until the lesion has reached a large size at times involving the entire ascending ramus. *This is because the primordial odontogenic cystic lesion initially extends in the medullary cavity along the path of least resistance, rather than expanding the cortex and clinically observable expansion of the bone occurs late* **(Fig. 38.65B)**.

The enlarging lesion may lead to displacement of the teeth, percussion of the teeth overlying the lesion may produce a dull or hollow sound, and show perforation of bony cortex. A single missing tooth from the normal series should invite suspicion of the existence of the KCOT. The teeth adjoining the lesion will have vital pulps, unless there is coincidental disease of the teeth. Buccal expansion of the bone is commonly seen, lingual and palatal expansion is rare. Large mandibular lesions, invariably deflect the neurovascular bundle into an abnormal position. If acute

infection sets in, with accumulation of pus within the sac, neuropraxia of the nerve results with the onset of labial paresthesia or anesthesia. When tension is relieved, with spontaneous discharge of pus via a sinus tract or surgical drainage, sensation returns to normal. These patients in later stages may present themselves with pain, swelling with discharge and paresthesia of the lower lip and teeth.

Maxillary lesions are more likely to become infected, even if they are smaller than mandibular lesions, because of proximity to maxillary antrum and hence are diagnosed at an early age. Enlarging lesions of maxillary antrum may cause displacement and destruction of floor of orbit and proptosis of eye.

Multiple KCOTs are found in children, and are often reflective of multiple KCOTs as a component of NBCCS. These multiple cystic lesions, however, may also be independent of the syndrome.

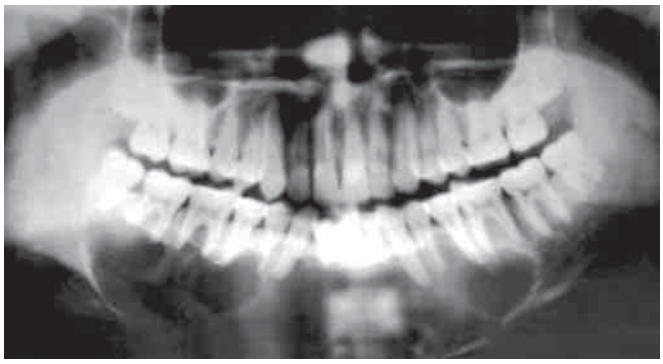


Fig. 38.65A: Orthopantomogram (OPG) of a large unilocular keratocystic odontogenic tumor (KCOT), having smooth periphery

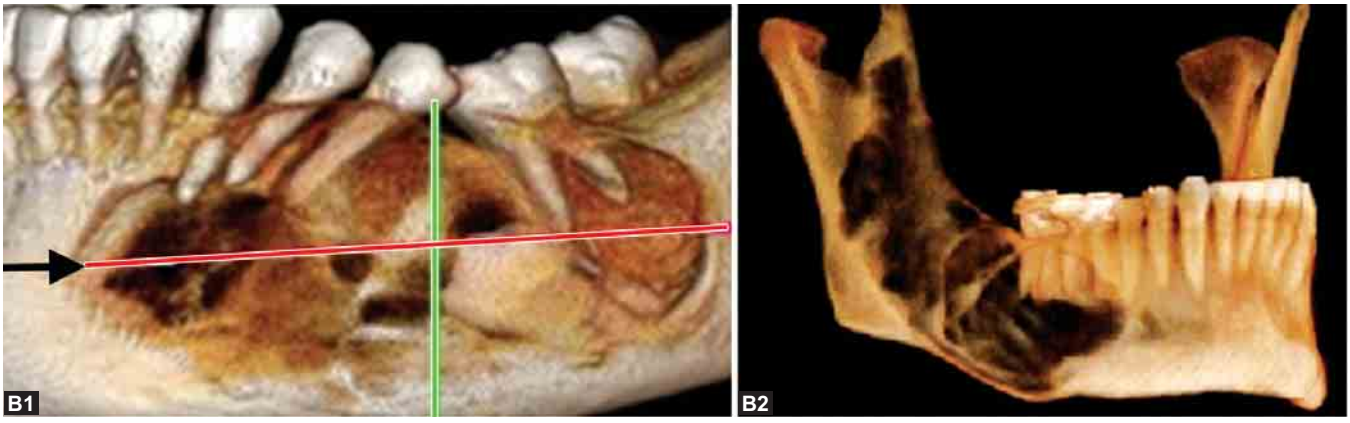
The most characteristic feature is the high rate of recurrence. (The lesion showing orthokeratinization or mixed types of keratinization have less recurrence than parakeratinized cysts.)

Radiological features: The KCOT can be unilocular or multilocular and is almost always associated with a sclerotic margin. Often, there can be considerable difficulty in distinguishing an ameloblastoma from a multilocular KCOT on radiologic grounds. Majority of the unilocular radiolucencies have a smooth periphery, some may have scalloped margins, which suggest an unequal growth activity **(Figs 38.65A and B)**. Multilocular cystic lesions can have various radiographic appearances, e.g. one large cyst and some smaller daughter cysts giving the polycystic appearance. It is reported, that later, these cystic lesions fuse with the primary lesion to give the multilocular appearance. Thirty percent of maxillary lesions and 50% of mandibular lesions show buccal expansion with resorption of the lower cortical plate of the mandible, as well as perforation of bone. Mandibular lingual expansion may be seen sometimes. When they occur in the periapical region of vital teeth, they can be mistaken for a radicular cyst. They may impede the eruption of related teeth and this results in a dentigerous cyst appearance radiologically, which contain the crown of an unerupted tooth within its cavity (25–40% of cases).

For larger KCOT, with possible cortical perforation, specialized radiographic assessment, such as conventional and specialized films like CT scan should be undertaken.

Histological Features (Tables 38.9 and 38.10)

The KCOT lesions are thin walled and are lined by a regular keratinized stratified squamous epithelium, which



Figs 38.65B1 and B2: Intramedullary anteroposterior invasion by keratocystic odontogenic tumor (KCOT) seen clearly in cone-beam computed tomography (CBCT)

is usually 5–8 cell layers thick and is devoid of rete pegs. The keratin formed by the epithelium is seen in two variants, parakeratin— in which there is persistence of the nuclei **(Fig. 38.66)** and orthokeratin— in which the nuclei are absent. Clinically, the parakeratinized variant appears to have a much higher incidence of recurrence. In 80–90% of cases). But sometimes, orthokeratinized and both forms are found in different places of the same cyst. Maxillary KCOTs are generally of orthokeratinized variety.

There is well defined often palisaded polarized basal layer, which is of cuboidal or low columnar cells shows budding into connective tissue. It shows increased mitotic activity. The cells superficial to basal layer (stratum spinosum) are polyhedral and exhibit acanthosis. The subepithelial layers show increased collagenolytic activity with paucity of inflammatory cell infiltrate. At intervals there are infoldings of epithelial lining into the fibrous cystic wall (satellite cystic lesion), which along with loss of rete pegs account for increased recurrence rates. The histological appearance of the cystic lesion changes in the presence of intense inflammatory process. The adjacent epithelium loses its keratinized surface, may thicken and develop rete pegs or may ulcerate.

The enucleated lining easily separates from the underlying connective tissue. The capsule is quite thin and normally free of inflammatory cells, and may contain strands of odontogenic epithelium resembling the dental lamina, cell nests and daughter cysts. Desquamated keratin may be present in the cystic cavity

- Typically the wall is *thin*, *collapsed* and *folded*
- *Uniform, parakeratinized stratified squamous* epithelium, 5–8 cell layers thick
- Key features are a narrow, folded *(corrugated)* zone of parakeratin layers, hyperchromatic palisaded basal cells showing reversed polarity– *picket fence/tombstone appearance*
- *Absence of rete ridges*
- *Weak epithelial—connective tissue interface*
- *Daughter/satellite cyst.*

Malignant Transformation

The MT of KCOT is a rare, but there is well-documented occurrence to squamous cell carcinoma.

Keratinization alone is a nonspecific finding in KCOT, because other odontogenic cystic lesions also can produce keratin.

Recurrence: KCOT have a pronounced tendency to recur. This aggressive pecularity was first reported by Pindborg and Hansen (1963). The recurrence rate may vary from 2.5% to 62% with most occurring in the first 5–7 years. Some lesions showed recurrence even after 10 years, hence long-

Table 38.9: Histological diagnostic criteria of OKC (now KCOT) by WHO (2001)

The lesion is characterized by a thin fibrous capsule and a lining of keratinized stratified squamous epithelium, usually about 5–8 cells layer in thickness and generally without rete pegs.

Table 38.10: Basic histological features of OKC (Now KCOT)

Pindborg and Hansen in 1963	
1.	A thin, uniform thickness, lining epithelium with little or no evidence of rete ridge formation
2.	A palisading cuboidal or columnar hyperchromatic basal cell layer
3.	A thin, spinous cell layer that often shows a direct transition from basal cell layer
4.	A spinous cell layer that frequently exhibits intracellular edema
5.	Keratinization that is predominantly parakeratotic, but may be orthokeratotic
6.	A keratinized inner cystic surface that is often corrugated, and
7.	A thin uninflammed cyst wall

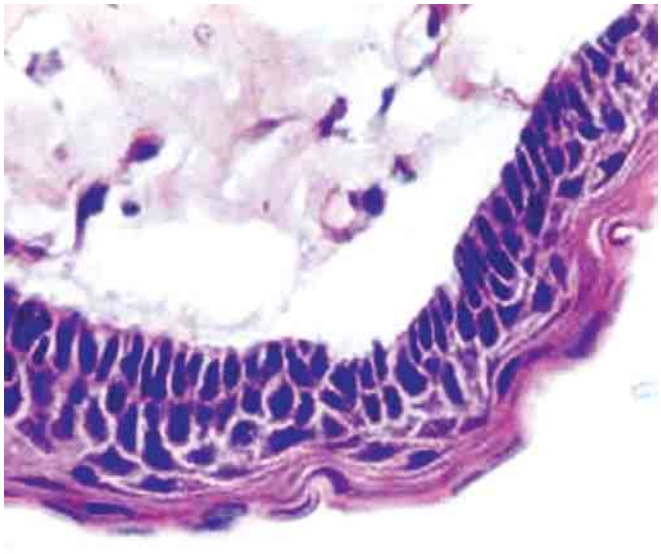


Fig. 38.66: Lining of a keratocystic odontogenic tumor (KCOT) lesion: Parakeratinized epithelium corrugated with tall columnar cells, and devoid of rete pegs

term follow-up is necessary. When associated with NBCCS or Gorlin Goltz Syndrome, the recurrence rate can be as high as 25–65%.

Some of the possible reasons reported for recurrence are as follows:

- Tendency to multiplicity
- Presence of satellite cysts
- Cystic lining is very thin and fragile, portions of which may be left behind
- Epithelial lining of KCOT have an intrinsic growth potential-clusters of epithelial islands
- Cysts can arise from basal cells of the oral mucosa
- Patients with NBCCS have a particular tendency to form multiple primordial type lesions.

Brannon in 1976, proposed three mechanisms for recurrence:

- Incomplete removal of cystic lining
- Growth of new KCOT from satelite cystic lesions or odontogenic rests left behind during surgery
- Development of new KCOT in an adjacent area, that is interpreted as recurrence

The possible mechanisms of recurrence have also been described by Voorsmit et al. in 1981. They stated that any lining epithelium left behind in the oral cavity may give rise to a new lesion formation. Daughter cysts, microcysts or epithelial islands can be found in the walls of the original lesion. New KCOT may develop from epithelial offshoots of the basal layer of oral epithelium.

Recent factors support emerging molecular evidence that the KCOT is more likely to be a benign cystic neoplasm than a simple odontogenic cyst. Even peripheral KCOTs are known to reoccur.

Genetics

The KCOT behaves like a tumor in many ways, for example involvement of large areas of the bone, high recurrence rate, distinctive histopathological features of the lesion, abnormal function or disregulation of the PTCH gene—a tumor suppressor gene is noted in both NBCCS associated and sporadic KCOTs, etc. Normally, PTCH forms a receptor complex with the oncogene SMO (smoothened) for the sonic hedgehog (SHH) ligand. PTCH binding to SMO inhibits growth signal transduction. SHH binding to PTCH releases this inhibition of the signal transduction pathway. If normal functioning of PTCH is lost, the proliferation-stimulating effects of SMO are permitted to predominate **(Figs 38.67 and 68)**.

Pathogenesis involves a 2-Hit mechanism with allelic loss at 9q22. The 2 Hit mechanism refers to the process by which tumor suppressor gene is inactivated. The first hit is a mutation of one allele which is dominating inherited has no phenotypic effect. The second hit is the loss of other allele and is known as loss of heterozygosity. In KCOT, this leads to dysregulation of oncoproteins cyclin D1 and P53.

Aspiration Biopsy

KCOT cystic lesion contents (aspirate): KCOT contains a very characteristic thick, creamy, dirty-white, viscoid suspension of keratin, which has an appearance of pus, but without an offensive smell (odorless) **(Fig. 38.69)**.

- The smear should be stained and examined for keratin cells
- Electrophoresis will reveal low protein content, with high albumin to globulin ratio
- Total protein will be found to be below 4 g/100 mL, which differentiates the lesion from other cystic lesions. Cholesterol crystals, keratin squames, hyaluronic acid, rushton bodies and heparin and chondroitan sulfate also can be found in the aspirate

The immunofluorescent studies by Kuusela et al. (1982), demonstrated an antigen in the cystic fluid, which is not present in other cystic lesions, nor in plasma or saliva and they named it as *"Keratocyst Antigen" (KCA)*.

Treatment

World Health Organization`s reclassification of the OKC as the KCOT, based on behavior, histology and genetics underscores the aggressive nature of the lesion and should motivate clinicians to manage the lesion in a correspondingly aggressive manner.

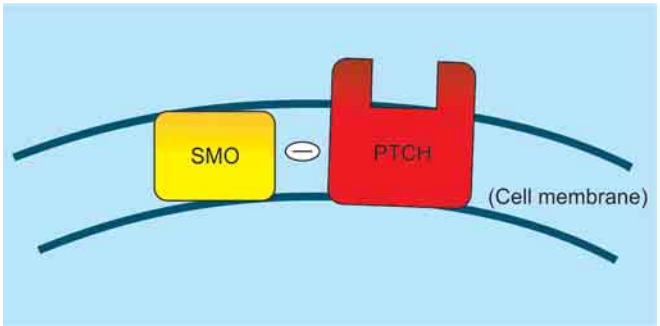


Fig. 38.67: Patched (PTCH) prevents the proliferation– inducing effect of smoothened (SMO)

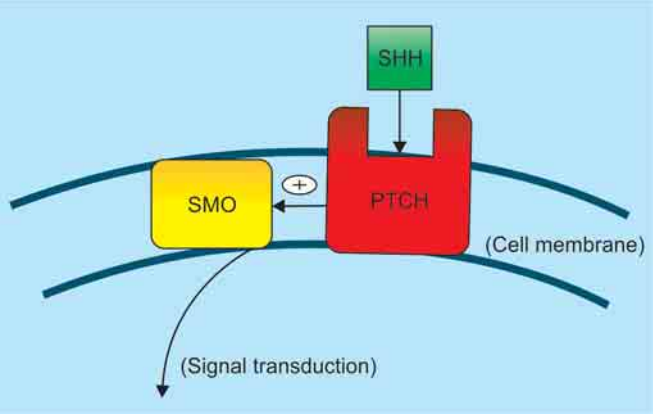


Fig. 38.68: Sonic hedgehog (SHH) releases patched (PTCH) from smoothened (SMO), allowing signal transduction



Fig. 38.69: Keratocystic odontogenic tumor (KCOT) aspirate: Typical thick, creamy, dirty-white, viscoid suspension of keratin

The KCOT behaves like a tumor in many ways, e.g. involvement of large areas of the bone, high recurrence rate, distinctive histopathological features of the lesion, dysregulation of the PTCH gene in NBCCS, etc. On the other hand, successful treatment by marsupialization denies its tumor characteristics. Truly, cases of carcinoma arising in KCOT have been reported. In fact, the recurrence of the lesion has been reported in a bone graft.

Various treatment modalities have been tried for the successful treatment of the KCOT, ranging from simple curettage, enucleation to resection, but none has been regarded as the ideal treatment and the issue is still a debate in oral and maxillofacial surgery, as to the most effective treatment for this lesion. In the literature, a wide range of treatment modalities have been used, they are:

- Decompression alone— placement of a drainage tube
- Marsupialization alone— creating a pouch
- Enucleation alone
- Enucleation with excision of overlying mucosa/soft tissue
- Enucleation with adjuvant therapy— mechanical curettage, chemical curettage or cryosurgery
- Decompression followed by enucleation with or without curettage or adjuvant therapy
- Resection without a continuity defect— peripheral ostectomy
- Resection with a continuity defect— segmental resection
- Resection with disarticulation.

Enucleation with Adjunctive Therapies

- Chemical cauterization treatment with Carnoy's solution/modified Carnoy's solution
- Electrocauterization– for the lesions with buccal and lingual perforation
- Peripheral ostectomy– use of rotary bur
- Cryotherapy– use of liquid nitrogen
- Use of carbolic acid– recent– Sun et al. 2009— Multidisciplinary sequential treatment (MST).

MST Approach

Decompression, enucleation, peripheral ostectomy, cauterizing bone cavum by carbolic acid.

According to Ghali G.E. et al. (2003), as with any odontogenic lesion, initial evaluation must include a thorough history and physical examination, radiographic studies, and the development of a probable differential diagnosis. Depending on size, location and behavior, the clinician should decide on an incision versus excisional biopsy. Prior aspiration may be helpful. A careful histological examination and necessity of obtaining biopsy material from various areas to prevent a misdiagnosis of large size lesions, should be always kept in mind in patients with multiple KCOTs, evaluation for the presence of basal cell nevus syndrome should be undertaken. Large KCOT with possible cortical perforations, deserves specialized radiographic assessment, such as CT scans, in addition to plain X-ray films.

When planning the treatment to minimize/prevent recurrence of the lesion, the following points should be kept in mind.

- Size and extent of the lesion—surface area measured radiographically of the lesions reported ranged from 2 cm to 15 cm
- Incidence as it relates to patient`s age
- Location of the lesion in the jaw— association with any vital structure
- Presence of perforation or soft tissue involvement
- Radiographic appearance— unilocular/multilocular
- Primary or recurrent nature of the lesion
- Time since the previous treatment, in case of recurrence.

Marsupialization is incorrect in principle, in the treatment of KCOT, owing to their high incidence and tendency to recur. But, in 2002, Nakamura et al. stated that marsupialization, as well as decompression, has the purpose of relieving the pressure within the cystic cavity and allowing the new bone to fill the defect. It consequently, saves the contiguous structures such as tooth roots, the maxillary sinus or the inferior alveolar canal can be saved from surgical damage. It also reduces the size of the KCOT before second surgery. It is more effective in the mandibular body than the ramus region. The characteristics of the KCOT may become less aggressive during the course of marsupialization.

Bramley (1971, 1974) had very rationally outlined the surgical management of these lesions as follows:

- *Small single cystic lesion with regular spherical outline* should be enucleated from an intraoral approach, provided the access is good.
- *Larger or less accessible lesions with regular spherical outline* should be enucleated from an extraoral approach, as an intraoral access would be inadequate and a blind procedure. Care should be taken to ensure that all fragments of the extremely thin lining are removed.
- *Unilocular lesions with scalloped or loculated periphery and small multilocular lesions*, should be treated by marginal excision, i.e. resection of the containing block of bone, while maintaining the continuity of the posterior and inferior borders as in the ascending ramus, angle and body mandible, if there is difficulty of access, extraoral exposure is necessary. If the cystic lining is found to be adherent and in contiguity to the overlying oral mucosa or muscle then it should be excised along with marginal excision. The defect is closed primarily and can be left to heal by secondary intention or can be filled with hydroxyapatite crystals, autogenous bone graft, corticocancellous chips or allogenous bone powder, chips or block **(Figs 38.70A to E and 38.71A to C)**.
- *Large multilocular lesions with or without cortical perforation*; may require resection of the involved bone followed by primary or secondary reconstruction with a choice of reconstruction plates of stainless steel, vitallium, titanium, use of titanium or stainless steel mesh and bone grafting procedures with iliac crest graft, costochondral graft or allogenous bone grafts.

In the recent studies, Stoelinga and Van Hoelst (1981, 2001, 2003) proposed a more *conservative approach* to large lesions, by treatment with enucleation, excision of the overlying mucosa and/or muscle, if attachment existed to eliminate epithelial rests and/or microcysts and careful cauterization of the bony defect with Carnoy's solution, this they stated prevented recurrence and reported only one case of recurrence in 40 cases over a period of 10 years.

In nutshell, both conservative as well as aggressive approach has been advocated for treatment of KCOT. Conservative method has not gained much popularity, because complete removal of the KCOT can be difficult because of the thin friable lining, limited surgical access, skill and experience of the surgeon, and desire to preserve adjacent vital structures. The goals of treatment should involve eliminating the potential for recurrence while also minimizing the surgical morbidity.

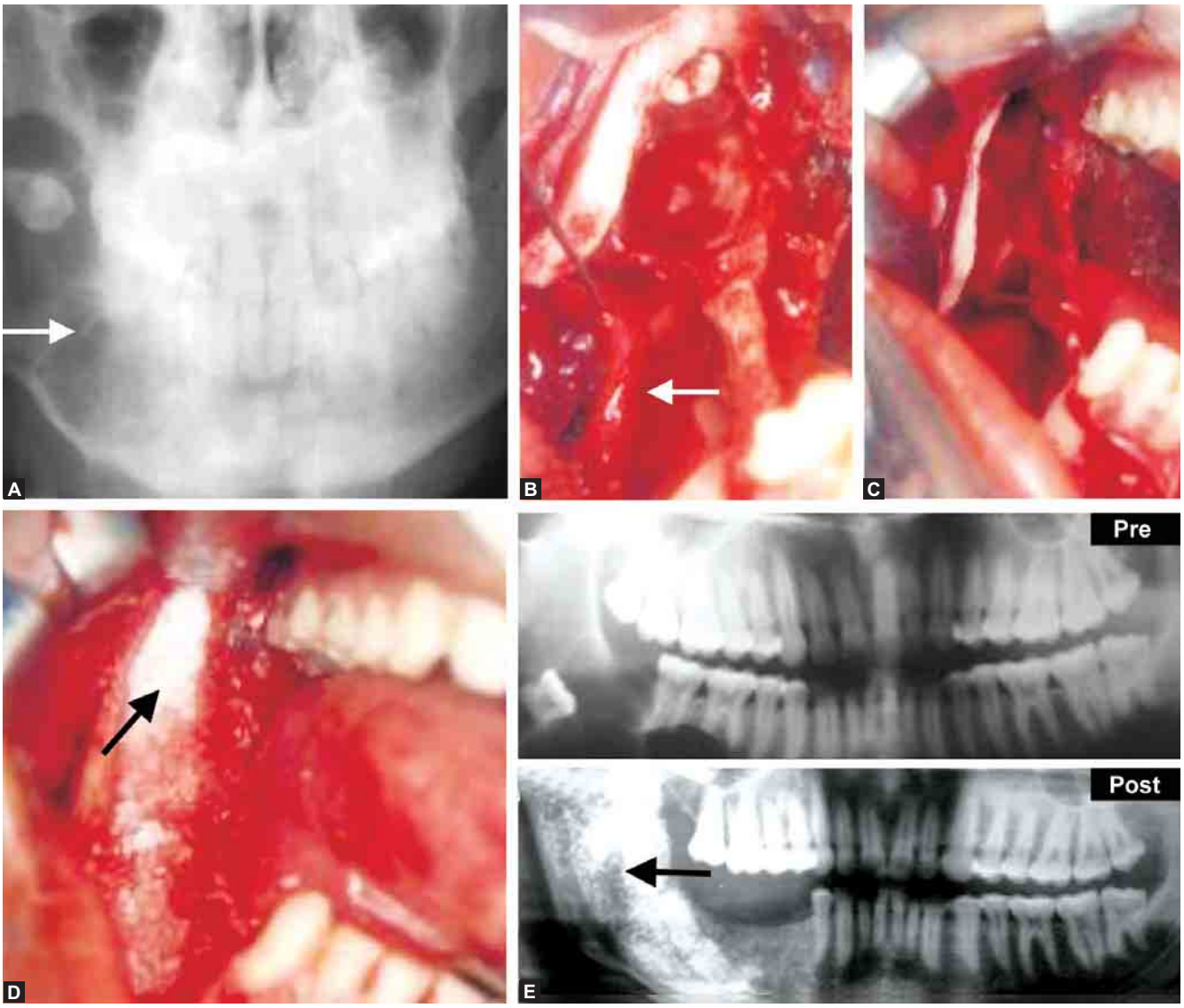
A strict follow-up protocol, which allows for early surgical intervention in case of recurrence, limits the extent of second surgery, thus there is less morbidity. It seems likely that offshoots of the basal layer of the epithelium of the oral mucosa are a major cause for the development of some KCOT and some recurrence.

The most accepted treatment modalities of KCOTs are:

1. Enucleation, followed by cryosurgery
2. Enucleation, followed by adjunctive chemical cauterization using Carnoy`s solution along with excision of overlying attached mucosa
3. Radical excision should be reserved for multiple recurrent lesions.

USE OF CARNOY'S SOLUTION

- Cutler and Zollinger: 1933—introduced the use first.
- Original composition: *A fixative composed of 60% ethannol, 30% chloroform, 10% glacial acetic acid.*
  It is composed of 1 g of ferric choride, dissolved in 24 mL of absolute alcohol, 12 mL chloroform and 4 mL of glacial acetic acid.
- *It is applied directly following enucleation. Protein coagulation is thought to limit uptake of these toxic material.*
- Recent ban on the use of Chloroform-(carcinogen and reproductive toxicity)-by Environmental Protection Agency-EPA-US-(Fabrizi-2003)
- Reformulated solution: Voorsmit-Morgan-2005-Ethanol, Ferric chloride, Glacial acetic acid without chloroform
- It penetrates cancellous bony depth up to 1.54 mm after 5 minutes of application– Stolinga-2005
- Used 3–15 minutes before enucleation or usually after enucleation. It is followed by washout procedure.



Figs 38.70A to E: Keratocystic odontogenic tumor (KCOT) lesion. (A) Multilocular lesion with a displaced tooth; (B) Enucleation. Multilocularity confirmed at operation. Neurovascular bundle salvaged; (C) Wound defect; (D) Hydroxyapatite crystals packed in defect; (E) Pre- and postoperative radiograph showing the lesion and after enucleating, hydroxyapatite crystals within defects

- It devitalizes and fixes the remnant tumor cells
- Success is due to both penetration and fixation action
- Stolinga-2003-recurrence rate-7.8 %,Chapelle-2004–2.5%
- Special care-eliminate all bony septae in multilocular lesion to ensure even application of solution
- Should not be used in the vicinity of neural structures and maxillary sinus to prevent necrosis of sinus wall
- Neurotoxic-bone wax is used to protect the nerve
- Cure rates of modified Carnoy's solution not available
- Debate-whether to use it fresh before use, or within 2 days of manufacturing. US Food and Drug Administration says that it can be used up to 6 months.

RECURRENCE OF KCOT LESIONS

- Kaczmazyk T, et al-Poland-2012 and Sharif et al. Reviewed articles from 1956 to 2010 about KCOT/OKC
- Out of 1,568 articles– 168 were considered for 2nd round, 14 for 3rd round, and only two review articles qualified for the final round

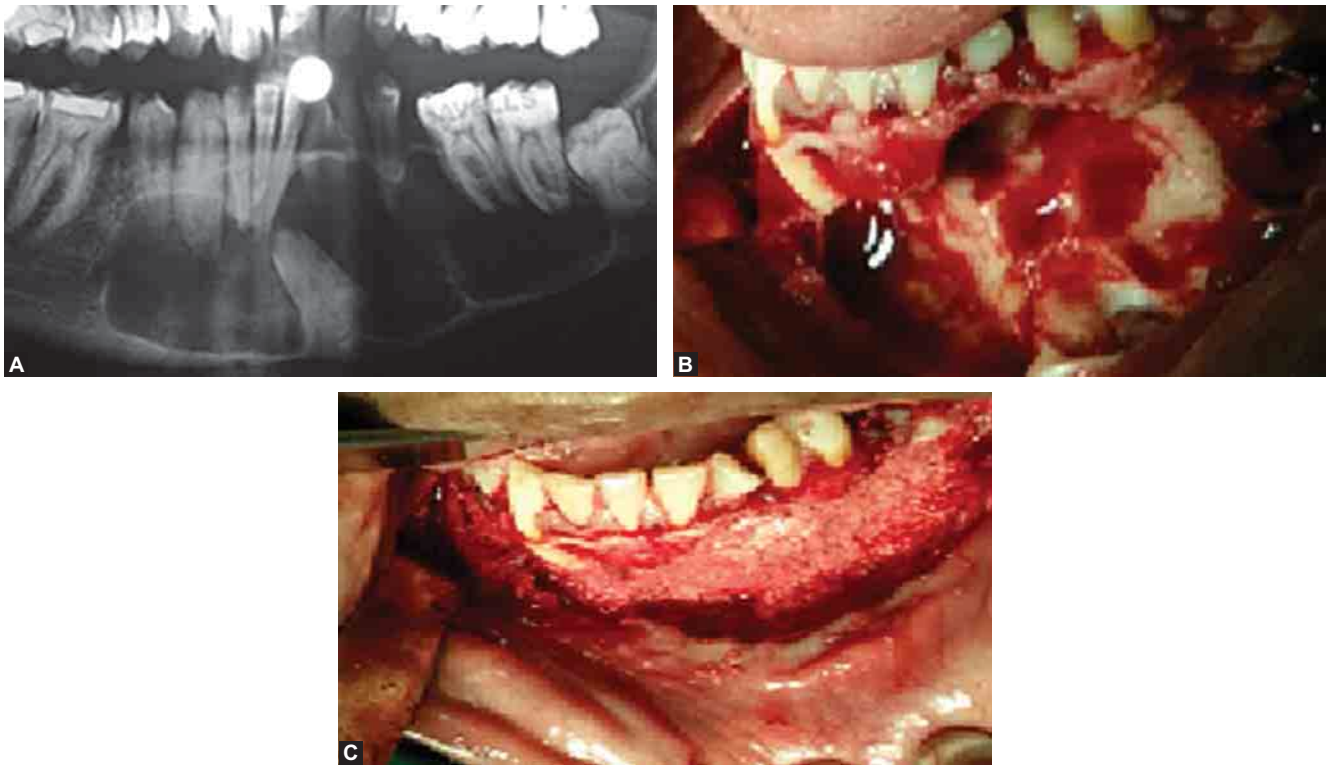


Fig. 38.71A to C: Keratocystic odontogenic tumor (KCOT) in 45 years old male. (A) Multilocular lesion in anterior and body mandible region, note the impacted canine; (B) Enucleation of the lesion with peripheral ostectomy; (C) Hydroxyapatite grafting

- 108 lesions and six treatment modalities
- Recurrence rate cited as follows-
  - Resection– 0%
  - Marsupialization– 40%
  - Enucleation alone– 26.09%
  - Enucleation with Carnoy's solution– 50%
  - Enucleation with peripheral ostectomy (PO)– 18.18%
  - Enuclation with PO and Carnoy's solution– 0%
- Overall recurrence rate– 23.15 %.

Possible Etiology for Recurrence

Brannon-1976,Bell and Deirks-2003, Pitak-Arnop-2010

- Incomplete removal of original cystic lining
- Retention of microcysts/satellite cysts or epithelial islands in the wall of original cyst
- Development of new keratocystic lesions from epithelial offshoots of the basal layer of the oral epithelium
- In case of cortical perforation-adherence of the cyst lining to adjacent bone or soft tissues
- In dentate area-residual remnants

Basal Cell Nevus Syndrome (Gorlin's Syndrome)

Multiple KCOTs may be present solely or may represent *the basal cell nevus syndrome.*

Jarisch (1894) first reported this disorder, detailed description was given by Gorlin (1965). It is most likely, a genetic disorder, which is inherited through an autosomal dominant gene. It is seen equally in both sexes. Some of the presenting features are as follows:

Facies

- Frontal and temporoparietal bossing
- Prominent supraorbital ridges in men
- Hypertelorism
- Mandibular prognathism **(Figs 38.72A and B).**

Skeletal Anomalies

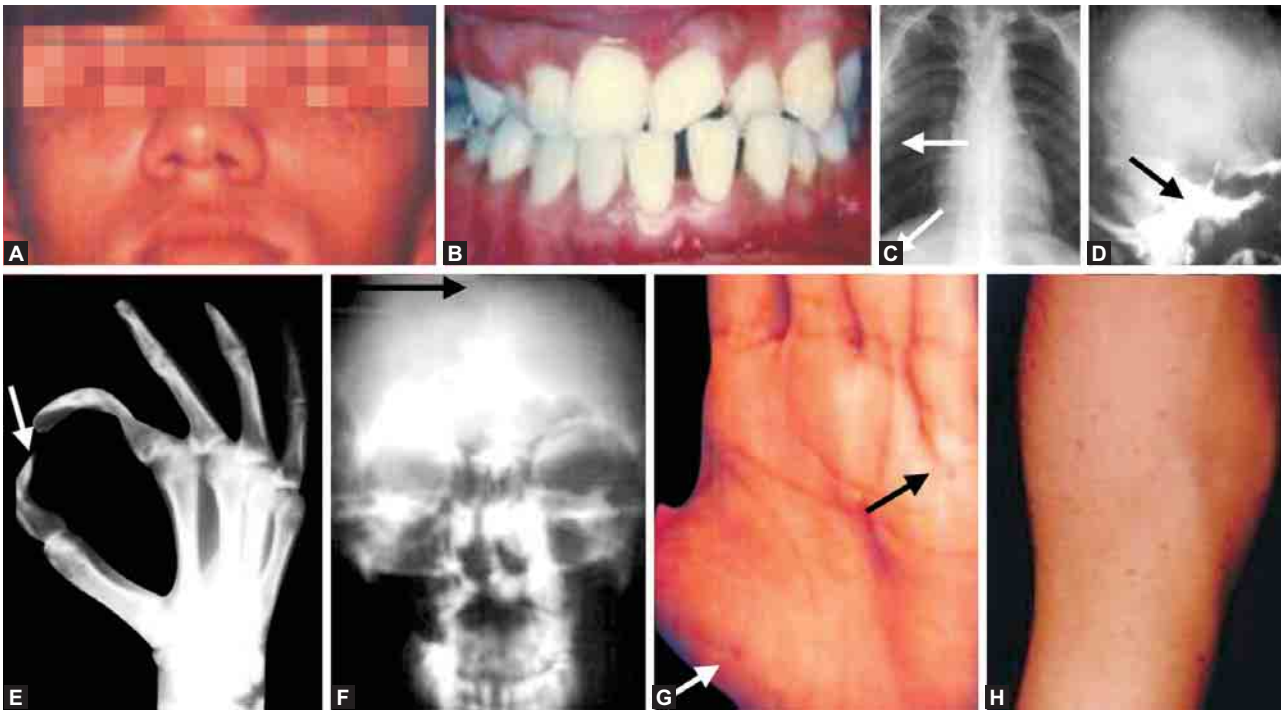
- Bifid, fused, rudimentary ribs
- Occult spina bifida
- Bridging of the sella turcica
- Shortening of metacarpals
- Calcification of falx cerebri **(Figs 38.72C to F)**.

Skin Lesions (Figs 38.72G and H)

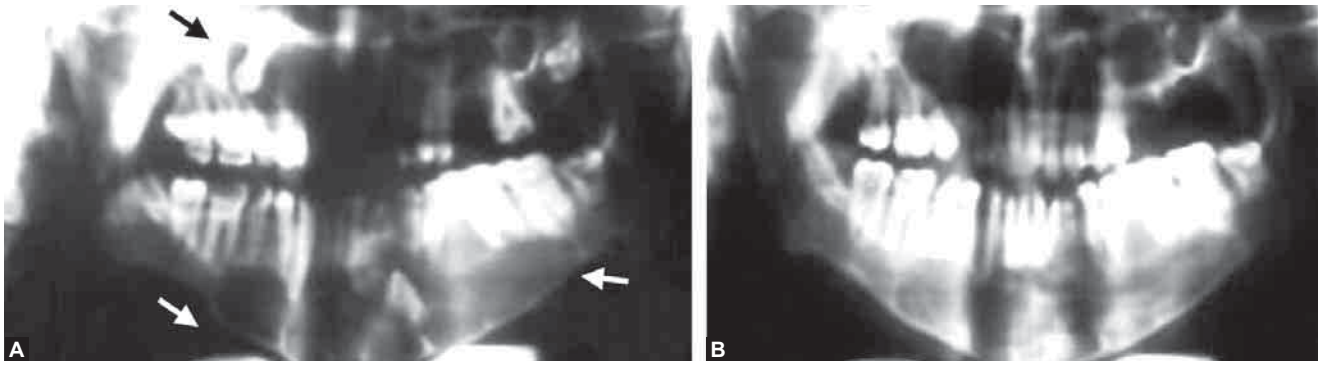
- Milia, around eyes
- Dyskeratosis (palms and soles)
- Epidermal cysts (mostly hands)
- Basal cell nevi
- Basal cell carcinomas.

Cystic KCOT Lesions

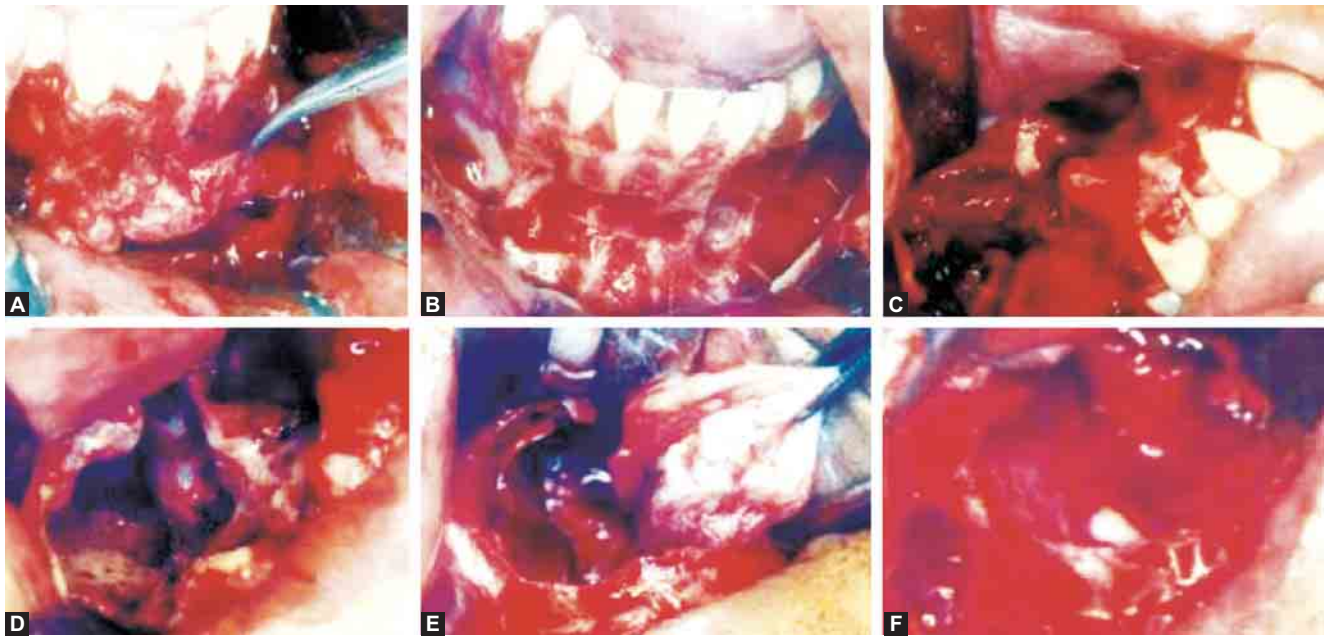
Fifty percent may show multiple KCOTs of the jaw bones **(Figs 38.73A and B)**.



Figs 38.72A to H: Gorlin's syndrome. (A) Multiple nevi and other features; (B) Mild mandibular prognathism; (C) Bifid ribs; (D) Bridging of sella turcica; (E) Shortening of metacarpals; (F) Calcification of falx cerebri; (G) Palmar nevi and dyskeratosis; (H) Multiple nevi on the arm



Figs 38.73A and B: Gorlin's syndrome. (A) Preoperative large multilocular radiolucency in the mandible and maxilla bilaterally; (B) Postoperative orthopantomogram (OPG) following enucleation and endodontic treatment



Figs 38.74A to F: Gorlin's syndrome. (A) Enucleation of mandibular lesion; (B) Mandibular defect; (C) Right side maxillary lesion enucleation; (D) Right side maxillary defect; (E) Maxillary left side lesion enucleation; (F) Maxillary left side defect

Soft Tissue Anomalies

- Ovarian fibromata
- Lipomas

Treatment: Shown in **Figure 38.74A to F.**

Future Trends

Genetic studies have thrown light on new modalities of treatment of the KNOT at a molecular level. These may reduce or eliminate the need for aggressive surgical management.

Taipale et al. in 2000, suggested cyclopamine, a plant-based steroidal alkaloid, inhibits the cellular response to the SHH signal. It is found that cyclopamine blocks activation of the SHH pathway caused by oncogenic mutation making it a potential "mechanism-based" therapeutic agent for human tumors, whose pathogenesis involves excess SHH pathway activity, as it is seen in the KCOT **(Fig. 38.75)**.

Zhang et al. in 2006, postulated that antagonists of SHH signaling factors could effectively treat KCOT. Strategies include the introduction of a wild type form of PTCH inhibiting the SMO molecule by synthetic antagonists and suppressing the downstream transcription factors of the SHH pathway. They suggest intralesional injection of SMO

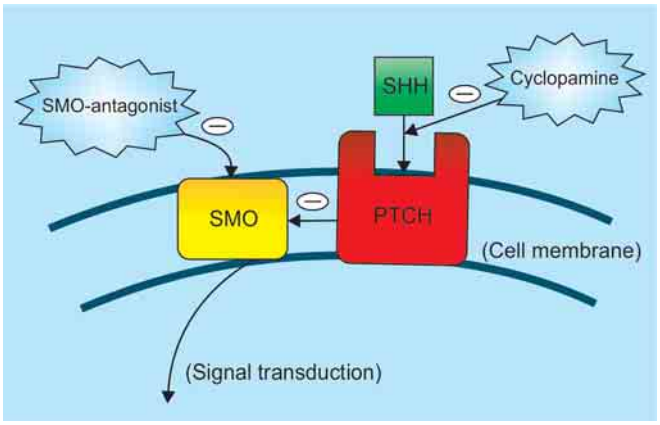


Fig. 38.75: Cyclopamine blocks sonic hedgehog (SHH) signal, preventing transduction, SMO antagonist blocks SMO, preventing transduction

protein antagonist has the greatest potential as a future treatment option.

Points to Remember

- Odontogenic tumors classifications
- Nonodontogenic tumors classifications
- General principles of management of a jaw lesion
- Clinical examination of the lesion
- Principles of surgical management of jaw tumors
- Odontogenic tumors of various origins
- Tumors arising from odontogenic ectomesenchyme with or without inclusion of odontogenic epithelium
- Nonodontogenic lesions of the jaws
- Nonneoplastic bone lesions
- Keratocystic odontogenic tumor.

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Section 10

Salivary Gland Disorders

39. Diseases of the Salivary Glands

CHAPTER 39

Diseases of the Salivary Glands

SALIVARY GLANDS: ANATOMY

Oral cavity depicts many pathological processes from the ubiquitous collection of tissues. Proper understanding of these disease processes is a must for a precise diagnosis of these conditions. Several times, the differential diagnosis of the oral lesions includes the diseases of the salivary glands. Thus, a thorough knowledge of their anatomy, physiology, diseases, their etiopathogenesis, differential diagnosis, investigations and treatment is required.

The salivary glands may be classified as major and minor glands.

Major glands are paired glands.

They are:

(1) Parotid, (2) Submandibular and (3) Sublingual glands

There are numerous minor salivary glands, which are widely distributed in the oral cavity **(Fig. 39.1A)**.

These glands function to produce saliva, which serves as a lubricant for the oral mucosa and speech and also has immunologic, digestive and cleansing properties. (To clear food, cellular debris and bacteria from the oral cavity) **(Table 39.1A)**.

Based on the type of secretion, the salivary glands may be grouped as: (1) Serous, (ii) Mucous and (3) Mixed.

Parotid gland secretion is "serous" in nature; the minor glands secrete "mucous" saliva. The sublingual gland secretes both serous and mucous, but predominantly "mucous" saliva, whereas the submandibular gland secretion is also "mixed", but is predominantly "serous". Salivary gland secretions in serous glands are high in alpha amylase, which digests starches, while mucous glands secretions are high in sialomucin (neutral and acid), glycoproteins, which provide a lubricating film on oral mucosa.

Salivary gland secretions contain water, electrolytes, urea, ammonia, glucose, fats, proteins and other substances **(Table 39.1B)**. Parotid secretions are more concentrated than other salivary glands. The pH of the saliva of the resting gland is around 6–7, and active secretions are about 8. Saliva may be used for diagnostic testing, as it is composed of various molecules that are filtered, processed and secreted from the vasculature that nourish the salivary glands.

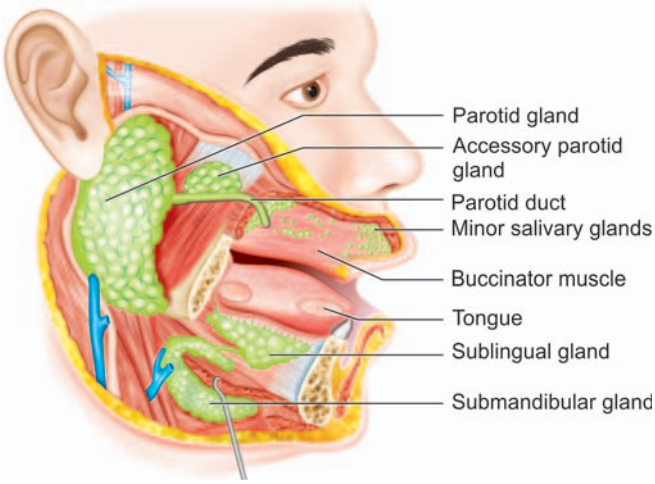


Fig. 39.1A: Salivary glands of the oral cavity

Table 39.1A: Functions of saliva

•	Moistens/lubricates oral mucosa—helps in speaking
•	Moistens and cools food, helps in swallowing and mastication
•	Assists in tasting the food, medium for dissolved food
•	Buffer (HCO_3)—bicarbonate acts as buffer
•	Digestive properties (amylase, lipase)
•	Antibacterial, immunological properties (lysozyme, IgA, peroxidase, flow)
•	Mineralization
•	Protective pellicle

Table 39.1B: Composition of saliva	
Organic	Inorganic
Proteins	Sodium
Urea, uric acid	Potassium
Lysozymes	Chloride
IgA	Bicarbonate
Amylase	Calcium and phosphate

Parotid Gland (Figs 39.1A to E)

- The parotid gland is the largest salivary gland, the secretion of which is "serous" in nature. It is paired and unilobular. Its weight is around 15–30 g.
- Size is 6 cm × 3 cm.
- It is located in preauricular area, inferomedial to external auditory meatus and between the mandible and sternocleidomastoid muscle. 80% of it overlies the masseter muscle and mandible, below the level of the external auditory canal and 20% in the retromandibular region. It is pyramidal in shape.
- The apex is towards the angle of the mandible, overlaps the posterior belly of digastric muscle. Structures passing through the apex are: (1) cervical branch of facial nerve, (2) anterior division of retromandibular vein and (3) formation of external jugular vein.
- The concave base is related to the external auditory meatus and posterior part of the temporomandibular joint. Important structures at the base are: (1) temporal branch of facial nerve, (2) superficial temporal vessels, (3) auriculotemporal nerve.

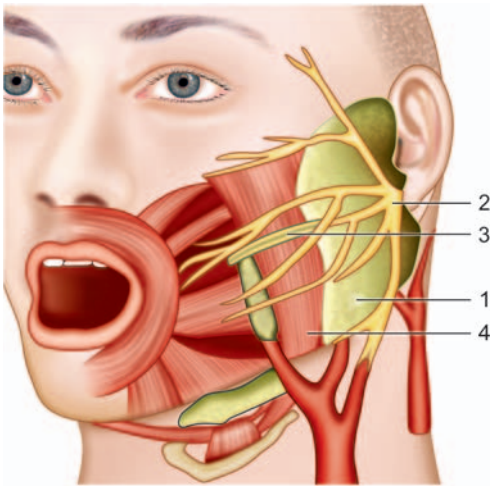


Fig. 39.1B: Parotid gland anatomy: (1) parotid gland; (2) facial nerve and its branches; (3) Stenson's duct; (4) Masseter muscle

- Anteriorly, the gland extends up to the buccal pad of fat and posteriorly encircles the posterior border of the mandible. Anteromedial surface is deeply grooved by posterior border of ramus of the mandible. Important relations are: (1) posteroinferior part of masseter, (2) medial pterygoid muscle insertion, (3) outer lip—branches of facial nerve, inner lip—internal maxillary artery, medial to neck of the condyle. Posteromedially, parotid gland extends into retromandibular area through stylomastoid tunnel into parapharyngeal space. Relations to posteromedial surface are: mastoid process with sternocleidomastoid muscle, tympanic process of temporal bone, posterior belly of digastric muscle, styloid process with its muscle attachments, facial nerve emerging from stylomastoid foramen pierces the gland.
- Parotid gland has two lobes: divided by facial nerve, while coursing anteriorly from the stylomastoid foramen to the muscles of facial expression, into (1) the superficial lobe and (2) the deep lobe. They are connected by an isthmus at the posterior part of the gland. (Stylomandibular tunnel, Isthmus of Parotid) Parotid deep lobe lies on:
  - V—internal jugular vein
  - A—external and internal carotid arteries
  - N—glossopharyngeal nerve, vagus nerve, spinal accessory nerve and hypoglossal nerve
  - S—styloid process, styloglossus muscle and stylohyoid muscle.

Parotid Capsule

Parotid gland has own capsule, which is continuous with superficial layer of "deep cervical fascia".

- Superficial layer
- Deep layer

The entire gland is invested by fascia that suspends the gland from the zygomatic arch. It is covered by a fibrous capsule, derived from investing layer of deep cervical fascia. The superficial thick lamina of the capsule is adherent to the gland, sending septa into the gland. Deep thin lamina is attached to styloid process and tympanic plate, forms stylomandibular ligament, which separates the parotid from submandibular salivary gland.

The Parotid Duct/Stensen's Duct

- 1.5 cm inferior to zygomatic arch. Arises from anterior part of the gland. It follows a line from the external auditory meatus to a point just above the commissure. It is also inferior to the transverse facial artery. It passes

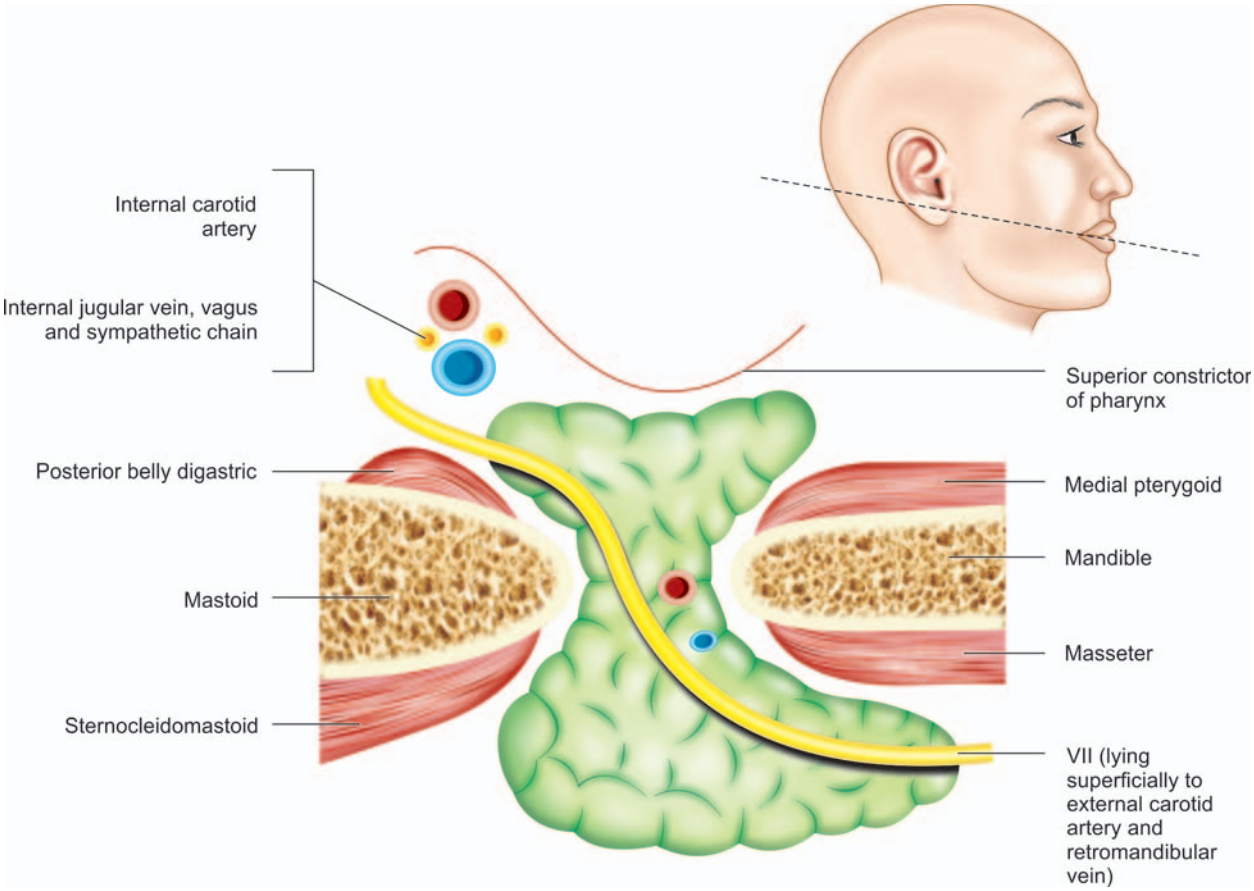


Fig. 39.1C: Parotid and its relation in a schematic horizontal section

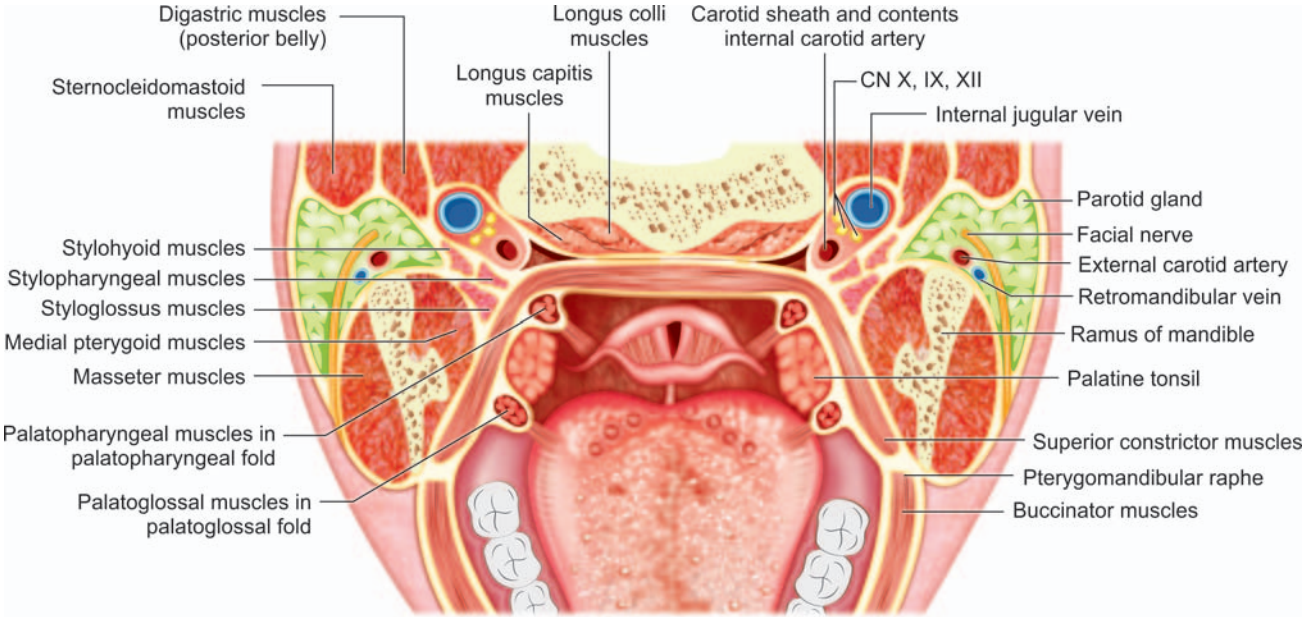


Fig. 39.1D: Diagrammatic representation of parotid gland with its anatomic relations

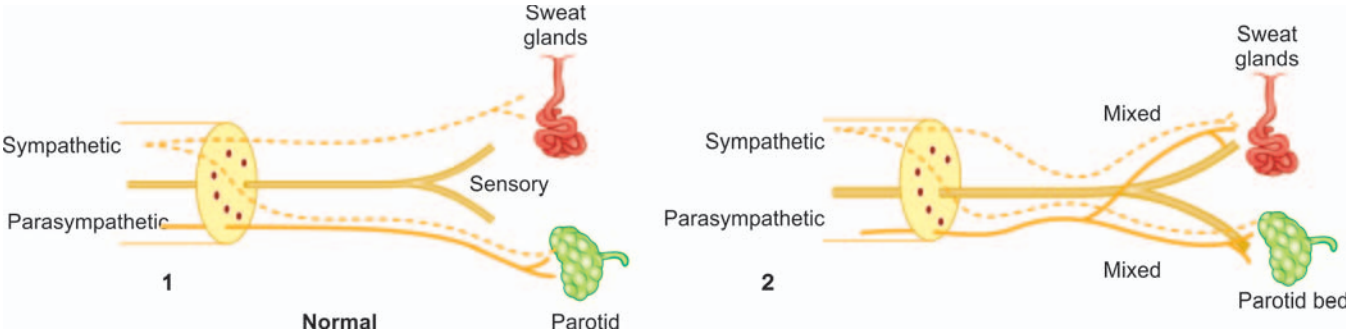


Fig. 39.1E: (1) Normal autonomic innervations of the parotid gland; (2) Proposed mechanism of Frey`s syndrome

horizontally across the masseter muscle, superficial to it, between upper buccal and lower buccal branch of facial nerve, then pierces through the buccal pad of fat, buccopharyngeal fascia and buccinator, to turn at right angles to reach the oral cavity.

- Stenson's duct opening is seen as a papilla in the buccal mucosa opposite the maxillary second molar.
- 4–6 cm in length
- 1–5 mm in diameter
- Accessory parotid gland may extend along parotid duct into the buccal space (20% have accessory parotid gland and duct).

Parotid gland has close association with external carotid artery, which divides at the inferior level of the gland into the superficial temporal and internal maxillary artery, near the retromandibular vein and the facial nerve. The facial nerve emerges from the stylomastoid foramen, branches out from anterior and inferior margins of the gland.

Blood supply—terminal branches of external carotid and internal maxillary artery, venous drainage to external jugular vein. Lymphatic drainage—superficial and deep cervical nodes via parotid nodes.

Clinical Considerations

- Because the adherent fibrous fascia is covering the parotid, its inflammatory swelling is tense and hard, therefore very painful.
- The parotid duct is wider at some distance before the opening. This leads to the storage of saliva. The epithelial cells and other organic matters can get lodged here causing obstructions, stone formation, etc.
- The right angle turn of the parotid duct also leads to stagnation of saliva.
- The close association of the facial nerve with the gland is very important consideration, during the surgical procedures. In case of parotid abscess, skin incision for the drainage, can be vertical, but through the parotid fascia, the deeper incision must be horizontal, to prevent the injury to the branches.
- In Frey's syndrome/auriculotemporal syndrome—due to the damage to autonomic innervations of the salivary gland and inappropriate regeneration of parasympathetic fibers. Secretomotor fibers of auriculotemporal nerve join with the greater auricular nerve. Stimulation of sweat glands overlying skin with stimulation of saliva **(Fig. 39.1E)**.
- Viral parotitis or mumps characteristically does not suppurate.
- Tumors, which arise within the deep portion of the parotid gland, may extend into the lateral pharyngeal space and may produce swelling of the lateral pharyngeal wall.
- Mixed parotid tumor is a slow growing, lobulated, painless mass without any involvement of the facial nerve. Malignant transformation of such a tumor is indicated by pain, rapid growth, fixity with hardness and involvement of facial nerve with enlarged cervical lymph nodes.
- During surgical excision of parotid gland or parotidectomy, the facial nerve is preserved by removing the gland in two parts, superficial and deep separately. The plane of cleavage is defined by tracing the nerve from behind forwards.

Submandibular Gland (Fig. 39.2)

- **Secretion:** The submandibular gland secretion is both "serous" and "mucous" in nature.
- **Location:** This gland is located in the submandibular space in digastric triangle/submandibular triangle, formed by anterior and posterior bellies of digastric muscle and inferior margin of mandible, wedged between the body of the mandible, extending inferiorly up to the digastric muscle, superiorly the mylohyoid

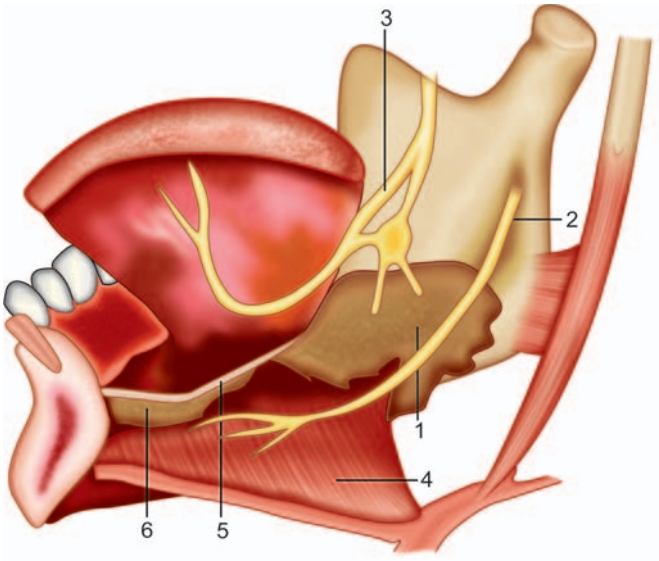


Fig. 39.2: Submandibular gland anatomy: (1) submandibular salivary gland, (2) hypoglossal nerve, (3) lingual nerve, (4) mylohyoid muscle, (5) Wharton's duct and (6) sublingual gland

muscle, posteriorly up to the angle of the mandible and anteriorly till the mid portion of the body of the mandible.

- **Size**: Its size is about the size of the walnut.
- **Weight**: 7–15 g.
- **Shape**: Roughly "J-shaped", being indented by posterior border of the mylohyoid muscle, which divides it into—(1) Superficial part—large and (2) Deep part—small. (Both are connected around the posterior border of mylohyoid muscle. Deep part extends up to the posterior end of sublingual gland and lies deep to the posterior border of mylohyoid and superficial to hyoglossus and styloglossus muscles.)

The submandibular gland has four surfaces: (1) Inferior, (2) medial, (3) lateral and (4) posterior.

1. Inferior surface—covered by skin, superficial fascia, platysma, deep fascia, and cervical branch of facial nerve, facial vein and submandibular lymph nodes are found here.
2. Medial surface—anterior part is related to mylohyoid muscle, nerve and vessels and deep lingual vein.
3. Middle part is related to hyoglossus, styloglossus muscles, lingual nerve, submandibular ganglion and hypoglossal nerve. Lateral surface—it is related to submandibular fossa on the mandible and insertion of the medial pterygoid muscle and facial artery.
4. Posterior part is related to styloglossus muscle, stylohyoid ligament, the nineth nerve, and wall of the pharynx.

The submandibular gland is in close association with the facial artery, facial vein, chorda tympani, branch of the facial nerve and lingual nerve.

- Blood supply—facial artery and drains into common facial or lingual vein.
- Lymph passes to submandibular lymph nodes.
- The submandibular duct (Wharton's duct) starts from the deep part of the gland, turns sharply at the posterior border of the superior surface of mylohyoid muscle, between to the lingual and hypoglossal nerves and then anteriorly and superiorly crosses the hyoglossus muscle. The lingual nerve winds around the duct, first being lateral, then inferior, and finally medial. The hypoglossal nerve runs inferior and parallel to the duct. The duct reaches the oral cavity and opens at the sublingual papilla in the floor of the mouth, on both sides of tongue frenulum, through a punctum. The right and left Wharton's ducts open up just few millimeters apart. The duct is about 2–4 mm in diameter and 5 cm in length.

Clinical Considerations

- The submandibular gland and duct are placed at a lower level to the oral cavity. It makes the gland prone to retrograde infection by oral flora. But, the punctum of the gland is constricted to limit the retrograde flow of bacteria laden oral fluids.
- Similar to the parotid duct, the Wharton's duct is also wider before reaching the papilla. This can lead to the stagnation of saliva and the organic matter.
- The long and tortuous course of the duct also leads to stagnation of saliva.
- The sharp bend of the Wharton's duct at the posterior border of the mylohyoid muscle allows stasis of the saliva favoring the formation of salivary stones.
- Sialolithiasis remains the most frequent reason for submandibular gland resection.
- Incision for excision of submandibular gland is taken 5 cm below the angle of the jaw to avoid injury to the marginal mandibular branch of the facial nerve.
- Bimanual palpation is essential for the differentiation of the enlarged submandibular gland and mass of submandibular lymph nodes.
- The submandibular glands are responsible for the production of over 60% of resting saliva so their preservation, where possible, will reduce xerostomia after radiation treatment.
- During neck dissection the submandibular gland is routinely excised although it does not contain any nodes.

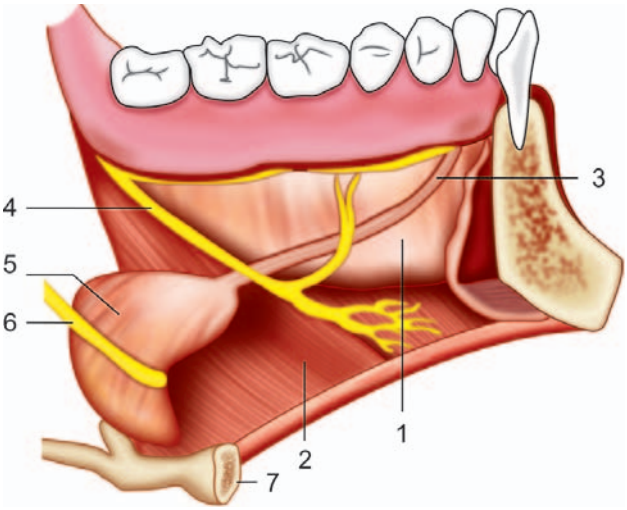


Fig. 39.3: Sublingual salivary gland anatomy: (1) Sublingual gland; (2) Mylohyoid muscle; (3) Wharton's duct; (4) Lingual nerve; (5) Submandibular gland; (6) Hypoglossal nerve; and (7) Hyoid bone

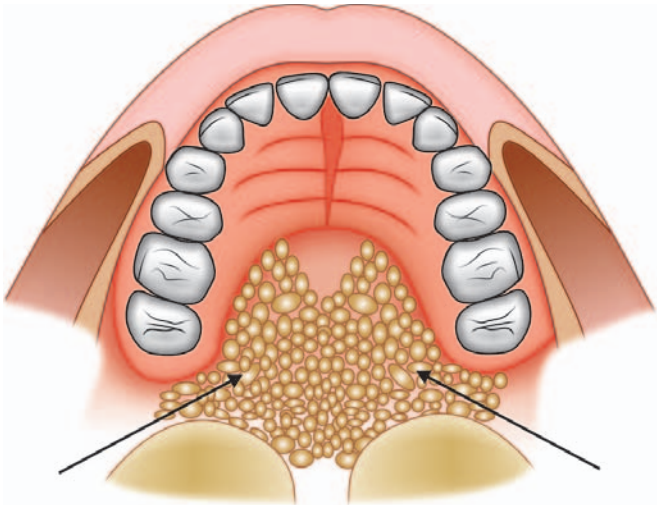


Fig. 39.4: Minor salivary glands in the palate

The latest literature has reported that unless there is gross disease, it is usually possible to clear all the nodes in the region without sacrificing the gland, as it rarely harbors occult tumor.

Sublingual Gland (Fig. 39.3)

The sublingual gland is the smallest of the three glands. It weighs nearly 3–4 g and secretes predominantly mucous saliva. This gland is located in the sublingual space. It lies beneath the oral mucosa in contact with the sublingual fossa on lingual aspect of mandible and above the mylohyoid muscle. It is lateral to genioglossus muscle. It is present in association with the sublingual folds below the tongue, and is divided into anterior and posterior parts. It has got many small ducts.

- **Ducts of Rivinus (8–20 ducts)**: In the posterior part, these ducts open through the sublingual folds directly into the floor of mouth. The ducts of the anterior part may join to form a large main duct called "Bartholin's duct". This either opens though the sublingual papilla or joins with the Wharton's duct. This gland has no capsule.
- **Blood supply—Artery/Vein**: Sublingual branch of lingual and submental branch of facial.
- **Lymphatics**: Submandibular nodes
- **Clinical importance**: Sialography is not possible.

It Involved in Ranula—complete excision of the gland.

The structures at risk, during dissection of sublingual gland are—submandibular duct and lingual nerve, sublingual artery and vein also lie on the medial aspect of the gland.

Minor Salivary Glands (Fig. 39.4)

More than 800–1,000 minor salivary glands may be present in the oral cavity. These are in groups scattered all over the mouth. Most of them are found at the junction of hard and soft palate. Rest are found in the oral cavity mucosa—lips, cheeks, floor of the mouth, retromolar area, etc. They also appear in other areas of the upper aerodigestive track including the tongue, oropharynx, larynx and even in trachea and paranasal sinuses. The minor glands secrete "mucous" secretions, with the exception of Ebner's glands, which are serous glands located in the circumvallate papillae of the tongue. These glands have numerous small ducts. Each gland is a unit with own simple duct.

Clinical Considerations

- The sublingual gland and the minor salivary glands have short ducts, where the chances of stasis are less. Thus, the obstructive lesions do not occur in these glands.
- Since the minor glands are placed superficially on the mucosa, the traumatic lesions such as mucoceles commonly affect these glands.

SALIVARY GLANDS: PHYSIOLOGY AND SALIVA CONTENT (FIG. 39.5)

Salivary secretion is under neural control. Mainly by parasympathetic signals from superior and inferior salivary nuclei. Salivary nuclei are excited by:

- Taste and tactile stimuli from tongue and other areas of mouth and pharynx.

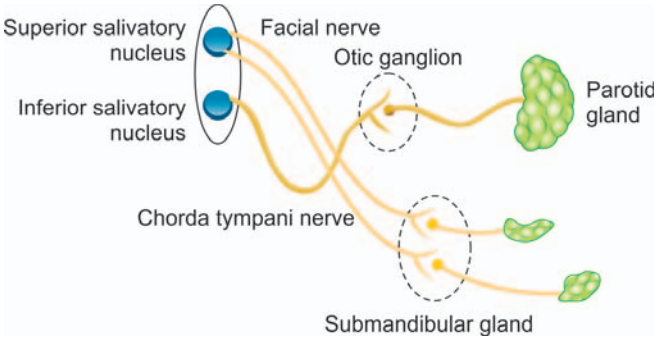


Fig. 39.5: Control of salivary secretion: diagrammatic representation

- Stimuli from esophagus and stomach—due to stimulation of vagal afferent fibers and unconditional reflex.
- Stimuli arising from higher centers of brain due to sight, smell or thought of food—conditional reflex.

AUTONOMIC INNERVATIONS

Salivary glands are innervated either directly or indirectly by the parasympathetic and sympathetic arms of the autonomic nervous system. Both result in increased amylase outflow and volume flow (Fig. 39.5).

Parasympathetic stimulation results in abundant, watery saliva with a decrease in amylase in saliva and increase in amylase in serum. Parasympathetic interruption to salivary glands results in atrophy, while sympathetic interruption does not cause a significant change. Increased sympathetic activity reduces the gland blood flow, decreases the salivary secretions, producing an enzyme-rich scant, viscous saliva.

Parasympathetic (secretomotor) pathway carried via cranial nerves begins in the superior salivary nucleus.
In case of parotid, parasympathetic fibers originate from glossopharyngeal nerve (CN IX) secretomotor fibers from both inferior salivary nucleus and auriculotemporal branch of V3. Preganglionic parasympathetic innervations (from CN IX) arrives at otic ganglion via lesser petrosal nerve. Postganglionic parasympathetic leaves the otic ganglion and distributes to the parotid gland via the auriculotemporal nerve.

Submandibular and sublingual parasympathetic fibers originate in facial nerve (CN VII).

- Preganglionic fibers pass through sensory root of facial nerve, geniculate ganglion, facial nerve, chorda tympani, lingual nerve to reach the submandibular ganglion. Posterior ganglionic fibers emerge from the ganglion and enter the submandibular gland.

Vasomotor function-sympathetic innervation—via preganglionic nerves in the thoracic segments—T1–T3, which synapse in the superior cervical ganglion on the postganglionic neurons. Stimulation by the sympathetic nervous system results in a scant, viscous saliva, rich in solutes with an increase in amylase in the saliva and no change in amylase in the serum. Vasomotor function regulates the secretions of all the glands through vasoconstriction of the artery, which supplies the individual gland. For all the salivary glands, there fibers originate in the superior cervical ganglion and travel with the arteries to reach the glands.

- External carotid artery for parotid gland
- Lingual artery for submandibular gland
- Facial artery for sublingual gland.

Applied anatomy: The chorda tympani supplying secretomotor fibers to the submandibular and sublingual salivary glands lies medial to the spine of sphenoid. The auriculotemporal nerve supplying secretomotor fibers to the parotid gland is related to lateral aspect of spine of sphenoid. Injury to the spine may involve both these nerves with loss of secretions from all three salivary glands.

Functions of Saliva (Flowcharts 39.1 and 39.2)

Saliva is a complex fluid, which has several proteins and digestive enzymes. **The protective functions include cleansing, lubrication, maintaining the integrity of the oral mucosa and also exhibit immunologic properties. Its lubricant property is also helpful for speech and swallowing and assists in tasting the food**.

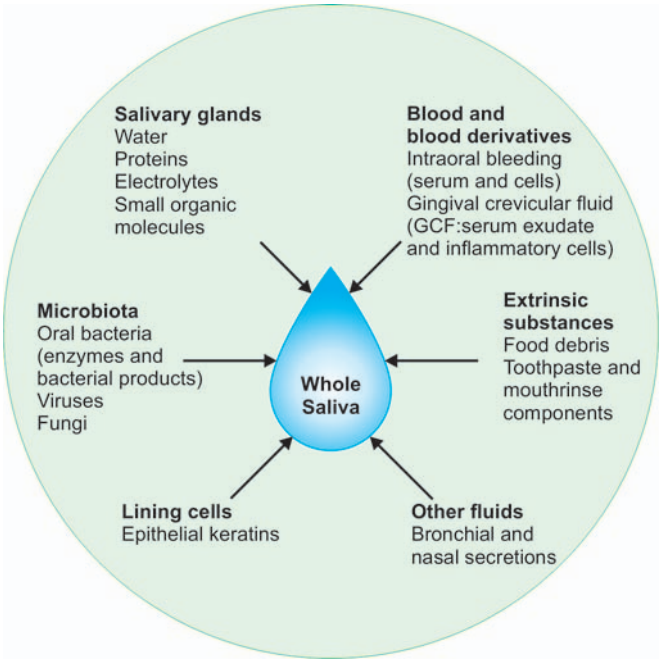
Normal daily production is around 1–1.5 liters. (1 cc/min) 45% is produced by parotid glands, 45% by submandibular glands and 5% each by sublingual and minor salivary glands. Saliva is produced at a low basal rate throughout the day, with flow increasing 10-folds during meals.

Saliva contents 98–99.5% water. The immunoglobulins, lysozymes, lactoferrin, sialoperoxidase, histamine and many other proteins—mucopolysaccharides and glycoproteins, contribute for the antibacterial property of the saliva. There are biologically active peptides, like epithelial growth factor, nerve growth factor and stomatostatin, which help in maintaining the integrity of the oral mucosa. They also help in wound healing.

The enzymes such as the salivary amylase, lipase, etc. are important in the digestive action.

Opiorphin: It is a newly researched pain killing substance found in human saliva.

Flowchart 39.1: Whole saliva production



Effects of aging: Total salivary flow independent of age and acinar cells degenerate with age. Submandibular gland is more sensitive to metabolic/physiologic change. Unstimulated salivary flow is more greatly affected by physiologic changes.

Calculus formation: Several proteins in the saliva influence the formation of calculus on the teeth. There are some other proteins like statherins, which will inhibit the formation of calculus by preventing crystallization of supersaturated calcium phosphate in ductal saliva and oral fluids. Phytate and magnesium are also protein inhibitors of apatite crystallization, by chelating the released ionized calcium.

CLASSIFICATION OF SALIVARY GLAND DISEASES

Salivary gland diseases may be grouped as follows **(Table 39.3)**.

The other detailed classification also can be considered **(Table 39.2)**.

Flowchart 39.2: Functions of saliva in relation to its constituents

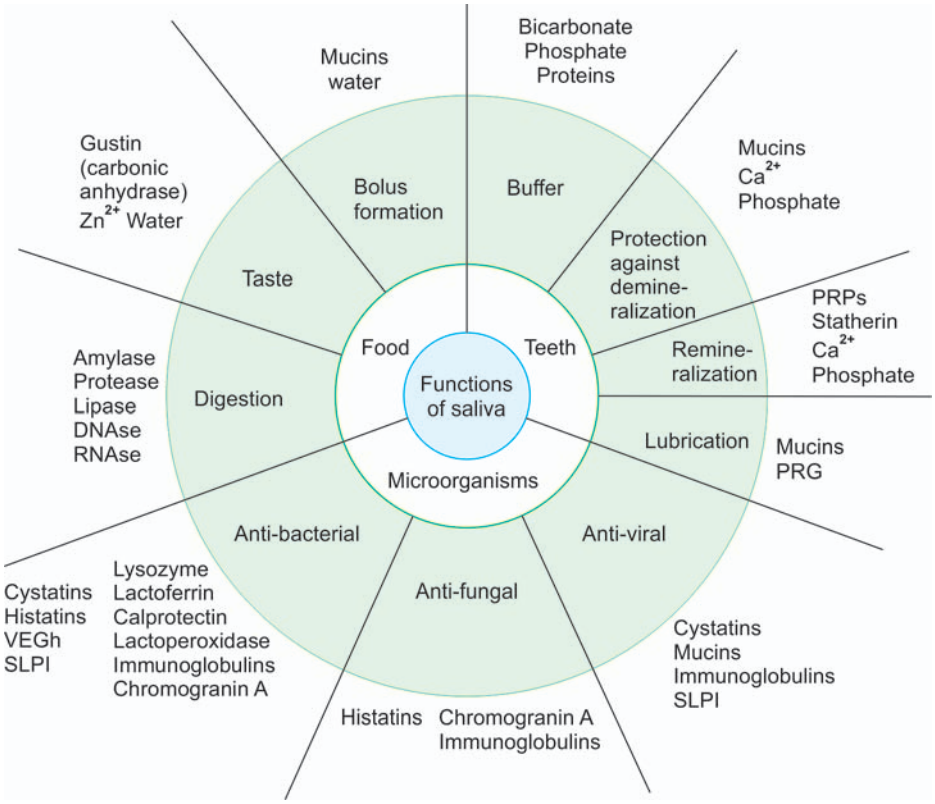


Table 39.2: General and etiological classification of salivary gland disorders

A. General classification

1. *Developmental anomalies:*
   a. Aplasia/agenesis
   b. Atresia of ducts
   c. Hypoplasia
   d. Congenital fistula
   e. Aberrancy
   f. Accessory ducts and lobes
2. *Inflammatory (sialadenitis):*
   a. Bacterial: (i) Acute (ii) Chronic, (iii) Recurrent parotitis of childhood
   b. Specific infections
   c. Allergic
   d. Viral: (i) Mumps (ii) Salivary inclusion disease
   e. Postirradiation
   f. Sialadenitis of minor glands
3. Obstructive and traumatic:
   a. Papillary obstruction of duct
   b. Obstruction of duct lumen, e.g. sialolithiasis
   c. Obstruction due to changes in and around duct wall, e.g. strictures, stenosis, ductal atresia
   d. Salivary duct fistula
   e. Frey's syndrome
   f. Mucocele (i) Mucous extravasation cyst, (ii) Mucous retention cyst, (iii) Ranula: (a) Superficial, (b) Deep, (c) Plunging
4. *Changes in salivary secretion and composition in disease:*
   a. Functional disorders of salivary glands
   b. Factors influencing salivary flow rate
   c. Xerostomia/dry mouth
5. *Ptyalism (sialorrhea):*
   a. Acute inflammatory conditions, e.g. abscess, herpes infection, aphthae
   b. Tooth eruption
   c. Mental retardation
   d. Parkinsonism
   e. Schizophrenia
   f. Epilepsy
   g. Hg poisoning
   h. Acrodynia
   i. Rabies
   j. Familial dysautonomia
6. *Tumors and tumor-like lesions:* The revised WHO histological classification of salivary gland tumors and tumor-like lesions:

   a. Benign-adenomas: (i) Pleomorphic adenoma, (ii) Myoepithelioma (myoepithelial adenoma), (iii) Basal cell adenoma, (iv) Warthin tumor (adenolymphoma), (v) Oncocytoma (oncocytic adenoma), (vi) Canalicular adenoma, (vii) Sebaceous adenoma, (viii) Ductal papilloma: (1) Inverted ductal papilloma (2) Intraductal papilloma (3) Sialadenoma papilliferum, (ix) Cystadenoma: (1) Papillary cyst adenoma (2) Mucinous cystadenoma

   b. Carcinomas: (i) Acinic cell carcinoma, (ii) Mucoepidermoid tumor, (iii) Adenocystic carcinoma (cylindroma), (iv) Polymorphous low grade adenocarcinoma (terminal duct adenocarcinoma), (v) Epithelial-myoepithelial carcinoma, (vi) Basal cell carcinoma, (vii) Sebaceous carcinoma, (viii) Papillary cystadenocarcinoma, (ix) Mucinous adenocarcinoma, (x) Oncocytic carcinoma, (xi) Salivary duct carcinoma, (xii) Adenocarcinoma (not otherwise specified), (xiii) Malignant myoepithelioma (myoepithelial carcinoma), (xiv) Carcinoma in pleomorphic adenoma), (xv) Squamous cell carcinoma, (xvi) Small cell carcinoma, (xvii) Undifferentiated carcinoma, (xviii) Other carcinomas

   c. Nonepithelial tumors—Angioma, lipoma, neural tumors

   d. Malignant lymphomas

   e. Secondary tumors

   f. Unclassified tumors

   g. *Tumor-like lesions:* (i) Sialoadenosis, (ii) Oncocytosis, (iii) Necrotizing sialometaplasia, (iv) Benign lympho-epithelial lesion, (v) Salivary gland cysts, (vi) Chronic sclerosing sialadenitis of submandibular gland (küttner tumor), (vii) Cystic lymphoid hyperplasia in AIDS
7. *Autoimmune disorders:* (i) Sjögren's syndrome, (ii) Benign lymphoepithelial lesions: (a) Godwin's (b) Mikulicz disease
8. *Degenerative disorders:* (a) Hormonal: (i) Diabetes, (ii) Acromegaly, (iii) Gynecomastia, (iv) Pregnancy, (v) Menopause (b) Neurohumoral disorders (i) Cardiac spasm, (ii) Gastric spasm, (iii) Bronchial asthma, (c) Dysenzymaticsialosis (Hepatogenic), (d) Sialosis: (i) Metabolic, (ii) Drugs, (iii) Hormonal and, (iv) Hypoglycemic, (v) Malnutrition, (e) Sjögren's syndrome: (i) Primary, (ii) Secondary, (iii) Aggressive, (f) Lymphoepithelial lesions: (Currently, Mikulicz disease: Sjögren's syndrome and Mikulicz syndrome: Mostly lymphomas)
9. Age changes and oncocytosis

B. Etiological classification

(a) Factors influencing salivary center: (i) Emotions: Fear, excitement, depression, (ii) Neurosis: Endogenous depression (iii) Organic disease: Brain tumor, (iv) Drugs—atropine (b) Factors affecting autonomic outflow pathway: (i) Encephalitis, (ii) Brain tumor, (iii) Accident (trauma to autonomic system), (iv) Neurosurgical operation, (v) Drugs—atropine, (c) Factors affecting salivary gland function: (i) Aplasis (ii) Sjögren's syndrome, (iii) Obstruction, (iv) Infection, (v) Irradiation, (vi) Excision (d) Factors producing changes in fluid and electrolyte balance: (i) Dehydration, (ii) Diabetes insipidus, (iii) Cardiac failure, (iv) Uremia, (v) Edema (e) Ptyalism (Sialorrhea): (i) Acute inflammatory conditions, e.g. Abscess, Herpes infection, Aphthae, (ii) Tooth eruption, (iii) Mental retardation, (iv) Parkinsonism, (v) Schizophrenia, (vi) Epilepsy, (vii) Mercury poisoning, (viii) Acrodynia, (ix) rabies, (x) Familial dysautonomia

Table 39.3: Classification of salivary gland diseases

A.	***Developmental-congenital***
	1. Aplasia—absence of the gland
	2. Atresia—absence of the duct
	3. Aberrancy—ectopic gland
	4. Hyperplasia
	5. Congenital fistula
B.	***Enlargement of the gland***
	1. Inflammatory-acquired
	a. Viral: Mumps, coxsackie virus A, CMV, echovirus, parainfluenza virus I and influenza virus
	b. Bacterial, fungal
	c. Allergic
	d. Sarcoidosis
	e. Obstructive
	2. Noninflammatory
	a. Autoimmune: Sjögren's syndrome and Mikulicz's disease
	b. Alcoholic cirrhosis
	c. Diabetes mellitus
	d. Nutritional deficiency
	e. HIV associated
C.	***Cysts***
	a. Extravasation cysts
	b. Retention cysts
	c. Ranula
D.	***Tumors of salivary glands***
	1. Benign tumors:
	a. Pleomorphic adenoma
	b. Warthin's tumor
	c. Basal cell adenoma
	d. Myoepithelioma
	e. Canalicular adenoma
	f. Ductal papilloma
	2. Malignant tumors
	a. Mucoepidermoid carcinoma
	b. Adenoid cystic carcinoma
	c. Malignant pleomorphic adenoma
E.	***Necrotizing sialometaplasia***
F.	***Salivary gland dysfunction***
	1. Xerostomia
	2. Sialorrhea

SALIVARY GLAND DYSFUNCTION

Sialorrhea or Ptyalism

It is excessive salivation seen in affected patients. It can be mild, intermittent or continuous profuse drooling. It can cause severe drooling, choking and social embarrassment to the patient. This condition is not so common and can occur due to various causes. Minor sialorrhea can be seen due to local irritation like aphthous ulcers or ill-fitting dentures. Idiopathic paroxysmal sialorrhea will have short episodes for 2–5 minutes. Profuse salivation is seen in rabies, heavy metal poisoning or after certain medications like lithium and cholinergic agonists. Mentally retarded children also have excessive salivation. Neurologically disabled persons (cerebral palsy) also suffer from this disorder. Drooling of the saliva is also seen after the resection of the mandible, because of poor neuromuscular control. The treatment is conservative. Anticholinergic medication can be tried (atropine). Behavioral modification, physical therapy has been tried.

Suggested Surgical Treatment

- Submandibular gland resection
- Transposition of parotid duct
- Parotid duct ligation
- Tiigimae-Saar et al., in 2012, injected botulinum neurotoxin type A into the major salivary glands to produce xerostomia. It reduced drooling but required GA and the effect lasted for only 2 months.

Xerostomia

This is a subjective sensation of a dry mouth. It affects women more than the men, and seen more commonly in older people, because of decreased glandular secretion due to aging as well as due to some medications which reduce the secretion. Antihistamines, decongestants, antidepressants, antipsychotics, antihypertensives, anti-cholinergics are known to cause xerostomia.

Other causes of xerostomia are—salivary gland aplasia, aging, excessive smoking, mouth breathing, local radiation therapy, Sjögren's syndrome, HIV infection, etc.

Clinically, dry mouth with foamy, thick, ropy saliva can be noticed. The tongue may have leathery appearance and fissures with atrophy of the filiform papillae. These patients are more prone for oral candidiasis due to reduction in cleansing and antimicrobial action of saliva. Dental decay is rampant with more of cervical and root caries.

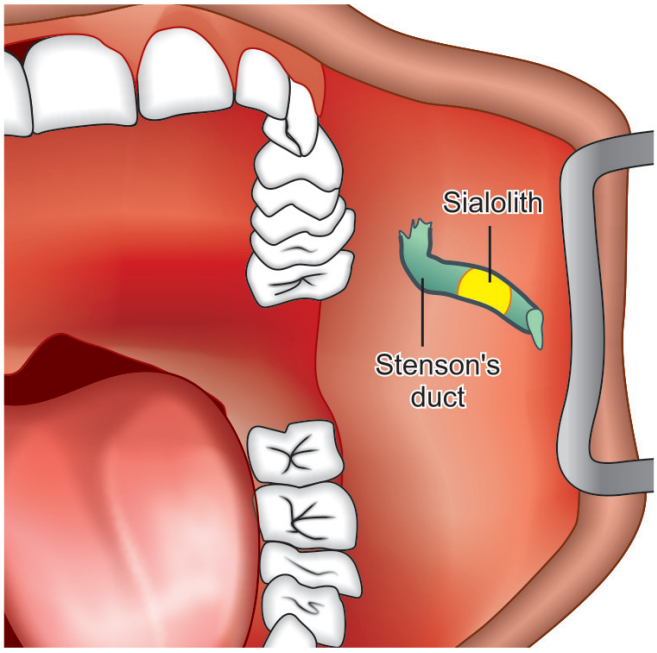


Fig. 39.6: Intraoral view of Stenson's duct and sialolith in the duct

Treatment is conservative, maintenance of oral hygiene, use of sialogogues (pilocarpine), systemic pilocarpine—5–10 mg, 3/4 times daily, sugarless gum chewing, topical fluoride application to the teeth, bromhexine 8 mg tds in adults, modification of medications in elderly patients may help to improve the condition.

SIALOLITHIASIS (FIG. 39.6)

Sialolithiasis is the formation of sialolith (salivary calculi, salivary stone) in the salivary duct or the gland resulting in the mechanical obstruction of the salivary flow.

Sialolith is a calcareous substance, which may form in the parenchyma or the duct of the major or minor salivary glands. Sialolithiasis accounts for more than 50% of the diseases of major salivary glands, and is the most common cause of acute and chronic infections of the salivary glands. It occurs usually from the 3rd to 5th decades of life. It is seen slightly more in males (4:3). Though any of the salivary ducts may be obstructed by the formation of the sialolith, about 80–94% of the sialoliths form in the submandibular duct or gland, 5–18% in parotid duct or gland and 2% or less in sublingual gland. Simultaneous sialolithiasis in more than one salivary gland is rare. Bilateral occurrence of the same gland is also rare. However, multiple sialoliths in the same duct or gland is common. The exact pathogenesis of sialolithiasis remains unknown. The following factors are thought to be responsible:

- Dehydration—increases the viscosity and concentration of saliva
- Reduced food intake/fasting/anorexia—decreases the demand for saliva, can bring about stasis of saliva.
- Certain drugs/medications lower the production of saliva, like antihistamines, antihypertensives, antipsychotics, antidepressants, anticholinergics, diuretics, etc.
- Some circumstances also bring about lack of saliva like aging, inflammation; local irritation, Sjögren's syndrome xerostomia, tobacco smoking, hypercalcemia, radiotherapy of the head and neck region. All these can cause stagnation of saliva leading to the build up of an organic nidus, which eventually will calcify. Though the metabolic cause for their formation is suggested, it is not yet established. Gout is the only systemic disease known to cause salivary calculi and these are composed of uric acid.

The predisposing factors are:

- Alkaline pH of saliva
- Long tortuous duct, situated at lower level than its orifice, increases the stagnation of saliva
- Neurohumoral condition leading to salivary stagnation
- A nidus or matrix for calculus formation
- Some metabolic mechanism may favor precipitation of salivary salts into the matrix in the presence of coexisting inflammation.

The most common site for a sialolith is submandibular gland and Wharton's duct, probably, as a consequence of its more alkaline, mucinous thicker secretion, a tortuous duct, uphill course-gravity and a dependent gland, a wider lumen, the smaller and tighter orifice of the duct. (This is because the long, curved Wharton's duct has increased chance of entrapment of organic debris, plus the secretion of this gland is higher in calcium and phosphate content and more alkaline and thick mucoid in consistency and the position of the gland increases the chances for the stagnation of the saliva).

Sialolith: The sialolith is a calcified mass with laminated layers of the inorganic material, around a central nidus. It results from the crystallization of salivary solutes. (Initially organic nidus, which increases in size progressively by deposition of layers of inorganic and organic substances) Stone composition—inorganic at the periphery. The minerals are various forms of calcium phosphate like hydroxyapatite, octacalcium phosphate, etc. Calcium and phosphorus ions are deposited on the organic nidus, which is in the center, which may be, desquamated epithelial cells, bacteria, foreign particle or product of bacterial decomposition, glycoproteins, mucopolysaccharides, etc. The foreign bodies reported in association with sialolith

formation, include tooth brush bristles, finger nail sliver, wood splinter, hair, blade of glass and fish bones. It is said that the sialoliths grow at the rate of 1 mm/year. The sialolith is yellowish white in color, single or multiple, may be round, ovoid or elongated having the size of 2 cm or more in diameter. Commonly reported size is 1–10 mm, but giant sialolith greater than 3.5 cm are also seen. Ledesma-Montes et al. reported only 16 cases of giant sialoliths ranging from 1.5 cm to 7 cm.

Clinical Features

Sialolithiasis may occur at any age; common in the middle aged persons. It is the most common salivary gland disease in adults and second most common salivary gland disease in children (after mumps). It is the major cause of unilateral diffuse (or focally enlarged in the duct) parotid or submandibular gland swelling.

Meal time syndrome: When a duct of the major gland is involved, there is moderate to severe pain with the psychic stimulation of the salivary flow. Patients complain of pain and swelling during and after eating the food, when saliva production is at its peak. In some instances the swelling is diffuse and resembles cellulitis. Then there is gradual reduction of pain and swelling, which occurs at the resting period. It recurs again repeatedly, when flow is stimulated. Recurrent episodes continue till complete obstruction and/or infection sets in. The obstruction of the duct by the sialolith causes prevention of salivary flow and increased pressure producing severe pain. Acute phase needs management at the earliest. Secondary infection often supervenes with fever. Tenseness, tenderness, trismus, decreased or absence of salivary flow, or purulent discharge at the orifice of the duct may be present.

On careful bimanual palpation/examination, of the floor of the mouth, along the duct, may reveal the presence of the stone. There is inability to milk saliva from the duct orifice. Occassionally, the sialolith presents no remarkable symptoms, and the only evidence may be firm, palpable mass in the duct or gland, particularly in the most peripheral portion of the duct, and if they are of sufficient size.

Investigations

- **Radiographs:** AP view, lateral, lateral oblique mandibular view for sialolith in the hilum or substance of the gland, or mandibular occlusal view for sialolith in the Wharton's duct.
- 80–90% submandibular stones are radio-opaque, 30% stones are multiple, 20–43% radiolucent.
- 50–80% parotid stones are radiolucent, 60% stones are multiple
- Intraglandular or small stones may be missed, because they are radiolucent and they are removed via sialadenectomy.
  - 15–20% sialoliths appear as elongated, smooth cylindrical radiopaque structures in the duct and round or oval, when located in the gland.
- Xeroradiography is used for radiolucent sialoliths.
- Scintigraphy, MRI also can be used in selected cases.
- Ultrasonography-operator dependent, can detect small greater than 2 mm stones, inexpensive, noninvasive method
- **Sialography:** The radiographs demonstrate the presence of salivary calculi, which can be appropriately located by the sialography.
- **CT scan:** Useful for chronic problems associated with gland enlargement.

Complications

- Bacterial infection of the gland may result in the obstruction of long duration. Chronic recurrent sialoadenitis and acute suppurative sialoadenitis.
- **Sialoangiectasis:** Dilatation of the gland and the duct system can happen because of the stasis of the saliva. It may be due to a sialolith, a stricture or chronic infection of the gland.
- The retention of the saliva may result in the formation of mucoceles, especially the mucous retention phenomenon.
- Rarely, the complete obstruction of the duct may result in the atrophy of the gland.

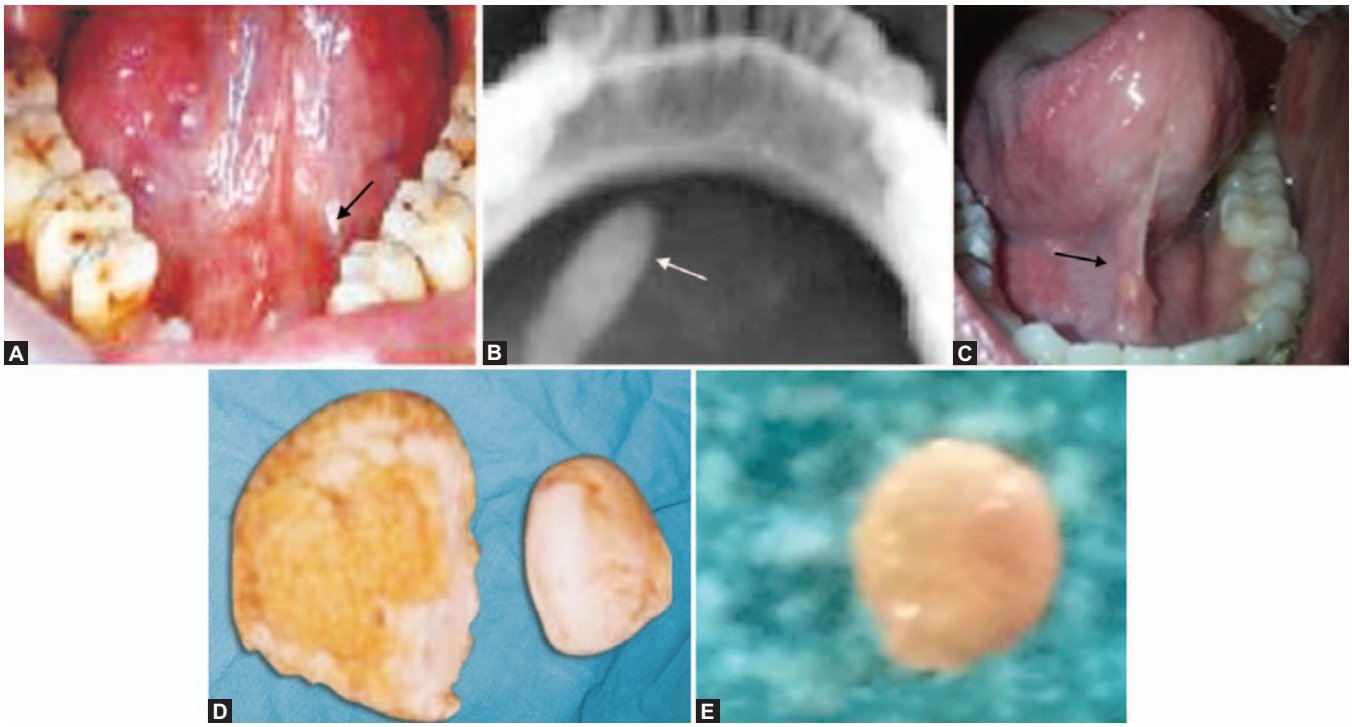
Management

The treatment depends on the number, size, and location of the sialolith. If the sialolith is small and single, conservative management is attempted with local heat, massage and sialogogues.

In case of infection, initially antibiotics and anti-inflammatory medication and enhanced use of sialogogues, sour food intake, salivary gland massage, hyperhydration, hoping for spontaneous passage of the stone.

There are several techniques available for the removal of the sialolith. A suitable procedure is selected depending upon the number, size, and site of the stone in the duct or the gland and age of the patient, etc.

- The smaller sialoliths, which are located peripherally near the ductal opening, no further than 2 cm, may be removed by manipulation (called milking the gland), with the aid of lacrimal probes or dilators **[Fig. 39.7(I)]**



Figs 39.7(I) A to E: Submandibular duct sialoliths near the orifice of the duct are removed with manipulation-milking the duct. (A) Patient number 1-intraoral view; (B) Occlusal X-ray; (C) Another patient- intraoral view; (D) Recovered sialolith; (E) Small salivary stone milked out

- Larger sialoliths in the anterior part are surgically removed, by sialolithectomy through a ductotomy, performed intraorally, under LA. Posterior stones are removed under GA.
- Sometimes, the stones, which are not impacted, may be extracted through the intubation of the duct with fine soft plastic catheter and application of the suction to the tube.
- **Ductal cannulation:** The pediatric cannula is inserted into the duct after removal of the stone, and two layer suturing is done, first to suture the duct, over the cannula, to keep the duct intact and orifice patent and then superficial mucosa layer. This maintains the anatomical continuity of the duct and prevents stenosis and restores the function of the entire gland. The cannula is kept in place for 2–4 weeks, by securing it to adjoining oral mucosa with a suture.
- Multiple stones or stones in the gland, very posterior stones, failed transoral route, require the removal of the gland. Extraoral approach—GA.

Two approaches to avoid surgery:

1. Some investigators have successfully used modern techniques like extracorporeal piezoelectric shock wave (ESW) lithotripsy —to fragment the salivary stones. Noninvasive method of application of shock waves from an externally applied lithotripter, which causes fragmentations of the stone. The fragments pass through the duct, as the salivary flow is stimulated and enhanced by the use of sialogogues. The first report on the use of shock waves to fragment sialoliths was by Marmary in 1986. In the ESW therapy, the average size of fragments produced was about 0.7 mm.
2. **Intracorporeal interventional sialendoscopy or endoscopic lithotripsy:** It is minimally invasive technique, in which shock waves are delivered directly to the surface of the sialolith lodged within the duct, without damaging the adjacent structures, such as Nahlieli sialendoscope Karl Storz, Germany (A 0.8 mm nematoblastic lithotripter probe is used in the working channel to ablate the stone). It can retrieve stones, may also use laser to fragment stones and retrieve.

Transoral sialolithotomy of the submandibular duct (Figs 39.7(II) to 39.8(I) and (II), and 39.9): Transoral sialolithotomy is the best procedure to surgically remove

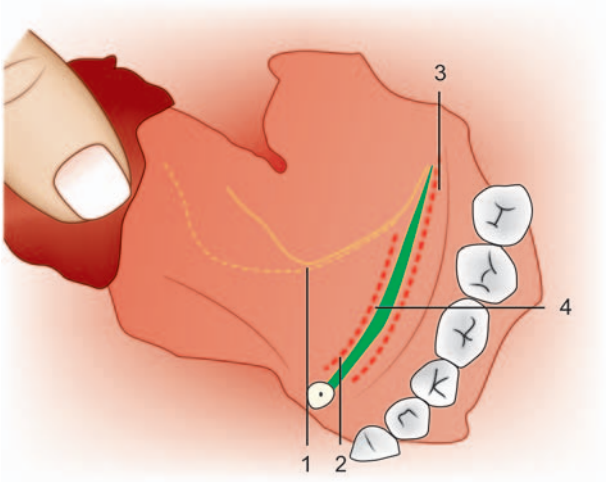


Fig. 39.7(II): Transoral sialolithotomy of submandibular salivary gland duct: (1) Lingual nerve—superficial course; (2) Incision for anterior stone; (3) Incision for posterior stone; (4) Submandibular duct

the submandibular duct stones. This procedure can be carried out under local anesthesia.

The exact site of the stone is located by X-rays and palpation. Following this, a suture may be placed behind the stone to prevent its backward movement. The tongue is lifted and held with the help of a gauze.

Incision is made in the mucosa parallel to the duct taking care not to injure the structures like the lingual nerve and the sublingual glands. After this, blunt dissection is carried out. The tissues are displaced to locate the duct. Once that part of the duct lodging the stone is identified, a longitudinal incision is made over the stone. The stone is removed using small forceps, in case the stone is large, it is crushed with the help of the forceps. Following this, a cannula may be passed to aspirate the pieces of stone, mucin, etc. The patency of the duct anterior to the surgical area should be ensured by passing a probe.

Sutures are placed at the level of the mucosa.

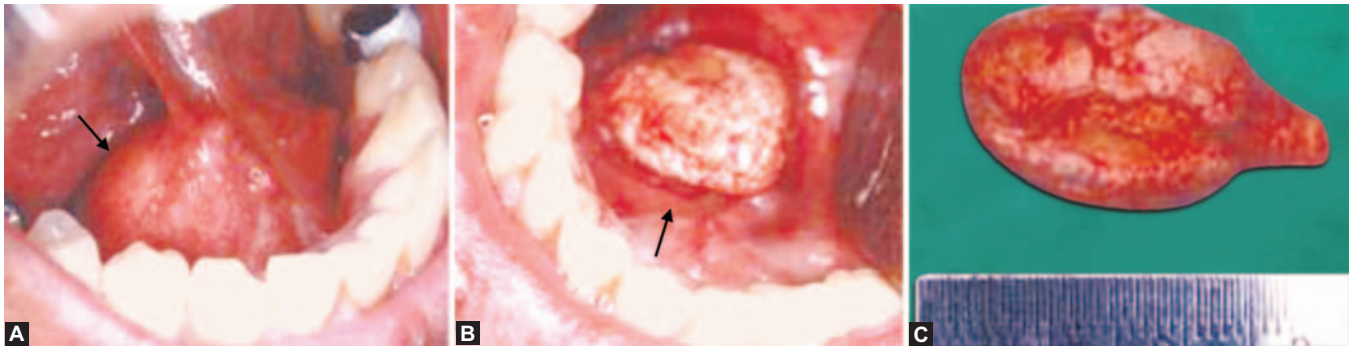
Sialadenitis

Inflammation of the salivary glands is known as sialadenitis. Pathogenesis—(1) Retrograde contamination of the duct and parenchymal tissues by bacteria inhabitating in the oral cavity. (2) Stasis of salivary flow promotes acute suppurative infection. Viral infections, bacterial infections, allergic reactions and systemic diseases are the major causes for sialadenitis. It may be acute or chronic.

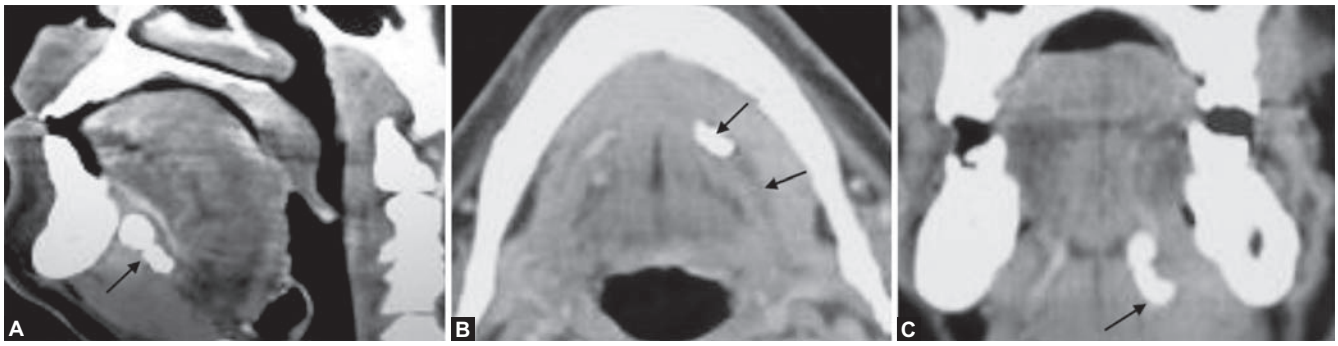


Courtesy: Dr Kumar Nilesh

Fig. 39.8(I) A to D: (A) occlusal view showing sialolith; (B and C) Transoral removal of sialolith; (D) Recovered sialolith



Figs 39.8(II) A to C: (A) Hard swelling in the right side of the floor of the mouth, in an anterior region. Note the inflamed Wharton's duct; (B) Sialolith from (R) Wharton's duct is being explored out; (C) Sialolith after the remova l from its bed



Figs 39.9A to C: Submandibular duct multiple sialoliths—CT scan. (A) Sagittal view; (B) Submental view; (C) Coronal view—all showing the presence of sialoliths.

Viral Infections

Mumps (epidemic parotitis) is the most common systemic viral infection affecting the salivary glands, which is caused by a paramyxovirus. It is an acute, contagious disease, spread by airborne droplets, enters through upper respiratory tract, usually affecting the parotid gland. Transmission can be through urine or saliva also. Occasionally, the submandibular or the sublingual glands may also be involved. 75% cases involve bilateral parotid glands, 25% will have unilateral involvement.

This disease is self-limiting one and not dangerous. In these days, the number of cases is reduced, because of the use of the mumps vaccine. It is a disease of the childhood, but when it affects the adults, it leads to greater complications.

Patients suffering from mumps give the history of local epidemic or contact with mumps' patients. This disease has the incubation period of 2–3 weeks. Patients are contagious up to 14 days after the resolution of the symptoms.

Clinical features: Initially, the patient may suffer from mild fever, headache, chills, vomiting, etc. followed by pain below the ear and sudden onset of firm, rubbery or elastic swelling of the salivary glands, frequently elevating the ear lobe. In viral parotitis, the glands of both the sides enlarge, which may be simultaneous or one following the other in 24–48 hours. There is excruciating ear pain during mastication. Xerostomia, trismus, cervical lymphadenitis, tender glands, edema of the overlying skin may also be present. These symptoms usually last for a week. The disease spreads through droplet dissemination as the virus is present in the saliva. Because of the inflammation of the glands, the salivary flow decreases, with the increase in viscosity and turbidity, which increases the chance of ascending infections.

The diagnosis is easy, when the above-mentioned features are present. In the absence of secondary infection, there is no suppuration and no pus discharge from Stenson's duct upon pressure on the gland; however, the papilla may be puffy and red.

Complications

- In adults, this viral disease may lead to the inflammation of gonads and central nervous system resulting in meningitis—10%, encephalitis, orchitis-testicular atrophy and sterility in 20% of young men, oophoritis in 5% females, epididymitis, deafness in less than 5%, permanent in 80% unilateral, myocarditis, thyroiditis, pancreatitis—in 5%, etc.
- In case of secondary infection, it leads to bacterial sialadenitis.

Investigations

- In acute phase, the serum amylase level is increased.
- Demonstration of the antibodies may confirm the disease.
- Urine, saliva and CSF can be sent for culture.

Differential diagnosis: Because the swelling can be near the angle of the mandible, one should not confuse mumps for an infectious swelling from lower molars.

Management: It is self-limiting. Symptomatic relief can be given by antipyretics. Antibiotics can be given to prevent the secondary infection.

Prevention: The live attenuated vaccine became available in 1967. It is commonly combined with the measles and rubella vaccines and the mumps vaccine is administered in a single subcutaneous dose after 1 year of age. Booster dose is given at 4–6 years of age.

Bacterial Infection

Bacterial infection can lead to the inflammation of major salivary glands. Depending on the onset, it may be acute



Fig. 39.10: Acute bacterial sialadenitis

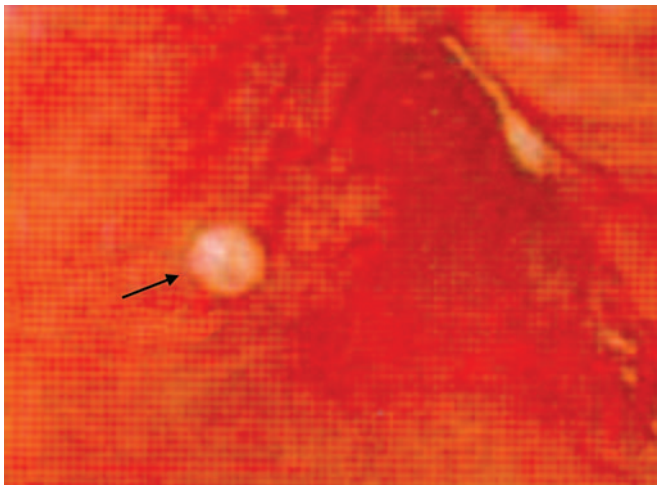


Fig. 39.11: Pus expressed from right parotid duct orifice

or chronic/recurrent. The bacterial sialadenitis affects the parotid gland more commonly; the submandibular glands are rarely affected.

Acute Bacterial Sialadenitis (Fig. 39.10)

The commensal organisms such as *Staphylococcus aureus*, *Streptococcus pyogenes*, *Streptococcus viridans*, *Pneumococcus*, *Actinomycetes*, etc. can cause the bacterial sialadenitis. It affects either the neonate and children or debilitated adults with poor oral hygiene. Some drugs like tranquilizers, anti-Parkinson drugs, diuretics, anti-histamines, tricyclic antidepressants, etc. decrease the salivary flow, with increased chance of infection of salivary glands.

Clinical features: The disease is characterized by sudden onset of pain at the angle of the jaw, which is unilateral. The affected gland is enlarged and tender and extremely painful. The inflammatory swelling is very tense and does not show much fluctuation. The overlying skin is warm and red. There is purulent discharge from Stenson's duct, which can be seen upon pressing the papilla **(Fig. 39.11)**. Patient might present with fever and other symptoms of acute inflammation.

Differential diagnosis: Bacterial sialadenitis can be differentiated from mumps by the discharge of pus at ductal opening.

Investigation: The leukocyte count is high—leukocytosis.

Sialography should not be performed in the presence of suppuration. The pus is collected from Stenson's duct taking care not to contaminate the swab with oral microfloa, for the culture and sensitivity test.

Management

- Antibiotics
- Palliative
  - Hydrating the patient
  - Stimulate the salivation by chewing sialogogues
  - Improve the oral hygiene by debridement and irrigation.
- If there is no improvement, surgical drainage may be done using needle aspiration guided by CT scan or ultrasonography.

Chronic Bacterial Sialadenitis (Figs 39.12 and 39.13)

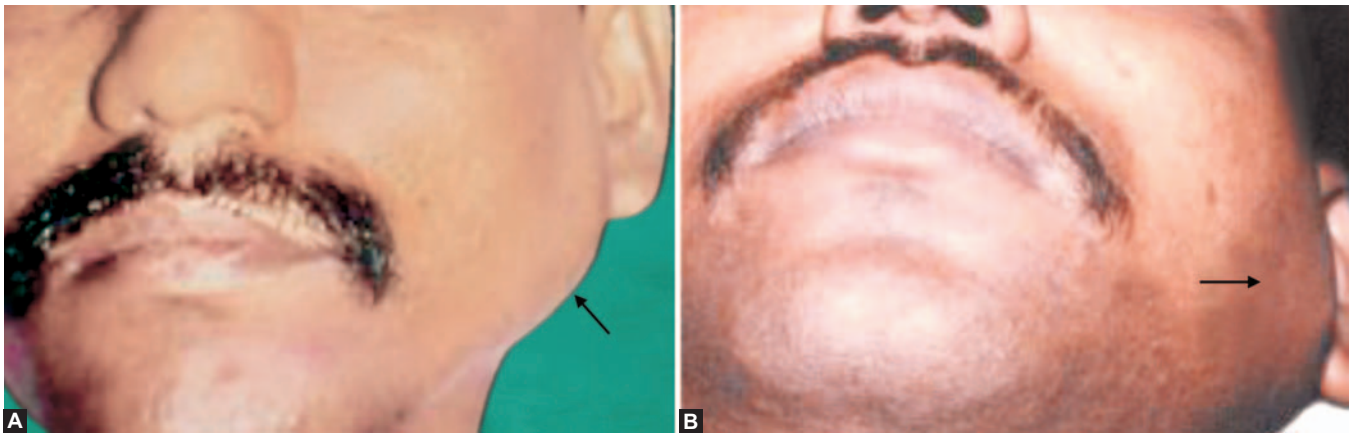
The chronic or the recurrent type of bacterial sialadenitis may be seen in children and adults. It may be idiopathic or with factors like duct obstruction, congenital stenosis, Sjögrens syndrome and viral infection. All these factors except the duct obstruction by stone are seen commonly in the parotid glands. The microorganisms may be *S. viridans*, *Escherichia coli*, *Proteus* or Pneumococci. Because these have low virulence, the changes are not sudden.

Clinical features: The disease starts as a unilateral swelling at the angle of the jaw.

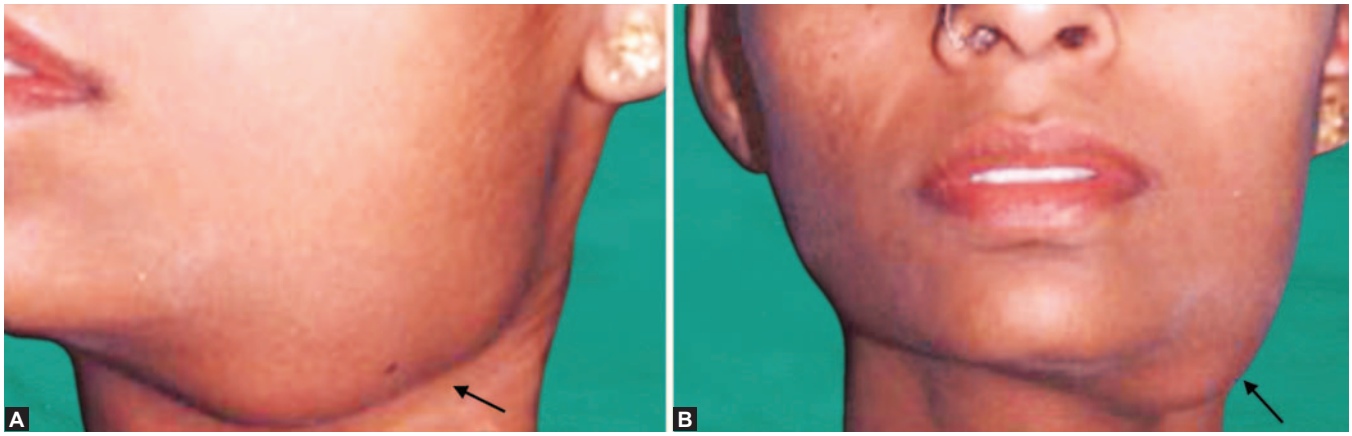
The recurrent sialadenitis shows periods of remissions. The gland may undergo atrophy, which results in decreased salivary flow.

Management

- Antibiotics
- Intraductal infusion of erythromycin or tetracycline
- Occluding ductal system with a protein solution
- In intractable cases, excision of the gland.



Figs 39.12A and B: Chronic bacterial sialadenitis of (L) parotid gland



Figs 39.13A and B: Chronic bacterial sialadenitis of left submandibular gland. Note the unilateral swelling at the left angle of the mandible

CYSTS OF THE SALIVARY GLANDS

The cysts of the salivary glands are known as "mucoceles". Muco-Mucous, Coele-Cavity.

Mucocele

This is a swelling due to the accumulation of saliva, as a result of obstruction or trauma to the salivary gland ducts.

Types

There are two types of mucoceles:

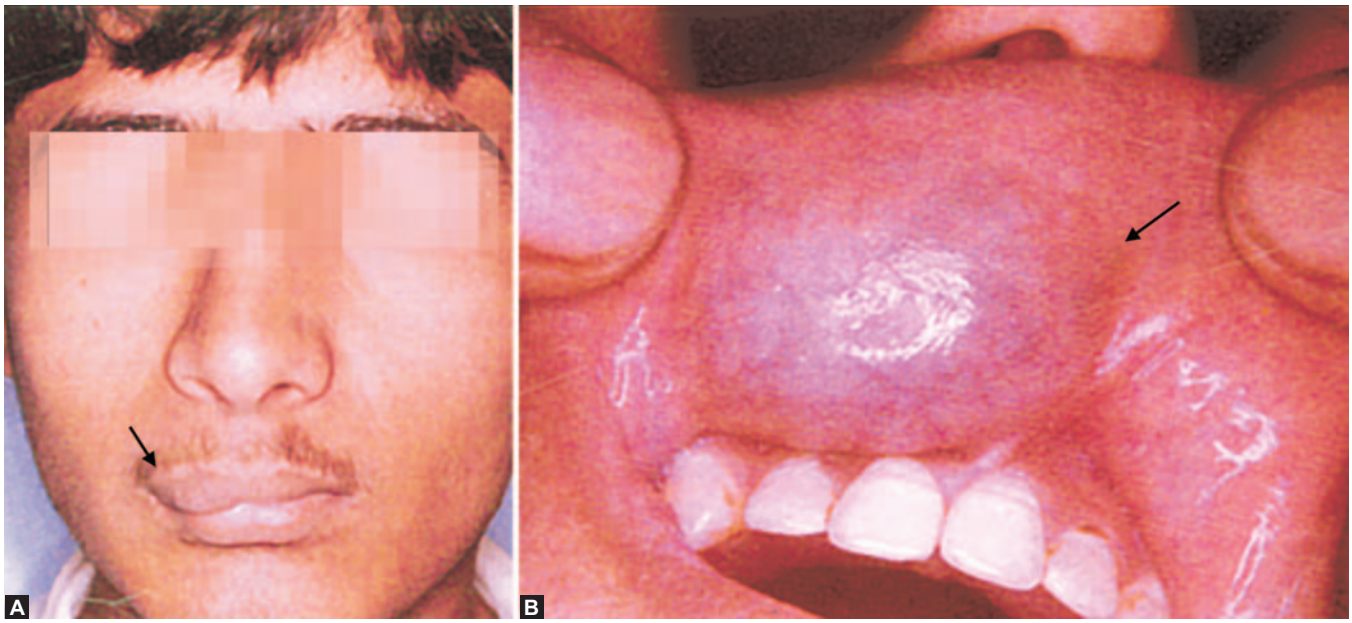
1. Extravasation type
2. Retention type.

These two types differ in the pathogenesis. The extravasation type is the common one.

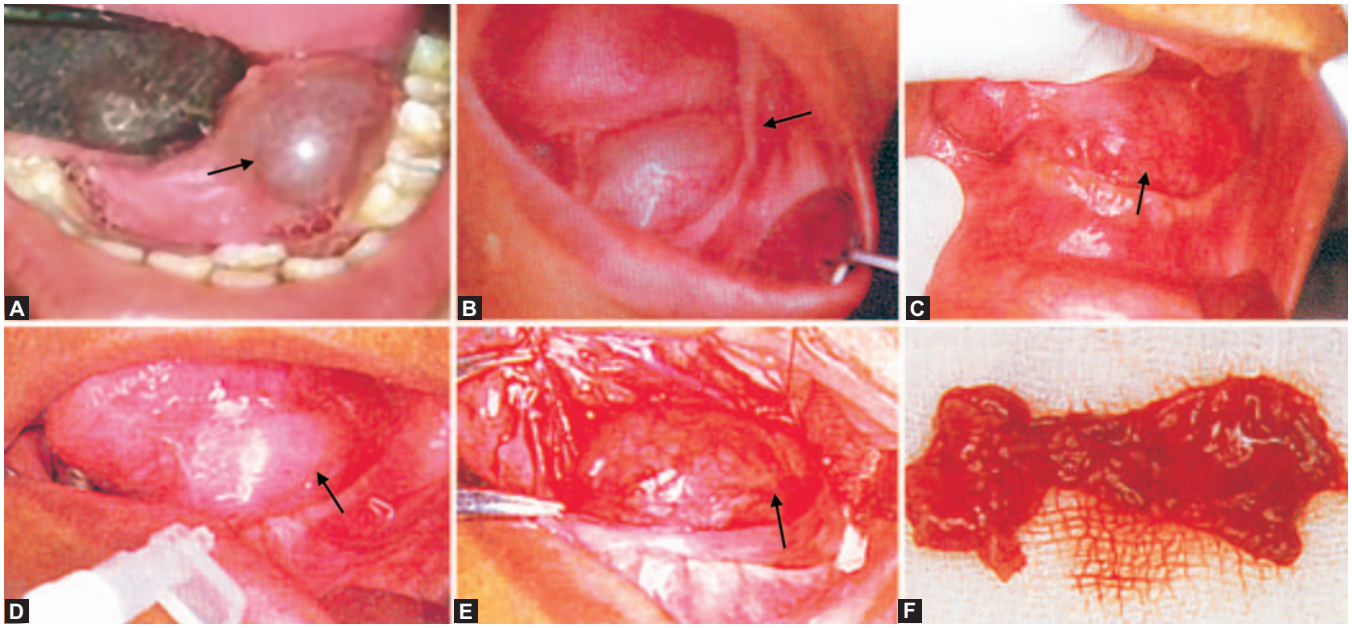
Pathogenesis

Mucous extravasation cyst is caused by trauma leading to the laceration of the duct, commonly of the minor salivary glands, resulting in extravasation of the mucin into the connective tissue. The trauma may be caused by biting of the lip, cheek, pinching of lip by extraction forceps, etc. The mucin which extravasates into the connective tissue, leads to inflammation, drawing the neutrophils and macrophages to the site, which in turn will result in the formation of the granulation tissue, which actually forms the wall of these extravasation cysts (no epithelial lining is seen). Finally scarring results in and around the gland.

Mucous retention cyst: In this case, it is the obstruction of the salivary duct, commonly because of a sialolith or may be due to periductal scar, or impinging tumor, resulting in the accumulation of the saliva in the duct. This leads to the dila-



Figs 39.14A and B: Mucocele of the upper lip—two different patients



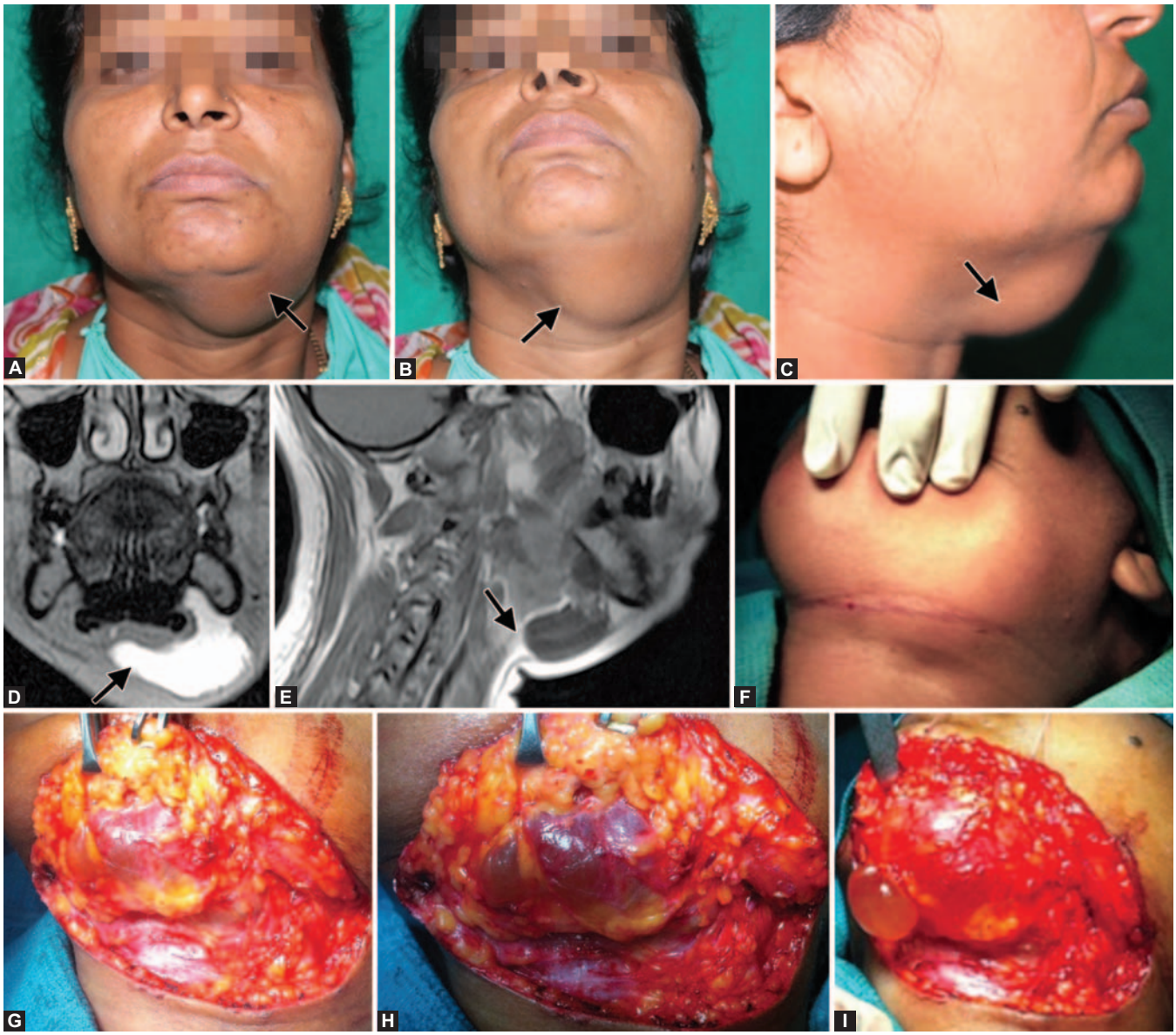
Figs 39.15A to F: (A) Ranula in a 10-year-old girl from sublingual gland; (B and C) Ranula in the floor of the mouth; (D) Cannulation of submandibular salivary duct; (E) Surgical excision of the ranula; and (F) Excised mass

tation of the duct resulting in a cyst like lesion. These cysts may show the presence of ductal epithelium histologically.

Clinical Features (Figs 39.14A and B)

Mucoceles occur as painless swellings, which may be recurrent (Some patients give the history of increase in size during meal time).

The common sites of occurrences of mucoceles, especially the extravasation type, are the lower lip and tongue, as they are the common sites for the trauma of the minor salivary glands. The retention type of mucocele is less common and rarely occurs in the lower lip. Instead, it occurs in palate, cheek, floor of the mouth and maxillary sinus.



Figs 39.16A to I: (A to C) Extraoral swelling over submental & left submandibular area since last one year; (D and E) MRI showing the Plunging Ranula; (F) Extraoral submandibular incision; (G) Subplatysmal dissection showing the superficial portion of the ranula; (H and I) Further dissection to expose the lesion

A well-demarcated lesion of the upper lip could be a salivary gland neoplasm than a mucocele.

The extravasation type occurs in 2nd decade and also in children. The retention type occurs in the middle-aged persons.

Based on the location clinically, there are two types of mucoceles:

1. Superficial
2. Deep type.

The superficial mucocele resembles a vesicle or a bulla. Since they are placed superficially, the bluish translucency is seen. They are fluctuant. Usually, these cysts are 4 mm to 1 cm in size. The wall is very thin and they rupture easily.

The deep mucoceles are covered by normal appearing mucosa, thus they are different from the superficial ones in the color. They are firm, well-circumscribed lesions and are present for longer period. Some lesions regress and enlarge periodically.

Differential Diagnosis

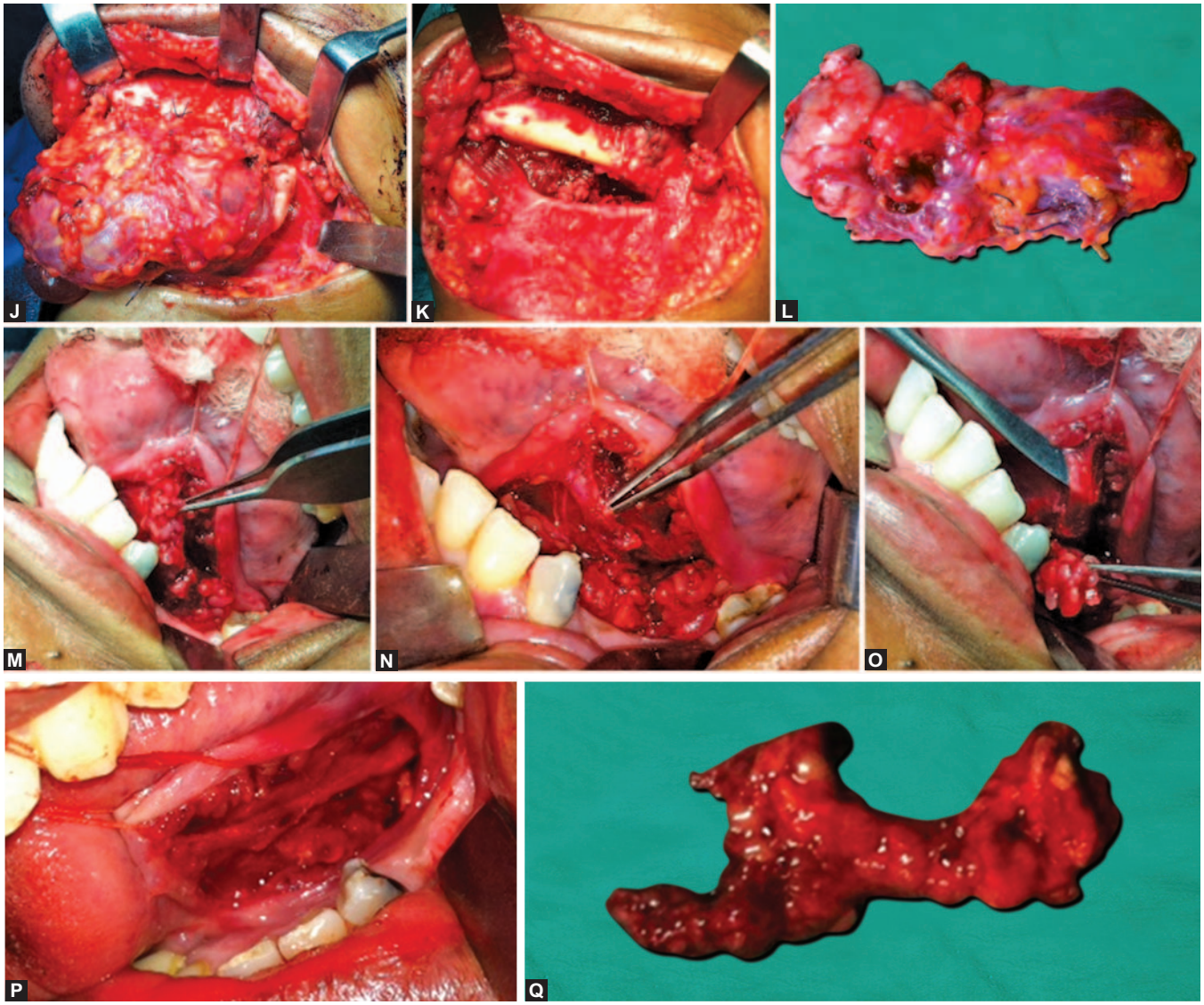
- Salivary gland neoplasms
- Vascular malformation
- Neurofibroma
- Lipoma.

Treatment

Mucoceles are treated by surgical excision. It is common to see the recurrence after excision. It can be minimized, if the associated salivary gland acini are also removed.

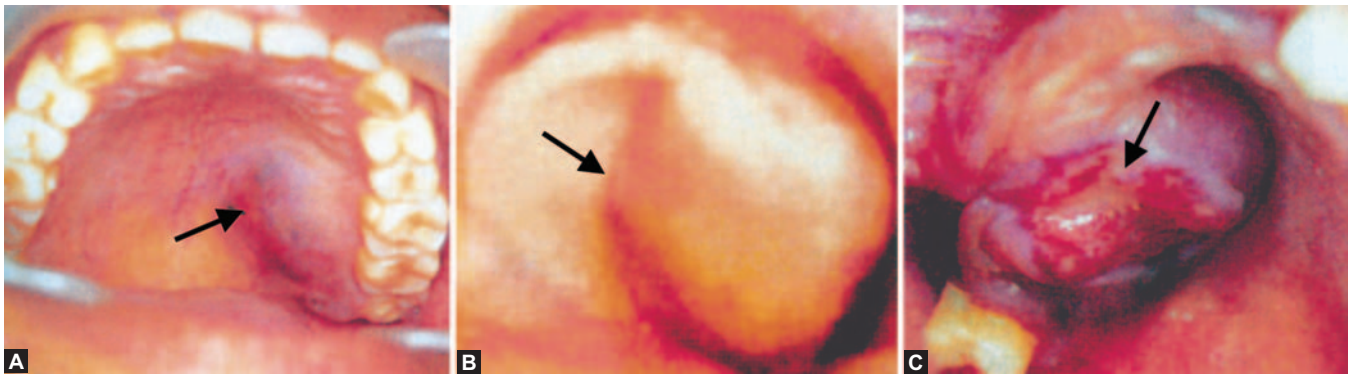
Ranula (Figs 39.15 and 39.16)

It is a special type of mucocele, which occurs in the floor of the mouth. Since the lesion appears like the translucent bluish dome, underbelly of a frog, it is called "**ranula**". (Rana-frog) Ranula is formed because of the trauma to submandibular or sublingual ducts. It starts as a painless swelling on one side of the floor of the mouth. The swelling is fluctuant, and nonpitting on pressure. It may be superficial or deep to the mylohyoid muscle. Superficial ranulas have bluish translucency, the deep



Courtesy: Dr. Kumar Nilesh

Figs 39.16J to Q: (J) Lesion dissected from surrounding attachments, facial vessels identified and ligated; (K) Submental and submandibular space, after excision of the lesion and submandibular gland; (L) Excised mass; (M) Incision over floor of the mouth; (N) Submucosal dissection, identification of submandibular duct, along the entire course; (O) Identification of sublingual gland and its dissection; (P) Site after the excision of sublingual gland; (Q) Excised sublingual gland along with remaining portion of ranula



Figs 39.17A to C: (A and B) Pleomorphic adenomas of the palate; (C) Ulceration is seen following biopsy of the lesion

ones have the color of the mucosa, soft in consistency and freely movable. When the size of the lesion is significantly large, it may produce the medial deviation and superior elevation of the tongue. A rare variety, which herniates through the mylohyoid muscle resulting as the swelling of the neck is called "**plunging ranula**". This develops as a result of mucous extravasation **(Fig. 39.16).**

Treatment

Large ranulas may be marsupialized. Due to large size of the ranulas, the mucosa, which is thinned out ultimately, ruptures when injured. The mucoid fluid spills into the connective tissues. As the area heals, the fluid accumulates, thus ranula may show remissions and reappearances. Sublingual gland removal via intraoral approach for simple ranula. Long-standing plunging ranula requires excision of both sublingual and submandibular gland along with the lesion to prevent recurrence, as shown in **Figure 39.16**.

Differential Diagnosis

- Angioma (not as firm as ranula)
- Lipoma (more firm than ranula)
- Dermoid cyst (in the midline, doughy feeling on pressure).

TUMORS OF THE SALIVARY GLANDS

The tumors of the salivary glands can affect the major and the minor glands. These tumors may be benign or malignant ones. Out of all the tumors of the salivary glands, nearly 75% of them involve parotid gland. 80% of parotid gland tumors are benign. 15% tumors are involving submandibular salivary gland—out of which 50% are benign and 50% are malignant. 10% of the total salivary glands tumors involve sublingual and minor salivary glands and 60–70% of them are malignant.

Benign Tumors

Pleomorphic adenoma, Warthin's tumor, basal cell adenoma, canalicular adenoma, oxyphilic adenoma, myoepithelioma, ductal papilloma, etc. are the benign tumors affecting the salivary glands.

Pleomorphic Adenoma

Pleomorphic adenoma constitutes more than 50% of all tumors and 90% of all the benign tumors of the salivary glands. It can affect both the major and minor salivary glands; it commonly affects the parotid gland (90% parotid, 7% submandibular gland, 3% rest of the glands).

This tumor has created lengthy arguments and spirited debate with regards to its histogenesis and management.

Most of the workers believe that the tumor arises from the myoepithelial cell of the salivary gland. The different tissue types of both epithelial and connective tissue elements are seen in the tumor giving the name "mixed tumor".

Clinical features (Figs 39.17A to C): Pleomorphic adenoma most commonly affects the parotid gland, followed by minor salivary glands of the palate, lip, less frequently affects the submandibular gland. Majority of the lesions are seen between 4th and 6th decades, more commonly in females. The tumor starts as a small painless nodule, either at the angle of the mandible or beneath the ear lobe. The nodule slowly increases in size, which may characteristically show intermittent growth. The tumor is well-circumscribed, encapsulated, firm in consistency, and may show areas of cystic degeneration. The tumor is readily movable without fixity to the deeper tissues or to

the overlying skin. The tumor can grow to a very large size, but does not ulcerate. Tissue destruction, pain or facial paralysis is not seen.

The intraoral pleomorphic adenomas, which affect the minor salivary glands of the palate, are noticed early, because of the difficulties in mastication, talking, etc. The palatal pleomorphic adenoma may show fixity to the underlying bone, but does not invade the bone.

Pleomorphic adenoma should be differentiated from other benign tumors and hyperplastic lymph nodes. Though the painless nodular, firm growth with no ulceration of the overlying skin, is suggestive of this tumor, it can be confirmed by biopsy. In case of minor salivary gland lesions, which are usually not more than 2 cm in diameter, it is better to perform excisional biopsy.

Differential Diagnosis

- Other adenomas like Warthin's tumor
- Lipoma
- Hyperplastic lymph nodes
- Neurilemmoma of the facial nerve.

Confirmation of the diagnosis is done by biopsy.

Treatment (Figs 39.18A to H): Pleomorphic adenomas are treated by surgical excision. The parotid tumors are removed with adequate margins, whereas the intraoral lesions can be treated little more conservatively. In case of submandibular tumors, excision of the gland with the tumor is performed.

The removal of pleomorphic adenoma should be performed with careful dissection and preserving the facial nerve in case of the parotid tumors. Also, one should take care not to spill any tumor tissue, as they are highly implantable.

Irradiation is contraindicated as the tumor is radioresistant.

Complications

- The incomplete excision of the tumor may lead to recurrence.
- The long-standing untreated benign pleomorphic adenomas may undergo malignant transformation. A tumor, which is hard, ulcerates and causes facial paralysis or lymph node involvement could have transformed into a malignant one.

Warthin's Tumor (Papillary Cystadenoma Lymphomatosum)

This benign tumor affects the parotid glands. Involvement of the submandibular or the minor salivary glands is very rare. Usually, males are affected more commonly in the 5th decade.

Recently, some investigators have highlighted the association of smoking habit in the pathogenesis of this tumor.

The tumor is seen as a firm, nontender, circumscribed mass in the region of angle or ramus of the mandible or beneath the ear lobe. Though both side parotid glands may be affected, the swelling might start on one side following the other.

Sialography: When the tumor attains sufficient size, the sialogram show nonfilling, space occupying, tissue displacing tumor. The diagnosis may be confirmed by biopsy.

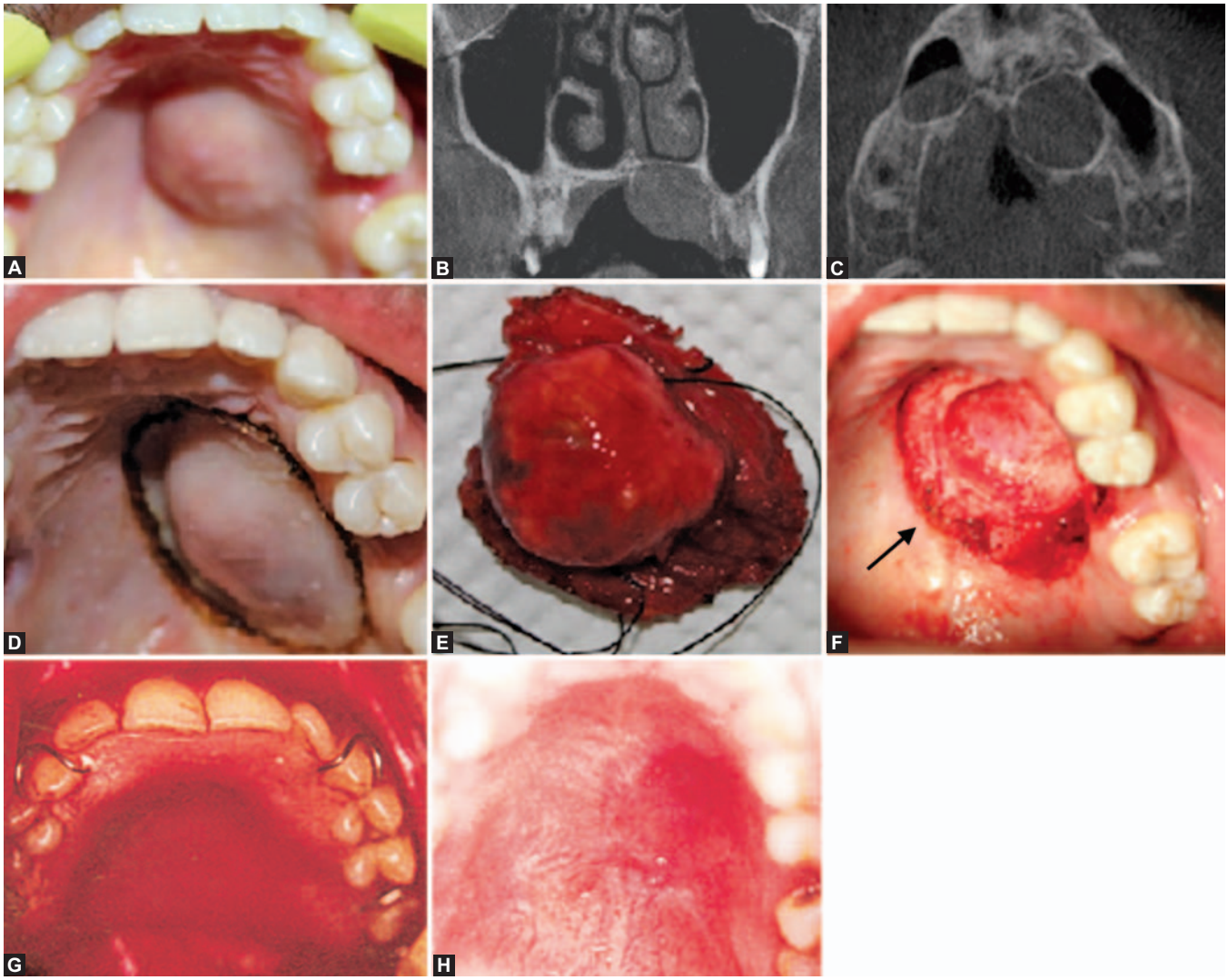
Treatment: The tumor is surgically excised.

Malignant Tumors

Mucoepidermoid carcinoma, adenoid cystic carcinoma, malignant mixed tumor and acinic cell carcinoma are the common malignant tumors occurring in the salivary glands. The malignant tumors can also affect both the major and the minor salivary glands. Usually the malignant tumors occur in elderly people of 50–60 years, i.e. 10 years more than the age group for benign tumors. Some malignant tumors may arise in younger age group, the most frequent one is mucoepidermoid carcinoma, which can affect the children also.

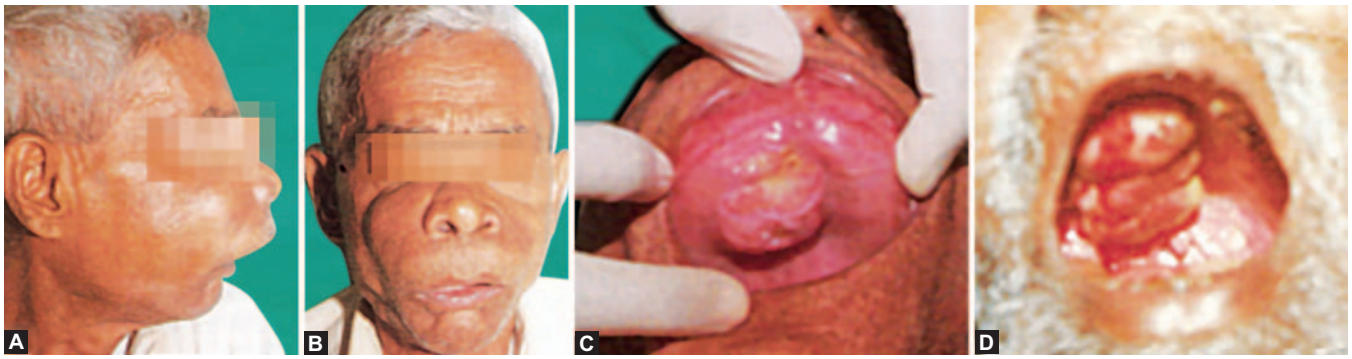
Mucoepidermoid Carcinoma

This malignant tumor of the salivary glands is famous for its varied biologic activity, which has created difference of opinion among research workers. The grading of mucoepidermoid carcinoma into low-grade, intermediate grade and high-grade has cleared the doubts about its behavior. The low-grade tumor behaves almost like a benign tumor with very good prognosis, whereas the high-grade tumor behaves very aggressive. It occurs with an equal distribution between males and females **(Figs 39.19A to C)**.



Courtesy: Dr Vidya Rattan

Figs 39.18A to H: Pleomorphic adenoma: (A) Painless growth on the palate of a 37-year-old male; (B and C) CT scan showing the extent of the lesion; (D) Intraoral marking of surgical excision; (E) Excised tumor specimen; (F) Denuded bone seen after removal of mass along with mucosa; (G) Raw area is protected by prefabricated splint; (H) Satisfactory wound healing with normal mucosal cover



Figs 39.19A to D: (A to C) high-grade mucoepidermoid carcinoma; (D) cylindroma

The clinical features depend upon the grade of the tumor. Thus, it may grow slowly or rapidly; usually as a painless swelling of the parotid or other major salivary gland, or in the minor salivary glands. Intraorally, it may affect the minor glands of the palate, buccal mucosa, tongue and retromolar areas. The high-grade tumor may produce pain, ulceration or facial paralysis, local destruction and metastasis to regional lymph nodes and distant metastasis to the lung, bone and to the brain in later stages.

It is common for intraoral mucoepidermoid carcinoma to undergo cystic degeneration, thus mimicking a mucocele clinically. The diagnosis should be confirmed by biopsy.

Intraosseous mucoepidermoid carcinoma: Mucoepidermoid carcinoma can occur intraosseously within the jaw bones; commonly in the mandible. The entrapped mucous glands, the epithelial cells of the odontogenic cysts or aberrant salivary glands present intraosseously may undergo neoplastic transformation. These tumors are similar in the behavior to the extraosseous variety.

Treatment: The tumor should be surgically excised and the excision should be more radical than for pleomorphic adenoma.

Adenoid Cystic Carcinoma (Fig. 39.19D)

The adenoid cystic carcinoma is also called as cylindroma, because of its histologic appearance. It may arise as a slow-growing swelling, sometimes may mimic a benign tumor clinically and histologically, but has greater potential for local destruction and invasiveness, commonly perineural invasion.

Treatment: Adenoid cystic carcinoma is treated by radical excision. As the tumor is radioresistant, irradiation is not a mode of primary treatment.

Other Malignant Tumors

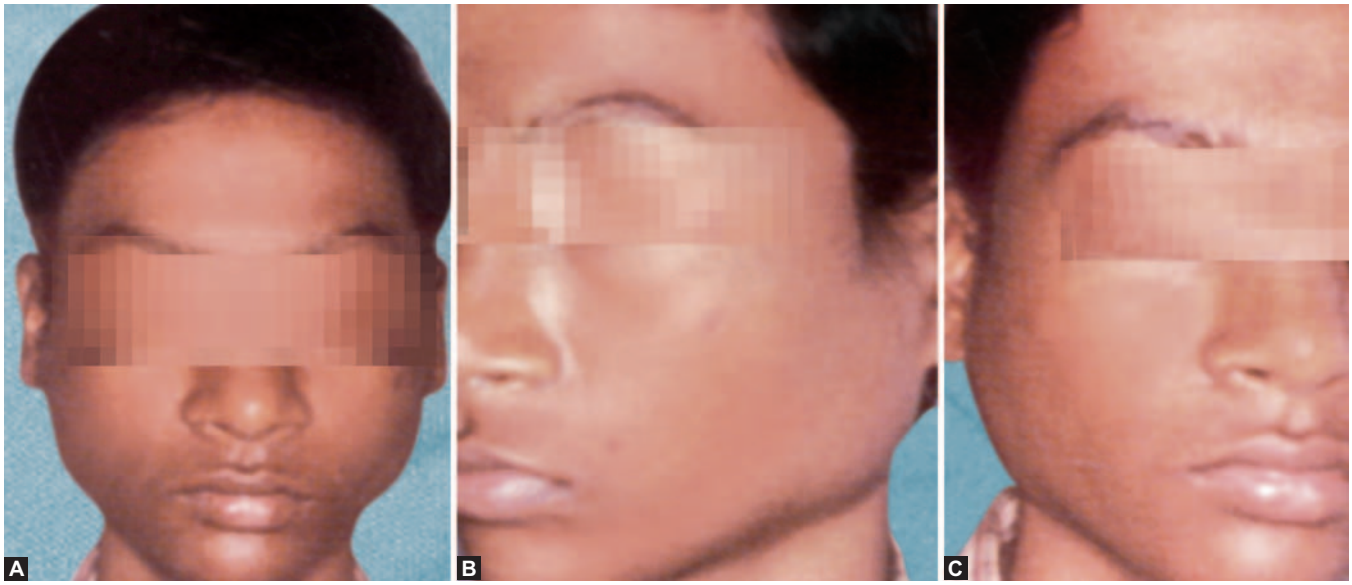
Basal cell carcinoma, papillary cystadenocarcinoma, serous cell adenocarcinoma, malignant oncocytoma, etc. are some of the other malignant tumors of salivary glands. These tumors are biologically aggressive and should be treated radically followed by irradiation.

NECROTIZING SIALOMETAPLASIA

Necrotizing sialometaplasia is an inflammatory lesion of unknown etiology, which affects the minor salivary glands. Trauma leading to ischemia, acinar necrosis and squamous metaplasia of the ductal epithelium is thought to be the pathogenesis. Since the lesion mimics a malignant lesion, both clinically and histologically, the diagnosis should be carefully done.

Clinical Features

Necrotizing sialometaplasia commonly occurs in men in 5th and 6th decade. Minor salivary glands of the palate; lip or retromolar pad may be affected. The lesion occurs as a



Figs 39.20A to C: Sialadenosis (sialoses)—bilateral, painless, noninflammatory, nonneoplastic swelling of the parotid glands in a 14-year-old male, since 6 years

large ulcer or ulcerated nodule, which is well demarcated from the normal tissue. The edge of the lesion presents with an inflammatory reaction.

Differential Diagnosis

Necrotizing sialometaplasia resembles the malignant lesions such as mucoepidermoid carcinoma, adenoid cystic carcinoma or squamous cell carcinoma.

Diagnosis should be confirmed by biopsy. One should include adequate amount of tissue in the biopsy, because this lesion can be confused histologically with malignancy.

Management

- Debridement by hydrogen peroxide or saline
- Application of gentian violet
- The lesion is self-limiting one and heals in 6–8 weeks.

SIALADENOSIS (FIGS 39.20A TO C)

There are several conditions which can produce noninflammatory, nonneoplastic swelling of the salivary gland, which are referred to as sialadenosis (sialoses). The enlargement is painless and usually bilateral, more common in women. Commonly affects parotid gland. Sialadenosis can occur in the following conditions:

- Autoimmune disorders
- Hormonal disorders—pregnancy, hypothyroidism
- Diabetes mellitus
- Alcoholic cirrhosis
- Diseases of pancreas and kidney
- Anorexia nervosa
- Malnutrition
- HIV-associated salivary gland disorders

Sjögren's Syndrome

This is a condition originally described as a triad, consisting of dry eyes, xerostomia and rheumatoid arthritis. Now, it has been found that patients may present either with dry eyes and xerostomia only (primary Sjögren's syndrome) or with the above two symptoms and accompanying rheumatoid arthritis, systemic lupus erythematosus, polyarteritis nodosa, etc. (secondary Sjögren's syndrome).

Though the etiology is unknown, various causes suggested are genetic, hormonal, infection and immunologic among others. Most authorities support the

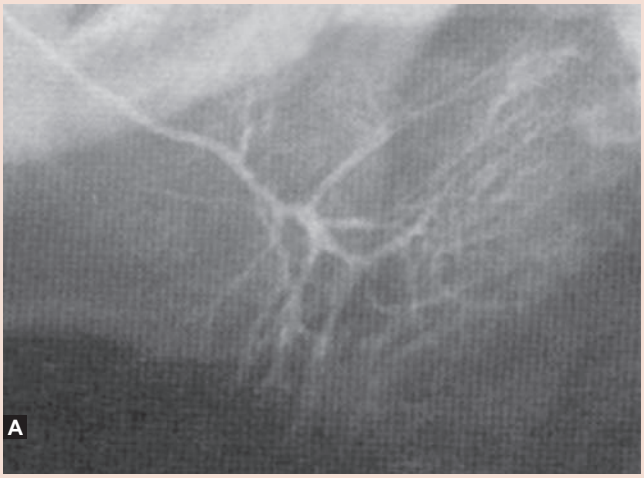
Table 39.4: Radiographic appearance on sialography

Normal parotid gland	Tree in winter appearance
Normal submandibular gland	Bush in winter appearance
Sialolithiasis (of main duct)	Filling defect(s) in the main duct
Tumor/cyst of gland	Ball in hand appearance
Sialodochitis	Sausage like pattern
Sialadenitis	Pruning of tree appearance
Sjögren's syndrome	Branchless fruit laden tree/ Snowstorm/cherry blossom appearance

Table 39.5: Sialography picture interpretation

Normal sialographic appearance of parotid gland [Tree in winter appearance]

- Main duct of even diameter (1–2 mm) and should be filled completely and uniformly with dye flow
- Duct structure in the gland branches should appear uniform and taper gradually towards periphery





Courtesy: Dr Kumar Nilesh

Normal sialographic appearance of submandibular gland (Bush in winter appearance)
- Main duct of even diameter (3–4 mm) and should be filled completely and uniformly with dye
- Duct branches uniformly and tapering gradually towards periphery (gland size slightly shorter than the parotid gland)





Sialographic appearance of calculi [Filling defect(s) in the main duct]
- Filling defect(s) in the main duct
- Ductal dilation proximal to calculus
- Contrast medium retained behind stone (emptying phase)





immunologic mechanism to be the main intrinsic factor in the etiology of this disease.

Clinical Features

Clinically, this disease occurs predominantly in women over 40 years of age, although children or young adults may be affected. The female to male ratio is 10:1.

Typically, patients present with dry eyes and dry mouth due to hypofunction of lacrimal and salivary glands. This leads to pain, burning sensation and ulcerations on the oral/conjunctival mucosa. Various other glands like nasal, bronchial, vaginal, etc. may also show hyposecretion. Rheumatoid arthritis most frequently accompanies the above symptoms in secondary Sjögren's syndrome. But patients with primary Sjögren's syndrome are seen to manifest parotid gland enlargement, purpura, lymphadenopathy, etc.

Laboratory Findings

The laboratory findings are very important and distinct in the diagnosis of Sjögren's syndrome. Over 75% of the patients show a polyclonal hyperglobulinemia and

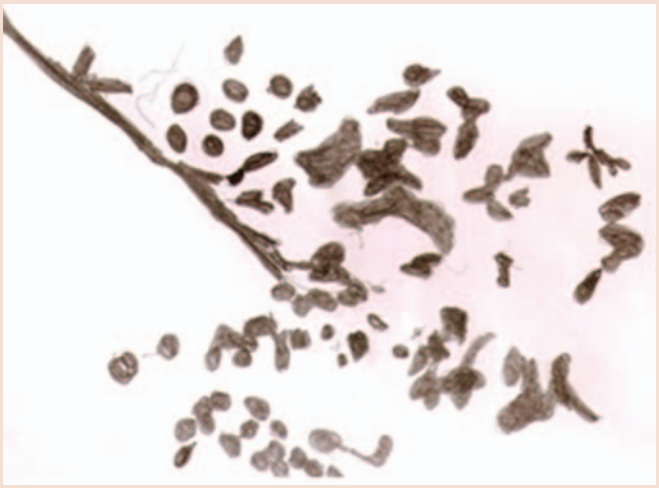
Sialographic appearance of sialodochitis (Sausage like pattern)
- Segmented sacculation/dilation
- Strictures of main duct
- Associated calculi or ductal stenosis





Sialographic appearance of Sjögren's syndrome [Branchless fruit laden tree/Snowstorm/cherry blossom appearance]
- Widespread dots/blobs of contrast media within the gland (punctate sialectasis)
- Considerable retention of contrast media during emptying phase
- Main duct is usually normal.





many develop cryoglobulins. Multiple organs or tissue specific antibodies are found, including antisalivary duct antibodies, rheumatoid factor and antinuclear antibodies. Increased sedimentation rate is present in 80% of patients.

The Schirmer test consists of placing a strip of filter paper in the lower conjunctival sac. Normal patients will wet 15 mm of filter paper in 5 minutes. Patients with Sjögren's syndrome will wet less than 5 mm of filter paper.

The Rose-Bengal dye test is used to detect the damaged and denuded areas of the cornea. The break up time (BUT) is performed using a slit-lamp and noting the interval between a complete blink and the appearance of dry spot on the cornea.

If two of the above three tests are abnormal, the patient is said to have dry eyes.

Salivary gland function in suspected cases can be measured by using parotid flow rate, biopsy and salivary scintigraphy. Sialochemistry studies have shown elevated levels of IgA, K, Na, etc. in these patients. Sialography demonstrates the cavitary defects which are filled with radiopaque contrast media, producing the "branchless fruit laden tree" or "cherry blossom" appearance.

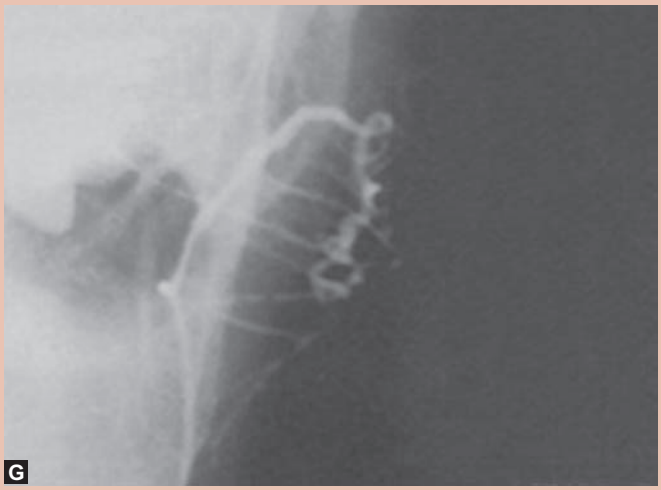
Sialographic appearance of sialadenitis (Pruning of tree appearance)
- Dots/blobs of contrast media within the gland (sialectasis)
- Main duct is usually normal





Sialectasis
Dots/blobs of contrast media within the gland are called sialectasis. Based on size of the blobs, it is called
- *Punctate (small spherical)*
- *Globular (Large spherical)*
- *Cavitatory (Largest nonspherical)*

Sialographic appearance of intrinsic parotid tumor [Ball in hand appearance]
- Area of under filling in the gland (due to ductal compression)
- Ductal displacement (Ball in hand)





DIAGNOSTIC IMAGING

Diagnostic imaging plays an important role in the evaluation of various disorders of major salivary glands. The modalities used for imaging include:
- Conventional radiography
- Sialography
- Ultrasonography
- Computed tomography
- Radionuclide imaging
- Magnetic resonance imaging (MRI). The abnormalities which can be evaluated by diagnostic imaging can be

divided into: (1) developmental, (2) inflammatory, (3) autoimmune, (4) metabolic, (5) traumatic and (6) neoplastic.

Conventional Radiography

Radiography of the salivary glands is the widely available technique. It is useful in detecting the calcification within the glands, to know the presence of metastasis to the salivary glands. But radiographs are not useful to know the extent of rapid, destructive, invasive lesions, because the changes can appear in the radiographs only after 30% of the mineral content is removed.

The posteroanterior, lateral, lateral oblique and frontal views may be used for the radiography of the salivary glands.

For parotid radiography, patient's head may be turned to 10° to the contralateral side. The intrabuccal view, wherein a periapical film is placed touching the buccal mucosa near the opening of the Stenson's duct is useful to demonstrate the calculi of the Stenson's duct.

Occlusal and lateral oblique views are useful in locating the stones of the submandibular duct.

Sialography (Tables 39.4 and 39.5)

It is a specialized radiographic procedure performed for detection of disorders of the major salivary glands (usually parotid and submandibular glands). The technique was first performed by Carpy in 1902, using mercury as the contrast agent. The technique is employed for examination of both parenchymal (acinar) and ductal abnormalities. It involves cannulation and filling with a radiopaque/contrast agent (Water soluble or oil-based dye) to make them visible on a radiograph. The procedure indicates the changes in the internal architecture and thus reveals the location and integrity of salivary glands.

Indications

- Detection of calculi or foreign bodies, obstruction, dilatation, narrowing of the duct
- Determination of the extent of destruction of salivary gland tissue secondary to obstruction such as calculi or foreign bodies
- Detection of fistulae, diverticuli and strictures
- Detection and diagnosis of recurrent swelling and inflammatory processes, abscess cavity
- Demonstration of tumor; its size, location and origin, presence of extraglandular mass
- Selection of the site for biopsy
- Outline the plane of facial nerve as a guide in planning a biopsy or a dissection
- Detection of residual stone(s), residual tumor, fistulae and stenosis or a retention cyst following prior simple lithotomy or other surgical procedures.

Contraindications

- Patients with a known allergy or hypersensitivity to iodine compounds; and/or other radiographic contrast media. All patients referred for sialography should be asked about possible previous adverse drug reactions to iodine or other radiographic contrast media. These reactions include: marked urticaria, dyspnea, asthmatic attacks and anaphylaxis.
- During the period of acute inflammation/infection of the salivary glands (e.g. acute suppurative sialadenitis). In this condition, sialography is contraindicated, because:
  - The contrast media cause irritation.
  - There is increased chance of rupture of duct and extravasation of contrast media into already inflammed gland.
  - There is a potential for retrograde dissemination of pyogenic organisms throughout the gland.
- Patients scheduled for thyroid function tests in the immediate future. Absorption of iodine present in the contrast material, across the glandular mucosa may interfere with these studies. Sialography should be deferred in patients scheduled for thyroid function tests or such tests should be performed prior to the sialography procedure.

Phases of Sialography

Sialography can be divided into three phases: (1) Ductal phase, (2) Acinar phase and (3) Postevacuation phase.
Ductal phase of both parotid and submandibular sialogram starts with the retrograde injection of contrast medium and ends when glandular parenchyma starts to become "hazy", reflecting the onset of acinar opacification. The normal opacified parotid ductal system is often described as having a "leafless tree" appearance with a progressive, gradual decrease in ductal caliber, because branching of various ducts occurs throughout the gland.

Visualization of duct(s) draining accessory parotid gland(s) often occurs during ductal phase.

The appropriate spot films taken following ductal opacification include: (1) AP, (2) Puffed AP views of the cheek and (3) Lateral view

Anatomically and sialographically, Wharton's duct can be divided into two distinct segments: (1) Vertical or superficial segment below the level of mylohyoid and (2) Horizontal or deep segment above mylohyoid muscle. The deep segment unites with the sublingual or Bartholin's duct before entering oral cavity.

The normal opacified ductal system often shows abrupt changes in ductal caliber as branching occurs. This is in marked contrast to orderly arborization seen in intraglandular parotid duct.

The fluoroscopic spot films for opacified submandibular duct obtained during ductal opacification include: (1) Film for horizontal portion of the duct, (2) AP view, (3) Lateral oblique of completely opacified ductal system, (4) Intraoral occlusal view or submental vertex view, using intraoral films are useful in showing pathology involving deep segment of submandibular duct.

Acinar phase: This phase starts with the completion of ductal opacification and ends when there is a generalized increased density to the gland reflecting filling of glandular acini.

The appropriate views for this phase of a sialogram include: AP and lateral views for parotid gland and AP and oblique lateral view for submandibular gland.

Evacuation phase: This phase is useful in assessing the secretory function of gland as well as accentuating any ductal pathology not detected in other phases.

This phase can be divided into two distinct subphases: (1) The first subphase lasts approximately 60 seconds and assesses the unstimulated, spontaneous clearing of contrast medium from the gland. The second subphase assesses glandular clearing of intraductal and/or intraparenchymal contrast medium following stimulation with a sialogogue, e.g. lemon juice. This phase is performed only if there is incomplete spontaneous clearing of contrast medium during the first phase.

Nonclearing or incomplete clearing of a gland during either phase can be due to: (1) A sialolith and/or stricture, (2) Extraductal or extravasated contrast medium, (3) Collection of contrast medium in abscess cavities or (4) Underlying physiological abnormality.

Contrast Sialography

Contrast sialography can be performed by either:
(1) Lipid soluble or oil-based, or (2) Water soluble agents.

Lipid soluble or oil-based agents: These agents contain 37% iodine, e.g.ethiadol. The advantages are: (1) It is not diluted by saliva, (2) It is not absorbed across glandular mucosa. This results in optimal opacification of both acinar and ductal elements. The disadvantages are: (1) The agents are more viscous, and hence higher injection pressure is required, (2) The injection is accompanied by greater degree of pain and discomfort, (3) Any calculus encountered in the duct may be displaced backwards, (4) When extravasated into glandular parenchyma, it is not readily resorbed; and if present in sufficient quantities, it can cause spray artifacts on subsequent CT studies, (5) Extravasated agents can cause foreign body reaction, and can induce inflammatory reactions and granuloma formation.

Water soluble or water-based agents: These agents contain 28–38% iodine, e.g. hypaque 50%, hypaque M 75%, renografin 60, 76% sinografin, isopaque, triosil, and dionosil.

The advantages include: (1) They have low viscosity, low surface tension and more miscible with salivary secretion, (2) The residual contrast medium is absorbed and excreted through kidney, (3) It is believed that water soluble media coat and outline the calculi more adequately than oil-based. The disadvantages include: (1) The injection is accompanied by little pain and discomfort, (2) Opacification, generally, is not as good as oil-based media. It is rapidly absorbed across glandular elements, often resulting in overall poor radiographic density and suboptimal demonstration of peripheral ducts and acinaropacification, (3) It is diluted by saliva.

Technique

Equipment

- Polyethylene tubing with a special blunt metallic tip with side-holes for parotid gland injection. A similar tubing for injection into submandibular gland with an end terminal hole.
- A 5–10 mL syringe
- Lacrimal dilator
- Contrast medium
- Lemon slices or artificial lemon extract in a plastic container.

Procedure

- **Identification of the location of duct orifices:** The parotid duct is located at the base of the papilla in the buccal mucosa opposite maxillary first and second molar teeth. The area of the mucosa in the vicinity of the orifice is dried with a small sponge. The application of gentle pressure over the area overlying the gland

would lead to expression of saliva; in case the gland has some degree of function. The submandibular duct orifice is situated on the summit of a papilla by the side of the lingual frenum.

- **Exploration of the duct with a lacrimal probe:** In view of the tortuous course of the parotid duct, patient's cheek must be turned outwards prior to the insertion of the probe into the duct. This eversion of cheek reduces the chances of penetration of the duct at the sharp angles in its course. In case of the submandibular duct, the probe should pass through the considerable length of the floor of the mouth to the level of the posterior border of mylohyoid muscle; approximately 5 cm. In both the ducts, the probe should slide easily back and forth and also rotate freely without dragging.
- **Cannulation of the ducts:** The duct orifice is slightly enlarged, and the salivary cannula is inserted into the duct; so that the tissue presses firmly into the orifice to prevent dye reflux. The cannula is held in place by taping the tubing to the face; or by having the patient bite on the tubing wrapped in a sponge.
- **Introduction of the radiographic dye:** The dye is slowly introduced into the duct. The amount to be injected for adequate filling of the gland varies from patient to patient; and on the condition of the gland. The amount used is best determined by fluoroscopic observation. The patient is instructed to inform the operator when the gland area feels tight or full. The approximate values of the dye required vary from 0.76 mL to 1.0 mL for parotid gland, and 0.5–0.75 mL for submandibular gland. The injection of the dye should be stopped, if the patient feels mild discomfort, or if the dye is extravasated, and when the gland is full.

Radiographic Projections

- **Lateral oblique projection:** This projection is best to delineate the submandibular gland, as the image is projected below the ramus of the mandible.
- **Lateral projection:** This projection also shows the ductal pattern.
- **Occlusal projection:** This view is useful for sialolith located in the anterior part of Wharton's duct.
- **Anteroposterior (AP) projection:** This projection demonstrates medial and lateral gland structures. In case of parotid, AP projection should be made with mouth open, so that the deeper portion of parotid gland will be visualized. In case of submandibular gland, the chin should be raised in such a way so that inferior border of the mandible and the base of the skull are approximately at the same horizontal level, which will prevent superimposition of the gland over either of these two bony structures.
- **Panoramic projection:** This projection is made during the filling phase. It has following advantages: (1) Easier to expose, (2) Radiation dose is relatively low, (3) Satisfactory bony details.

At the end of final sialographic views, the cannula should be removed from the duct orifice. The patient is instructed to chew gum; or suck on a lemon; or take other sialogogue, such as 1% citric acid solution is given and then asked to rinse the mouth. The purpose of this step is to stimulate glandular function and cause excretion of the dye. The projections lateral jaw, lateral oblique or AP should be made again 5 minutes after the removal of the cannula.

Interpretation: Prior to embarking on interpretation of the results of sialography, the normal structures seen on a sialogram should be considered.

1. **Parotid gland:** AP view shows opacification of the parenchyma and ductal system. The two portions, superficial and deep part of the parotid gland, are connected by isthmus in which the ducts are normally stretched which should not be mistaken as pathological finding. Normally, the Stenson's duct is 5–6 cm long and 3 mm in width. The distance between the lateral border of mandible and the duct is 2 cm. Lateral displacement of the duct may indicate a possible mass. Accessory parotid gland situated superior to the duct may be present. The ducts in children are finer and delicate than adults.
2. **Submandibular gland:** It is situated in the submandibular triangle in the neck. Wharton's duct is 5–6 cm in length and 2–4 mm in width. The orifice of the duct is narrower and situated in the floor of the mouth.

The information obtained from a sialogram is the distribution of the ductal pattern, the uniformity of the ductal caliber, the filling or nonfilling of acinar and parenchymal regions. The dye injected into a diseased gland can flow only through an intact duct to areas that are continuous with ductal structures **(Tables 39.6 and 39.7).**

Observations

- The salivary calculi, stricture or other obstructions appear as radiolucent lesions.
- In Sjögren's syndrome, sialographs demonstrate many large dye-filled spaces (sialectosis), giving the "Cherry-blossom" or "branchless fruit laiden tree" appearance.

Table 39.6: Integrity of the glandular architecture in various disease conditions in different phases of sialography

	Calculus	*Sialodochitis*	*Sialoadenitis*	*Sjögren's syndrome*
Filling phase	Feeling defect, segmental strictures, secondary to multiple passage of stones	Segmental constriction, secondary to inflammation and fibrosis	Acinar and terminal ductal ectasia, mildly dilated ducts due to flattening of epithelium	Acinar ectasia and extravasation due to acinar atrophy. Thin and few ductules due to myoepithelial hyperplasia which obliterate the lumen
Emptying phase	Large amount of retained contrast media	Small residue	Small residue	Residue only in acini
Advanced cases	Secondary infection, pseudodiverticulum, abscess, fistula	Combined sialoadenitis and adenitis, abscess, fistula	Irregular cystic formation, sialoadenitis and adenitis, abscess, fistula	Pseudocystic formation, cavitations, superimposed infections

Table 39.7: Glandular architecture in different pathological conditions during the phases of sialography

	Extrinsic tumor	*Intrinsic solid encapsulated tumor*	*Intrinsic encapsulated inflammatory cyst*	*Intrinsic invasive tumor*
Filling phase	Glandular architecture is preserved but displaced acini are compressed and ducts are intact	Glandular architecture remains intact but the intracapsular position of nodular tumor allow it to impinge on ductal system causing localized narrowing surrounding acini may be lacking owing to atrophy	Large cyst stretches the adjacent ducts. No localized narrowing seen, as pressure of cyst is applied uniformly over the length of the duct	Normal ductal architecture is completely destroyed and and replaced by bizarre puddling and a pooling of contrast media
Emptying phase	The ductal system empties normally, since the tumor is extracapsular: glandular parenchyma functions normally	Trapping of contrast medium in the ductal system distal to the site of narrowing is the characteristic of intrinsic tumor	There is no area of localized obstruction of the duct system as in solid tumor, as the contrast medium is almost completely evacuated	Pattern remains essentially unchanged except for further diffusion of contrast medium which occurs as the glandular parenchyma is replaced by invasive tumor which has cost its secretory function

The dye could be passing through the weakened salivary gland duct to give this effect.

- **Tumors**: Sialography is not useful in case of tumors of the salivary gland. The adenomas of the major glands demonstrate displacement of the glandular structure, which leads to the curving of the collecting ducts giving the "hand-holding the ball" appearance.

Radionuclide Salivary Imaging

Radionuclide scanning is a valuable diagnostic tool for major salivary glands. It is useful for evaluation of physiology as well as pathology. It is particularly indicated in patients with suspected obstructive sialadenitis, in whom, the contrast sialography is either contraindicated or cannot be performed due to anatomical or technical reasons. Radionuclide scans differentiate between acute obstructive and nonobstructive sialadenitis. It shows the presence of parenchymal masses greater than 1 cm in diameter and identifies specific types of tumor.

Procedure

Radionuclide salivary imaging is performed using an oxidized form of technetium 99m (Tc 99m) pertechnetate. Imaging is performed with a gamma camera following IV injection of 10–20 μCi of technetium-99m pertechnetate. The activity of the salivary gland is recorded over a given period of time. This information is then used to generate quantitative time-activity curves as well as images of salivary glands.

Phases of Radionuclide Salivary Imaging

It represents the physiological process occurring in the glands.

First phase or flow phase: It lasts approximately 15–25 seconds and represents the submaximal accumulation of technetium by the gland. It is represented by a line with a positive slope on the time-activity curve. Static images show bolus of activity in major vessels of head and neck.
Second phase or concentration phase: It represents the continued uptake of Tc-99m at a maximal rate. The phase starts 44–60 seconds after administration and progresses for next 10 minutes. This phase is represented by a horizontal line on time-activity curve. Static images show an increase in activity in major salivary glands and oral cavity.

Third phase or excretory (washout) phase: This phase is performed following salivary stimulation by a sialogogue, such as lemon juice, applied to the tongue. There is a marked decrease in activity in normal salivary glands within 3–5 minutes of stimulation as well as a transient increase in activity in oral cavity following stimulation.

Radionuclide salivary imaging does not allow for volumetric quantitation of actual salivary flow.

Gallium Scanning

Gallium-67 citrate is a radiopharmaceutical useful in evaluation of a number of inflammatory and neoplastic processes involving major salivary glands. Imaging is normally performed 24, 48, and 72 hours following the IV administration of 3–5 μCi of Gallium-67citrate.

Increased uptake can occur in salivary tumors, lymphoma, acute and chronic inflammation, post-irradiation salivary adenitis, abscess and active sarcoid. Patients with sarcoid often show increased lacrimal uptake reflecting involvement of lacrimal glands.

Computed Tomography and Magnetic Resonance Imaging

Computed tomography (CT) and magnetic resonance imaging (MRI) studies provide an excellent soft tissue details. They show (1) lesions and also, (2) involvement of the adjacent structures. MRI is especially helpful in showing early extension along various neurovascular pathways. CT is especially useful in evaluation of the following:

- Inflammatory processes involving major salivary glands; as these processes are often associated with sialoliths, which are readily identifiable on CT studies.
- CT provides better definition of cyst walls, thereby making it possible to differentiate between various fluid containing masses, e.g. true cyst, sialoceles and abscesses.
- Contrast-enhanced CT studies, especially useful in evaluation of abscess formation, as hypervascular wall of an abscess will show characteristic enhancement.
- Provides better definition of focal osseous erosions or sclerosis.

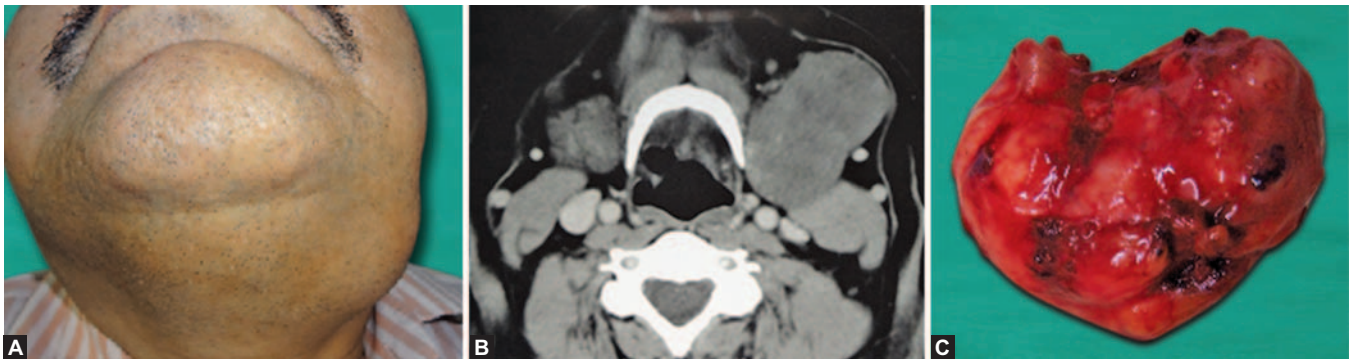
Computeed tomography (CT) and MRI are important in evaluation of clinically palpable masses involving parotid gland and adjacent structures and their relationship to facial nerve. The relationship of a mass to facial nerve will dictate the surgical approach to be used for its removal. On an axial CT examination, the relationship of parotid mass to facial nerve can be inferred by noting the relationship of the mass to retromandibular vein. Lateral displacement of retromandibular vein is indicative of a lesion arising medial to facial nerve whereas lack of/or medial displacement of retromandibular vein is indicative of a lesion arising lateral to facial nerve. MRI, by the virtue of its greater soft tissue resolution, is capable of directly visualizing facial nerve as well as showing possible early perineural spread in case of a malignancy. MRI also provides better delineation and definition of soft tissue masses.

T2-weighted images provide an insight into the cellularity of salivary gland tumors. Highly cellular masses, e.g. high-grade malignancies, tend to have low to intermediate intensities on all images; whereas masses with lesser degrees of cellularity, e.g. benign tumors or low-grade malignancies, tend to be bright on T2-weighted sequences.

Techniques of CT Examination (Parotid and Submandibular Glands)

Computed tomography for parotid and submandibular glands is performed using continuous 5 mm slices through the gland under study. Thinner sections can be used if higher resolution is necessary. It is usually performed in true axial plane. However, semiaxial or direct coronal planes can also be taken.

Salivary CT studies can be done with or without IV contrast. Nonenhanced images show: presence of radiodense sialoliths, glandular enlargement, focal masses, alteration in glandular texture, loss of adjacent tissue planes, focal masses in adjacent structures and adenopathy in adjacent and draining lymph nodes. Enhanced images should be evaluated for normal glandular enhancement, abnormal enhancing masses (e.g. tumoral enhancement, abscess wall enhancement) and nodal enhancement **(Fig. 39.21A to C)**.



Courtesy: Dr Vidya Rattan

Figs 39.21A to C: (A) Left-side submandibular pleomorphic adenoma; (B) CT scan showing the extent of the lesion; and (C) Excised specimen

Magnetic resonance imaging (MRI) does not use ionizing radiation to generate images, but relies on a combination of magnetic field and radiofrequency energy. In contrast to CT in which it is not possible to obtain direct images in coronal, sagittal planes: with MRI, direct images in axial, sagittal and coronal planes can be obtained. The IV MRI contrast agents aid in showing and defining: (1) The extent of neoplastic processes involving major salivary glands and (2) Differentiating between benign and malignant lesions. The widely used MRI contrast agent is gadolinium-DTPA.

Fine needle aspiration biopsy can be done by CT guidance.

Ultrasound Evaluation of Major Salivary Glands

Noninvasive, cheap, accurate and easily accessible first-line investigation, with no ionizing radiation and that differentiates malignant from benign disease in almost 90% of cases and also distinguishes between salivary stones and cystic and noncystic disease.

The submandibular gland and larger portion of parotid gland, because of their superficial location, can be readily examined with high resolution ultrasound. The only region that may be difficult to evaluate on ultrasound is the anterior portion of deep lobe of parotid, which is obscured by overlying ramus of mandible. Ultrasound: (1) differentiates between intraglandular and extraglandular masses, (2) demonstrates the presence of solid, cystic and complex masses and sialoliths, (3) when combined with fine-needle aspiration cytology (FNAC) or core biopsy examination is useful in diagnosing diseases of the major salivary glands.

Sialoendoscopy

This is a new, minimally invasive technique for diagnosis and treatment of salivary gland diseases, especially for obstructive diseases of the salivary glands (sialoliths, strictures, mucous plugs, adhesions, etc. Strictures are seen due to prior salivary gland infection, childhood infection, like mumps, chronic recurrent sialoadenitis.). The technique is promising for its superior diagnostic potential as well as its decreased morbidity, compared to traditional more invasive techniques for managing gland obstruction. It is also safe and effective treatment modality for sialoadenitis and other conditions.

It uses a small video camera with a light source at the end of the flexible canula, which is introduced into the salivary duct/gland via the duct. The endoscope is highly flexible semirigid canula with nithinol sheath. Usually 80 mm long and 1.1 mm outer diameter endoscope is used. Semirigid endoscope allows for visualization of the diseased process, but the stiffness allows manipulation and navigation of the internal salivary gland anatomy. Katz, in 1991, had first introduced 0.8 mm flexible endoscope for salivary gland pathology.

Depending on the obstruction, sialoendoscopy can be conducted under LA in the dental office or in the operating room under GA.

Procedure

Endoscope is introduced into the ductal orifice either after prior dilatation or by taking small incision. Once the scope is in place, saline is utilized to dialate the duct and its branching. Constant irrigation with isotonic saline through separate channel is necessary to overcome the sphincter like contractile mechanism that helps the duct to stabilize, which is in a collapsed state and allows an

adequate luminal dimension. Irrigation also plays a pivotal therapeutic role, allowing the removal of debris and mucous plugs from the ductal system. This also helps in adequate visualization of the lumen in order to allow the smooth progression of the scope in the ductal system. Once the endoscope is in the gland, the internal anatomy is explored, either for diagnosis or for the treatment of a specific disease entity. For the salivary calculus (5 mm or less sized) removal, intraoral technique is used. Common techniques used to remove salivary stones using endoscope are: (1) The grasping method—using grasping/biopsy forceps, (2) Using a small wire dormina basket retrieval system, (3) Mechanical fragmentation—drills, needles, (4) Laser fibers fragmentation (Laser lithotripsy—carbon dioxide laser—coagulative effect and protection of surrounding soft tissue). For more than 5 mm stone, twofold approach is used. First the stone is localized through the endoscope, dissected and removed. Secondly a sialastic stent is inserted into the ductal lumen and kept it for 2–4 weeks. For ductal stricture, insertion of a dilation balloon, which can be inflated up to 3 mm is carried out. The pressure created by the inflation is sufficient to dilate most of the strictures or expand the stricture region with grasping forceps used as a dilator.

SALIVARY ANALYSIS: SIALOCHEMISTRY—EXAMINATION OF ELECTROLYTE COMPOSITION OF SALIVA

The analysis of the composition of saliva though it gives large information, its application in the diagnostic field is not yet fully known. Both total mixed saliva and secretions collected directly from parotid, submandibular and sublingual glands are useful for the analysis. Cups designed by different investigators are useful in collecting the saliva. Clinical applications are possible in the investigation of the following:

- Total salivary flow (mixed saliva)
- Rate of flow—Sialometry-measure of salivary flow
- Concentration of Na and K in parotid saliva
- Salivary phosphate concentration in parotid saliva
- Sodium and chloride concentration in parotid saliva
- Salivary IgA concentration
- Salivary amylase
- Potassium concentration
- Calcium concentration
- Protein content
- Immunoglobulin content/concentration.

Table 39.8: Salivary analysis

	Investigation	*Observation*	*Condition/diagnosis*
1.	Total salivary flow	Decreased Increased	Xerostomia, sialorrhea
2.	Rate of flow	Reduced Increased	Sjögren's syndrome Cirrhosis enlargement
3.	Na concentration (parotid)	Increased	Inflammation Sjögren's syndrome
4.	K concentration (parotid)	Increased	Sialadenosis Cirrhosis enlargement
5.	Salivary IgA	Increased	Sjögren's syndrome
6.	Phosphate concentration (parotid)	Reduced	Sjögren's syndrome
7.	Calcium concentration (parotid)	Increased	Cirrhosis enlargement
8.	Protein concentration (parotid)	Increased	Cirrhosis enlargement
9.	Concentration of amylase	Increased	Cirrhosis enlargement

Concentration of Na and K which normally changes with salivary flow rate. Changes in the concentration of electrolytes are indicative of salivary gland disease.

In addition, diagnostic uses of saliva in exfoliative cytology, virus isolation, immunoglobulin concentration, taste dysfunction, etc. are being explored **(Table 39.8)**.

CLINICAL EXAMINATION: DIFFERENTIAL DIAGNOSIS (TABLE 39.9)

Diagnosis of the salivary gland diseases can become a challenge as both the local and systemic diseases can affect these glands. A good correlation of the history, clinical examination, interpretation of radiographic and sialographic images and other laboratory investigations is essential.

Duration, Nature and Rate of Growth

The information regarding the duration, nature of onset and rate of growth helps in differentiating the inflammatory and neoplastic lesions.

- The sudden onset and painful nature suggests an acute inflammatory lesion like mumps.
- The lesion with long duration and relationship to eating, with episodes of remission and exacerbation suggests obstruction by a sialolith. Painful swelling—60%,

Table 39.9: Some diagnostic features in salivary gland lesions

	Lesions	*Features*
1.	Sialolith	Relationship with food, remission and exacerbation
2.	Acute sialadenitis	Surrounding area red, erythematous Warm, tender glands. Pus discharge from ductal opening
3.	Mucocele	Blue, fluctuant, history of recurrence
4.	Ranula	Soft, blue, in the floor of the mouth
5.	Associated with AIDS	Multiple bilateral cysts
6.	Pleomorphic adenoma	Slow growing, mobile, painless, nodular, no ulceration, no facial paralysis, periods of inactivity
7.	Warthin's tumor	Elderly male, softer, cystic consistency
8.	Malignant tumor	Rapid growth, surface ulceration, fixation, induration, facial paralysis

painless swelling—30%, pain only 12%. Sometimes described as recurrent salivary colic and spasmodic pain on eating.

- Slow growing swelling which recurs periodically, suggests cysts of the salivary gland.
- The benign tumor grows slowly and steadily. Painless swelling of long duration, which is mobile, lobulated suggests pleomorphic adenoma. The true neoplasms can show periods of biologic inactivity, but do not regress on their own.
- The sudden onset of a painless swelling, which grows rapidly suggests high-grade malignant tumor.

Examination

The inspectory findings are important in differentiating lesions. The skin over the inflammatory lesion appears red and edematous. The swellings of the parotid gland appear tense, as it is confined within the fascia.

The changes in the facial musculature should be observed when a malignant tumor is suspected.

Palpation: Bimanual palpation with one finger palpating the lesion, the other finger into the mouth should be carried out. The finger palpation helps in separating the lesions of adjacent structures like branchial cleft cyst, dermoid cyst, inflammation of lymph nodes, etc. The consistency of the uninvolved gland will be normal. Intraoral palpation is helpful for the ductal pathologies. If the intraoral finger can displace the lesion, and it is felt by the extraoral finger, it indicates that it is lateral to the musculature of the mouth.

The gland and ductal opening should be pressed and the secretion should be examined. Purulent discharge indicates bacterial infection. Pain upon palpation indicates inflammation, no pain in case of neoplasms.

Fixation: The mobility of the lesion should be examined. Pleomorphic adenoma, Schwannoma, inflammatory lymph nodes are readily movable. Acute inflammation, abscesses, malignant neoplasms and metastatic lymph nodes are not readily movable.

The indurated hard lesion suggest malignant lesion. Sometimes, the inflammatory lesion of the parotid may also be hard, but it involves the entire gland, whereas the malignant lesion usually involves a portion of it.

Sometimes pathologies of neighboring structures may mimic salivary gland lesions. The lymph nodes situated adjacent to the parotid or submandibular gland may become enlarged due to inflammatory or neoplastic causes.

Osteoma, odontogenic tumors like ameloblastoma, odontogenic keratocyst, lesions occurring at the angle or ramus of mandible, Garre's osteomyelitis, metastatic carcinoma, etc. can be differentiated from salivary gland lesions through radiographs.

SURGICAL MANAGEMENT

Parotid Gland: Superficial Parotidectomy (Figs 39.22A to C)

Indications

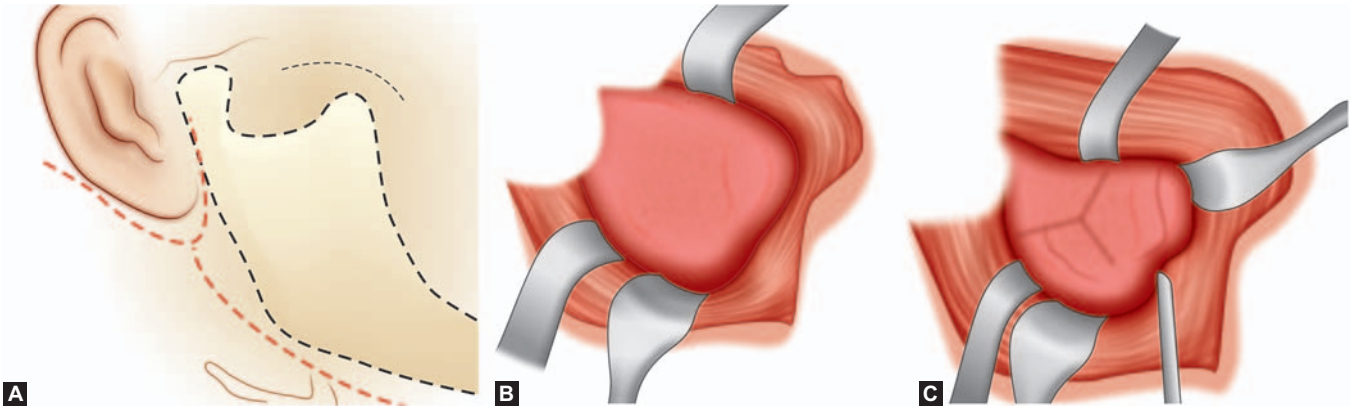
- **Tumor**: The most common is pleomorphic adenoma.
- Massive
- **Enlargement secondary to**: (1) Sjögren's syndrome, or (2) Calculus in the hilum of gland—calculus is removed without removal of the gland, (3) Chronic infection.

Approaches

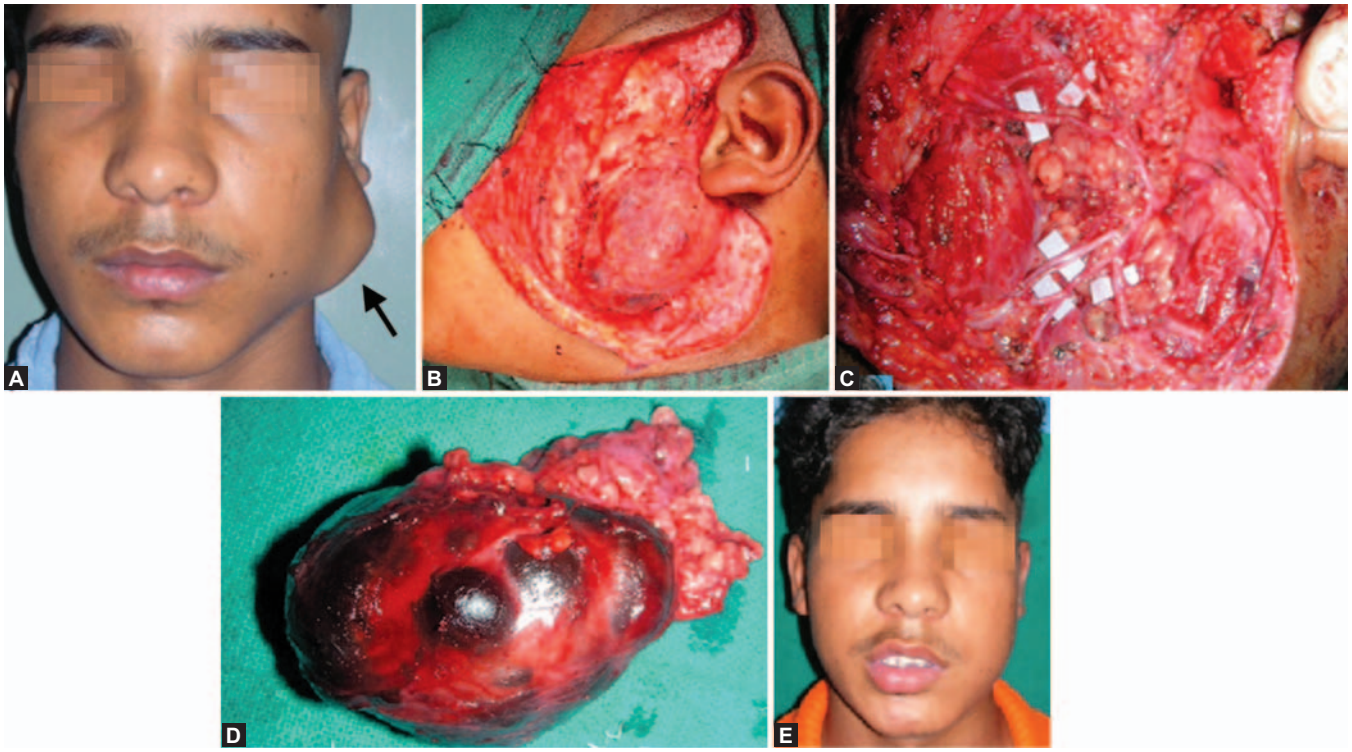
- Preauricular
- Submandibular
- Combination of the two approaches.

Preauricular: Useful for the big sialolith in the parotid duct at the posterior aspect. Incision is taken in the skin. Platysma and superficial fascia dissected. The duct is identified at the anterior border of the gland. The duct is followed backwards through the substance of gland until the calculus identified and recovered.

Extreme caution should be exercised for the preservation of branches of facial nerve, particularly the



Figs 39.22A to C: Surgical exposure for parotid gland excision: (A) Incision for parotid gland excision; (B) Retraction of the ear lobe and anterior flap to expose the superficial portion of the tumor; (C) Superficial portion is freed and elevated from branching facial nerve



Courtesy: Dr Sujata Mohanty

Figs 39.23A to E: Superficial parotidectomy. Pleomorphic adenoma of parotid gland, left side in 23-year-old male (A) Front face showing slow growing swelling since 5 years; (B) Extraoral incision and exposure of tumor mass in superficial lobe of parotid gland; (C) Preservation of the branches of facial nerve; (D) Superficial parotidectomy, tumor mass; (E) Uneventful recovery of the patient

lower zygomatic branch, which lies on the surface of the duct just below the accessory parotid. The fascial sheath encasing the gland is closed completely. This prevents saliva leaking into the tissues. A piece of corrugated rubber drain is placed and the wound is closed over the drain in layers. A pressure dressing is applied over the site of surgery.

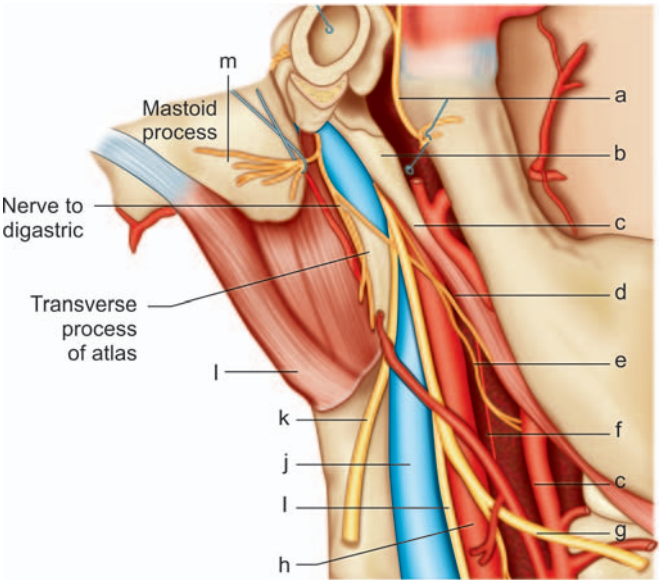
Incision for superficial parotidectomy is extraoral Y-shaped, as shown in **Figure 39.22A**. Superficial parotidectomy surgical procedure is shown in **Figures 39.23A to E**.

Preventing Injury to the Facial Nerve

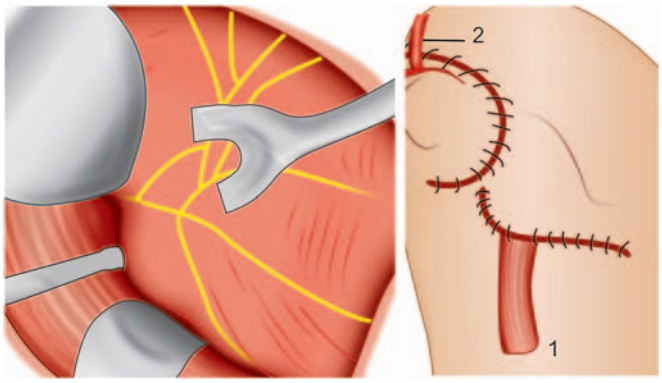
Sternocleidomastoid muscle is followed superiorly to find the main trunk. In cases, this route is not successful, a peripheral branch, usually the marginal mandibular, may be found and traced proximally.

Identification of facial nerve may be accomplished by one of the three methods:

1. Direct identification of the main trunk as it exits through the stylomastoid foramen (Lathrop 1949).
   Antegrade approach: Tragal pointer-Conley's pointer—inferior portion of cartilaginous canal is traced. Facial nerve is 1–1.5 cm deep and inferior to its tip, or 1 cm deep to upper border of posterior belly of the digastrics muscle. Facial nerve exit is immediately superior to it. A proximal marker—tympanomastoid fissure is a reliable and reproducible landmark was used by Bushey et al. in their cadaveric study.
2. Retrograde approach to the trunk from either the mandibular branch, where it passes over the retromandibular vein (Byars 1952), or the peripheral branches alongside the parotid duct (State 1949). The incidence of facial nerve injury is 10% higher, but most of the injuries recover after 12 months.
3. Supravital staining of parotid gland, contrasting the blue normal gland from the unstained tumor and the gleaming white facial nerve fibers.
4. Use of nerve stimulator also helps in identifying the branches of the facial nerve during dissection.
5. Magnifying loops also help in preventing injury during surgery.



Figs 39.24: Parotid bed after total parotidectomy: (a) Auriculotemporal nerve, (b) Styloid process, (c) External carotid artery, (d) Stylohyoid muscle, (e) Glossopharyngeal nerve, (f) Ascending pharyngeal nerve, (g) Hypoglossal nerve, (h) Internal carotid artery, (i) Vagus nerve, (j) External jugular vein, (k) Accessory nerve, (l) Digastric posterior belly, (m) Facial nerve. During dissection, it is important to know the anatomy



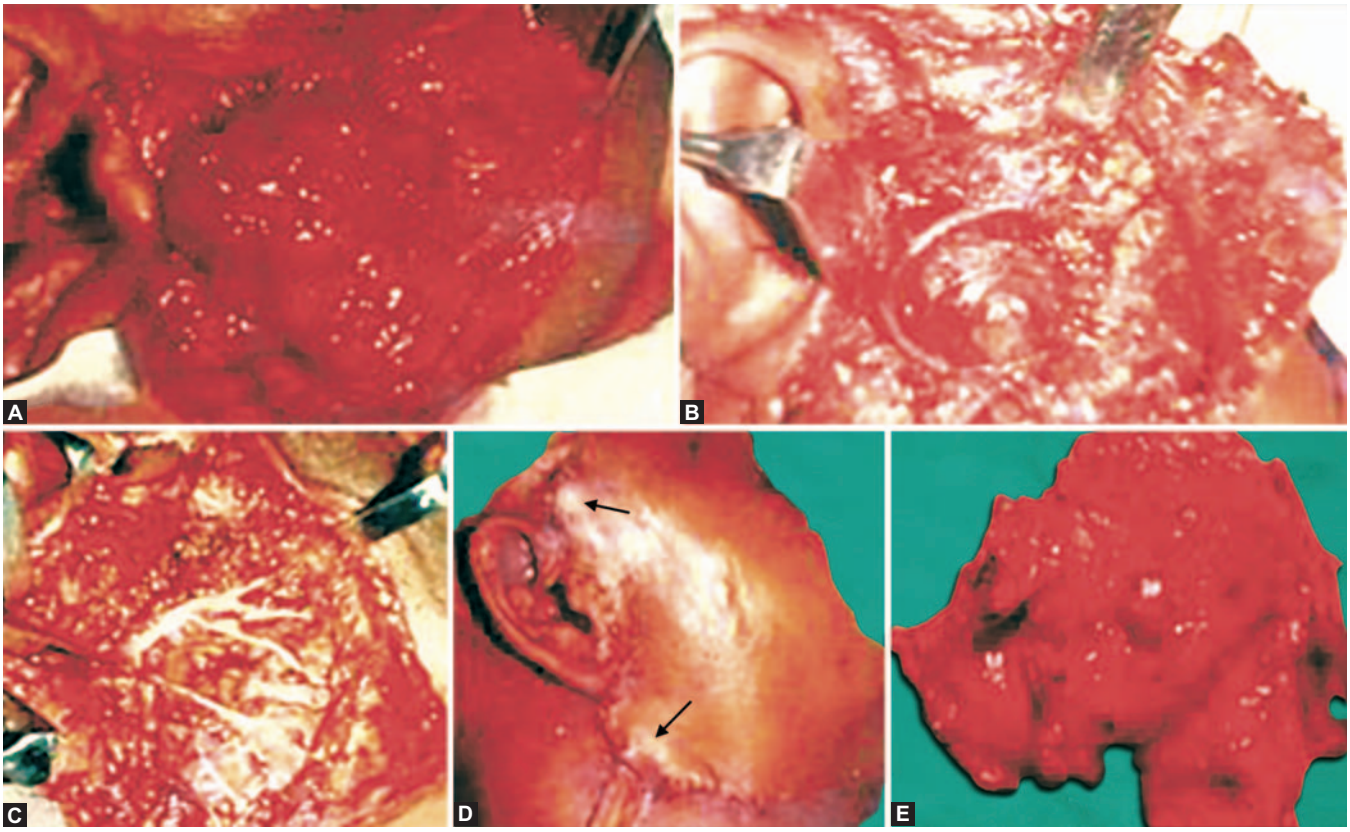
Figs 39.25A and B: (A) Complete excision of parotid gland; (B) Wound closure and placement of soft rubber penrose drains in the upper and lower portion of the closure (1 and 2)

Complete Excision of Parotid Gland (Figs 39.24 and 39.25)

During complete removal of parotid gland, the prime concern is to conserve the facial nerve and its branches. In malignant lesions, however, this may not be possible and the resultant deformity should be explained to the patient.

Incision and Dissection (Figs 39.26A to E)

The Y-shaped incision is planned, starting from the superior attachment of the pinna downwards and anteriorly towards the angle of the mandible and anteriorly, forward till the hyoid bone. The second arm of the incision is made posterior to the pinna. The ear lobe is retracted upwards and the skin flap is developed on the cheek side of the incision. An electrical nerve stimulator is used to identify the facial nerve. After the nerve trunk is located, then the course of the nerve is followed and the superficial lobe is freed from its attachments. The Stenson's duct is located, ligated and cut. The deep lobe is approached after this, by further retracting the ear lobe posterosuperiorly. Ligation of external carotid artery and the posterior facial vein is carried out. The facial nerve is then carefully elevated from the deep portion. The retromandibular vein is also



Figs 39.26A to E: Total parotidectomy with preservation of facial nerve: (A) Reflection of the flap-extraoral incision; (B) Tumor mass exposed; (C) Exposure of facial nerve and its branches; (D) Final closure with drain in place; (E) Specimen after total parotidectomy (pleomorphic adenoma)

divided from its inferior and superior branches and its stumps ligated. The deep portion is gently dissected out of the retromandibular space. This deep portion rests on the styloid process and the stylohyoid, styloglossus and digastric muscles. If the tumor is very bulky, the ascending ramus may be divided and reflected to facilitate the excision of the deep lobe. The mandible is then rewired in position. The wound is closed in layers and a drain is placed.

Submandibular Salivary Gland (Figs 39.27 and 39.28)

Extraoral Procedures

Procedure for biopsy or excision of the gland: An incision, 4–5 cm in length, is taken in the skin in the submandibular region. The incision is placed in, or parallel to the skin creases, about 2.5–5 cm below the submandibular border. The wound is deepened through platysma and deep fascia. The branches of facial nerve in the field are identified, mobilized and retracted. The facial vein is identified and

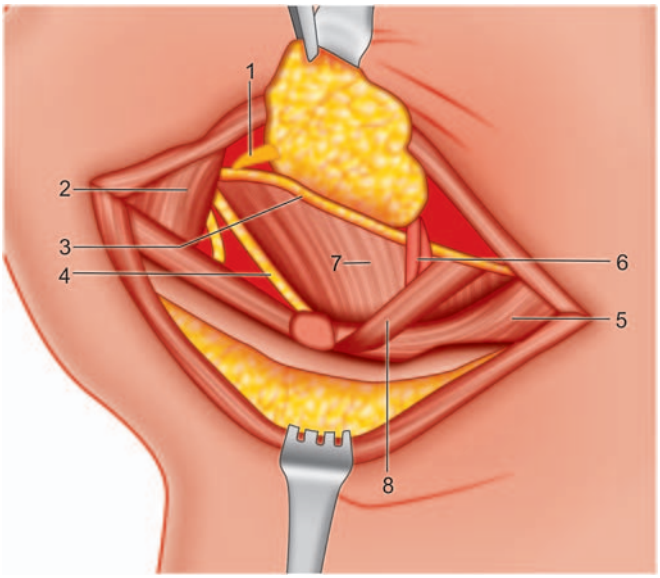
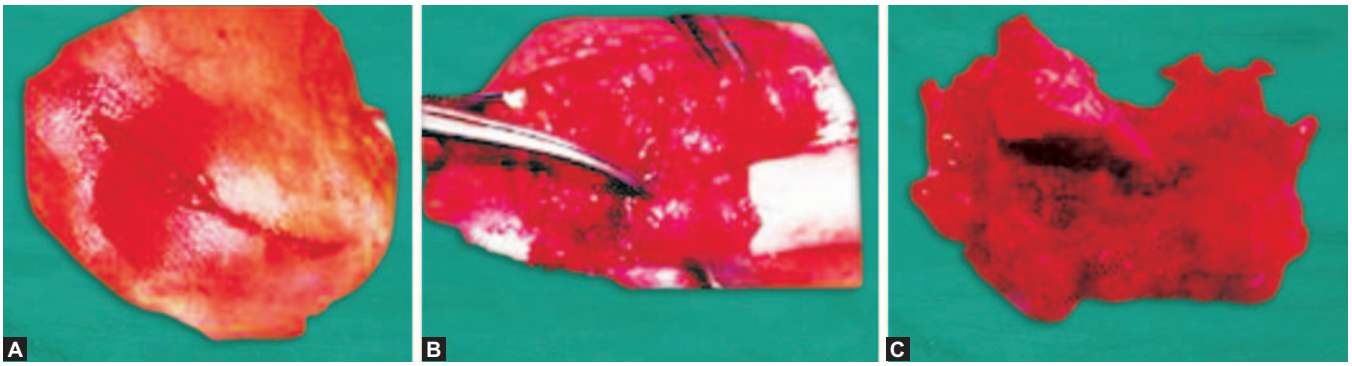


Fig. 39.27: Submandibular salivary gland excision: (1) Submandibular duct, (2) Mylohyoid muscle, (3) Lingual nerve, (4) Hypoglossal nerve, (5) Digastric muscle, (6) Facial artery, (7) Hyoglossus muscle, (8) Stylohyoid muscle



Figs 39.28A to C: Excision of submandibular gland along with the tumor

ligated. The lower pole of the gland is exposed, grasped with Allis's forceps and turned upwards and forwards. The posterior belly of digastric and stylohyoid muscles are retracted downwards and backwards to expose facial artery lying deeper to the gland. It is ligated and divided. The gland is separated from the lower border of mandible. Here again the facial artery lies lateral to the gland. It is divided and ligated again. With the help of Allis's forceps, the gland is held from the front of lower pole, and the gland is turned backwards, so that the attachment to the posterior border of mylohyoid can be exposed. The gland then can be mobilized and brought down to display the lingual nerve. The nerve is in relation with the upper pole of the gland from the point of emergence of the duct. Extreme caution has to be taken while carrying out the dissection. At times, due to the scarring caused by inflammation around an adjoining calculus, the nerve may be adherent. Once the lingual nerve is carefully dissected, and the duct is identified, the mylohyoid muscle is retracted. Then a ligature is passed anterior to ductal pathosis, if it exists. The second ligature is passed posterior to the first one, but still anterior to the ductal pathosis and the duct is sectioned between the ligatures. This prevents the seepage of infected material into the wound. The deep part of the gland then can be excised. This is preferably ligated and divided. A vacuum drain is kept in the wound and the wound sutured in layers.

COMPLICATIONS OF SURGERY OF SALIVARY GLANDS

Most of the complications of salivary gland surgery are as a result of damage to the nerves. Hence, the complications should be explained to the patient, and informed consent taken, prior to embarking on the surgery.

Intraoral Approach

- Anesthesia or paresthesia in the area of distribution of lingual nerve due to damage to lingual nerve, and
- Damage to Wharton's duct.

Extraoral Approach

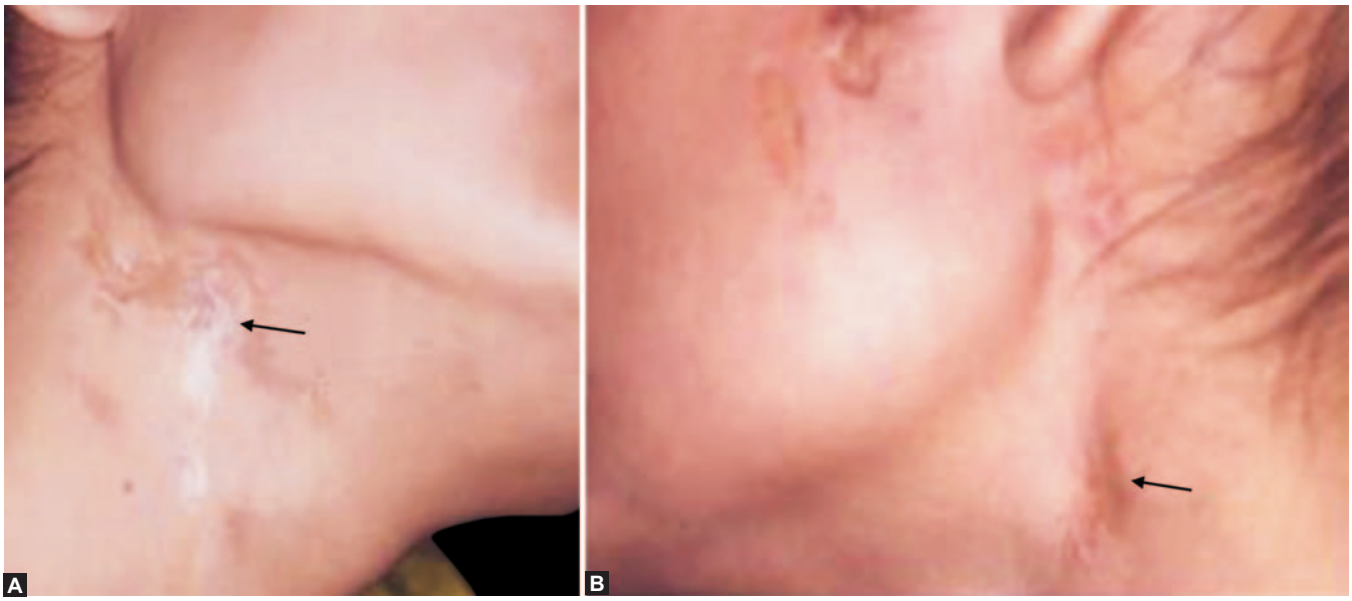
- Weakness of muscles of facial expression resulting in facial paralysis as a result of damage to the branches of facial nerve. Meticulous dissection should be done in order to minimize the trauma. In case of malignant lesions, however, the resection has to be judicious.
- Weakness of muscles of upper eyelid. It is necessary to patch up the concerned eye in order to prevent corneal abrasion.
- Auriculotemporal nerve or Frey's syndrome.
- Numbness of the ear secondary to severance of greater auricular nerve.

Auriculotemporal Nerve or Frey's Syndrome (Figs 23.21A and B)

It is a condition wherein sweating and sometimes flushing of the skin in the area of distribution of the auriculotemporal nerve occurs, which is caused by a stimulus to secretion of saliva. It is thought to be the result of damage to auriculotemporal nerve postganglionic parasympathetic fibers from the otic ganglion become united to sympathetic fibers arising from superior cervical ganglion going to supply the sweat glands of the skin.

It rarely occurs and has no treatment. The syndrome can occur in the following circumstances:

- Surgery of parotid gland
- Surgery of TM Joint
- Injuries to this area of the face
- Injections into this region.



Figs 39.29A and B: Bilateral salivary fistula. Note the dripping of saliva from the small openings in both right and left submandibular salivary gland region. Patient gave history of surgeries for lymphadenitis

Currently, porcine dermal collagen (permacol, Ireland) or human-derived grafts like DermaMatrix (DePuy Synthes, UK), alloderm (Lifecell Corporation, USA) are used to cover the defect after excision of the parotid gland, to minimize Frey's syndrome.

Facial Nerve Paralysis

Commonly, postoperative patients may experience transient facial nerve weakness, primarily involving the marginal mandibular branch, but also occurring in the zygomatic branch. This affects the depressor muscle of the lip and the orbicularis muscle of the eye, respectively. The onset of paresis is usually 1–3 hours postoperatively. Supportive care to prevent corneal irritation may be required during this phase of paresis. Full recovery usually occurs within days to months.

Salivary Fistulae and Sialoceles (Figs 39.29A and B)

Salivary fistulae and sialoceles are uncommon. They consist of a collection of saliva under the skin flap with drainage through the wound. Treatment consists of aspiration of fluid, compression dressings and removal of salivary stimulants. Crrently, the most commonly used treatment is botulinum neurotoxin type A and systemic hyoscine or propantheline bromide. The problem usually resolves gradually with this simple treatment regimen.

Points to Remember

- Salivary glands: anatomy and physiology
- Classification of salivary gland diseases
- Tumors of the salivary glands
- Diagnostic imaging
- Salivary analysis
- Clinical examination: differential diagnosis
- Medical and surgical management
- Complications of surgery of salivary glands
- Salivary glands: anatomy and physiology
- Classification of salivary gland diseases
- Tumors of the salivary glands
- Diagnostic imaging
- Salivary analysis
- Clinical examination: differential diagnosis
- Medical and surgical management
- Complications of surgery of salivary glands.

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Section 11

Orofacial Clefts

40. Cleft Lip and Cleft Palate Management

CHAPTER 40

Cleft Lip and Cleft Palate Management

INTRODUCTION

The dictionary meaning of cleft is a crack, fissure, split or a gap.

The orofacial clefts are congenital deformities, which manifest at birth. Any disturbance during the embryological formation and development and growth of orofacial region will result in the formation of orofacial clefts.

Orofacial clefts are the most frequently occurring craniofacial birth defects, and second most common birth anomaly, second only to clubfoot.

The zones affected by common orofacial clefts are as follows:

1. Upper lip
2. Alveolar ridge
3. Hard palate
4. Soft palate
5. Nose (not so common)
6. Eyes (not so common).

The old terminology *Lagocheilos*—harelip is credited to Galen around 120–200 AD.

The commonly accepted terms now are cleft lip, cleft palate or cleft lip and palate (CLP). It is very distressing for the parents, once the child is born with this deformity. The psychological and socioeconomic implications of these congenital deformities can be severe and their management becomes a major issue for healthcare system. Facial esthetics, speech, mastication, deglutition (swallowing) and dental occlusion, dental set-up can be impaired because of the orofacial clefts **(Figs 40.1A to C)**.

The management of these deformities is challenging and requires multidisciplinary approach, complex long-term treatment plan and a rehabilitation program designed for the individual case. The goals and objectives of the entire treatment plan are aimed at the following:

1. Increased survival rate.
2. Improved overall masticatory and other associated functions.
3. Improved/normalized facial esthetics.



Courtesy: Dr Amresh S Baliar Singh, Head, Department of Plastic Surgery, Nair Hospital, Mumbai, Maharashtra, India.

Figs 40.1A to C: Bilateral complete cleft lip and cleft palate deformity

4. Better social acceptance and social integration. Normal psychosocial development.
5. Improve airway patency and achieve integrity of the primary and secondary palate.
6. Improve speech and hearing.

INCIDENCE

No statistical figures in regard to incidence of CLP in India (as a whole) are available. Some international figures are given here. Incidence of clefts is thought to be increasing. Native North Americans have the highest incidence rates followed by Asians, Caucasians and Africans. (Prevalence as per races cited: White—1:800 live births, Blacks—1:2,000 live births, Japanese and Indians—1:700 live births).

Fogh-Andersen (1942, Denmark) cited 1:665 as the frequency.

RH Ivy (1963), from the state of Pennsylvania, USA quoted the incidence of cleft occurrence to be 1:760. M Oldfield (1959), found the incidence to be 1:600 in UK population.

In India, the survey conducted by Christian Medical College, Vellore, Tamil Nadu, India, reported the incidence of CLP in the regional population as 1:639.

Hence, the overall incidence stands out to be 1:700 in live human births in nonsyndromic cases.

Fogh-Andersen (1956) from Denmark, while reporting the overall incidence of 1:665 gave the detailed statistics—preponderance of prealveolar cleft in males (65%) than females (35%), and a higher frequency of occurrence of postalveolar clefts in females (66%) than males (35%) *Males are more affected by orofacial clefts, than females by a ratio of 3:2. Cleft lip deformity is more common in males, whereas cleft palates are more common in females. Cleft lip with or without cleft palate is the most common type of facial cleft.* Prevalence of CLP is 0.77 per 1,000 live births. Cleft lip is 0.29 per 1,000 live births and cleft lip with palate is 0.48 per 1,000 live births. Submucous clefts are rare—1:1,200 live births.

Prevalence of isolated cleft palate is 0.31 per 1,000 live births.

Further giving a break-up of prealveolar clefts in 498 cases, Fogh-Andersen stated that complete clefts were more common than prealveolar clefts. He further stated that in Denmark, of all the cleft lip palate, 25% constituted cleft palate alone.

It is now well accepted, that in cases of prealveolar clefts, unilateral clefts (75%) are more common (some have stated: 9 times) than the bilateral clefts (25%). (Unilateral CLP and bilateral CLP prevalence ratio has been reported as 4:1) In cases of unilateral prealveolar clefts, *left-sided cleft is more common than the right side*. The ratio of left to right to bilateral clefts is 6:3:1.

About 3–5% of the cleft lip and palates may be associated with congenital deformities of the other parts of the body-syndromic cases **(Fig. 40.2)**. 50% of the deformities are combined clefts of the lip and palate. About 25% of these are bilateral ones. Associated anomalies are seen in 21–37% cases, like cardiovascular-congenital heart defects:24–25%, mental retardation, musculoskeletal and facial dysmorphia, genitourinary system disturbances. 400 syndromes are mentioned in the literature, include CLP as a component.

Prevalence varies according to parental race/ethnicity and geographic origin, infant sex and family's socioeconomic status.

Risk of having a child with CLP

- If the parents have one child with CLP: 4%
- If one parent has CLP: 2–4%.
- Parents with two children with CLP: 9%
- One child and one parent with CLP: 14–17%.

Most cases are sporadic and of multifactorial etiology, but some may be X-linked, familial, autosomal dominant.

ETIOLOGY

Exact cause is unknown. It is supposed to be due to multifactorial reasons. Numbers of potential contributing factors are identified. But in nut shell—several genetic



Fig. 40.2: Cleft lip and palate with congenital deformities of other parts of the body

Table 40.1: Probable etiological factors for cleft lip and palate (CLP)

1.	Genetic disorders—over 400 genetic syndromes
2.	Chromosomal aberration
3.	Teratogenically-induced disorders—environmental teratogenic agents interfere/interrupt normal fetal development
4.	Mechanically-induced abnormalities/physical obstructions—amniotic rupture, intrauterine crowding, uterine tumors, irregularly shaped uterus.

and environmental factors interacting to shift the complex process of morphogenesis of the primary and secondary palates, are responsible for CLP deformity **(Table 40.1)**.

Hereditary/Genetics

Transmission is said to be caused through a male, sex-linked recessive gene. With a family history of CLP, preponderance of occurrence is about 40%, whereas it is only 18–20% with cleft palate alone (Fogh-Andersen in 1942). The genetic basis is significant, but not predictable **(Fig. 40.3)**.

Environmental Influence

Like in other congenital anomalies various factors, which influence the incidence of CLP during pregnancy in the first trimester are as follows:

- Viral infections: Rubella
- Exposure to radiation
- Intrauterine exposure/influence of drugs—excessive use of antibiotics, steroids, and insulin (it is a potent teratogenic agent) and antiepileptic drugs. Hormonal pills, anti-inflammatory drugs, tetracyclines, metronidazole, trimethoprim, sulfonamides, quinine should be avoided.
- Deficiency of vitamins A and B-folic acid.
- Excessive amount of vitamin A/retinoids
- Anemia
- Anorexia
- Stress
- Excessive consumption of alcohol
- Exposure to chemicals—insecticides/pesticides
- Maternal hypoxia
- Excessive tobacco chewing and smoking
- Consanguineous marriages are believed to have a significant influence in the occurrence of congenital anomalies (26%)
- Maternal age—older the mother, greater the chance of incidence of congenital anomalies, since there is a greater chance of a defective zygote over 30 years of age.



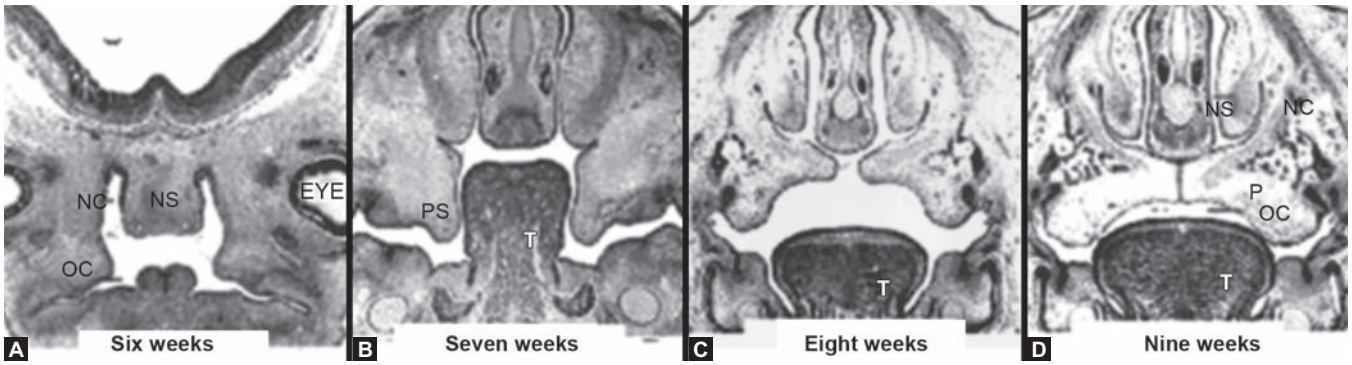
Fig. 40.3: Mother and child with hereditary cleft lip deformity

EMBRYOLOGICAL ASPECTS

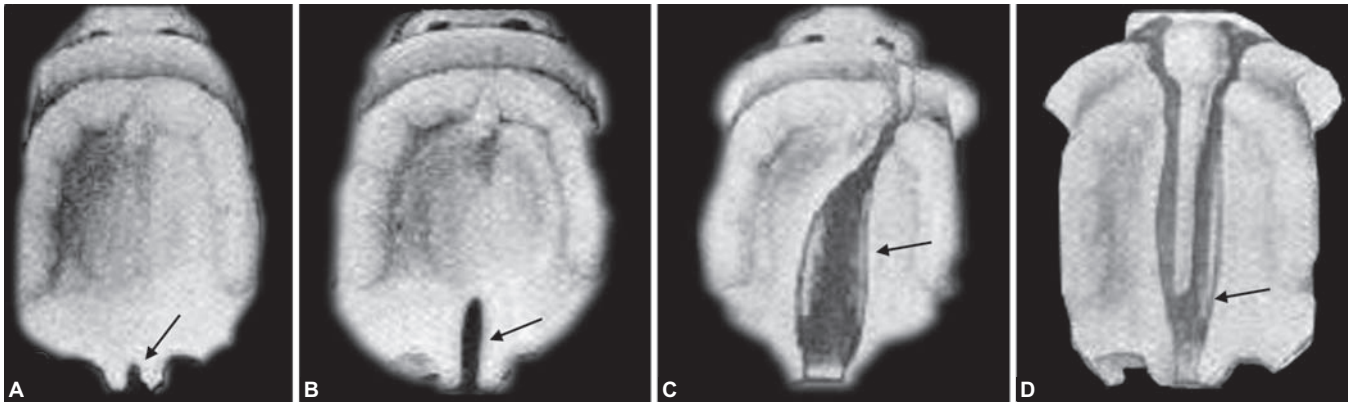
The embryologic development of the face takes place between 4th and 8th weeks of gestation. The midportion of the face develops immediately anterior to the forebrain by differentiation at broad midline frontonasal prominence. Thickened ectodermal plates, the nasal placodes arise from either side of the frontonasal prominence just above the stomodeum. Progressive elevation of the mesoderm at the margin of the placodes produces a horseshoe-shaped bridge, which is open inferiorly. The limbs of placodes become the median and lateral nasal processes (MNP and LNP) **(Figs 40.4A to D)**.

The paired median nasal processes (MNP) merge with frontonasal prominence to form major portion of the frontal process. The median nasal processes coalesce during the 6th week. Their caudal prolongation forms premaxilla and philtrum of the upper lip, columella, nares, lip, cartilaginous portion of the nasal septum and the primary palate. The lateral nasal processes (LNP) form alar region of the nose.

Mandibular arch lies between the stomodeum and the first branchial groove marking the caudal limit of the face. Its paired free ends enlarge and converge ventrally to complete the continuity of the arch during 6th week. The lower lip and the mandible are developed from mandibular arch. Paired lateral elevations of the pharyngeal surface of this arch unite in the midline to form anterior portion of the tongue.



Figs 40.4A to D: Coronal section of the developing palate
Abbreviations: NC, nasal cavity; NS, nasal septum; P, palate; OC, oral cavity; T, tongue, PS, palatal shelf.



Figs 40.5A to D: Formation of cleft lip and cleft palate: (A) Bifid uvula; (B) Soft palate cleft-submucous cleft palate; (C) The complete cleft-unilateral-involving the lip, alveolar ridge, hard palate, and soft palate; (D) Bilateral complete cleft of the lip and palate

Budding off the mandibular arches are paired postoccular masses of paraxial mesoderm, which constitute maxillary processes (MXP). These masses enlarge toward the ventral surface. The inferior border of the maxilla separates from the mandibular arch. The maxillary processes ultimately coalesce with the mesoderm of the globular process to form upper lip. The cheek, maxilla, zygoma and the secondary palate are derived from the maxillary processes.

The secondary palate is formed by two shelf-like outgrowths from the MXP. These palatine shelves appear in the 6th week of intrauterine life and are directed on either side of the tongue downward and obliquely. In the 7th week, the palatine shelves ascend to attain a horizontal position above the tongue and fuse together and form the secondary palate.

Anteriorly, the secondary palate fuses with triangular primary palate and the incisive foramen is formed at this junction between 7th and 10th weeks of development. At the same time, the nasal septum grows downward and joins the superior surface of the newly formed palate. The secondary palate makes up 90% of the hard and soft palate, is from the maxillary process.

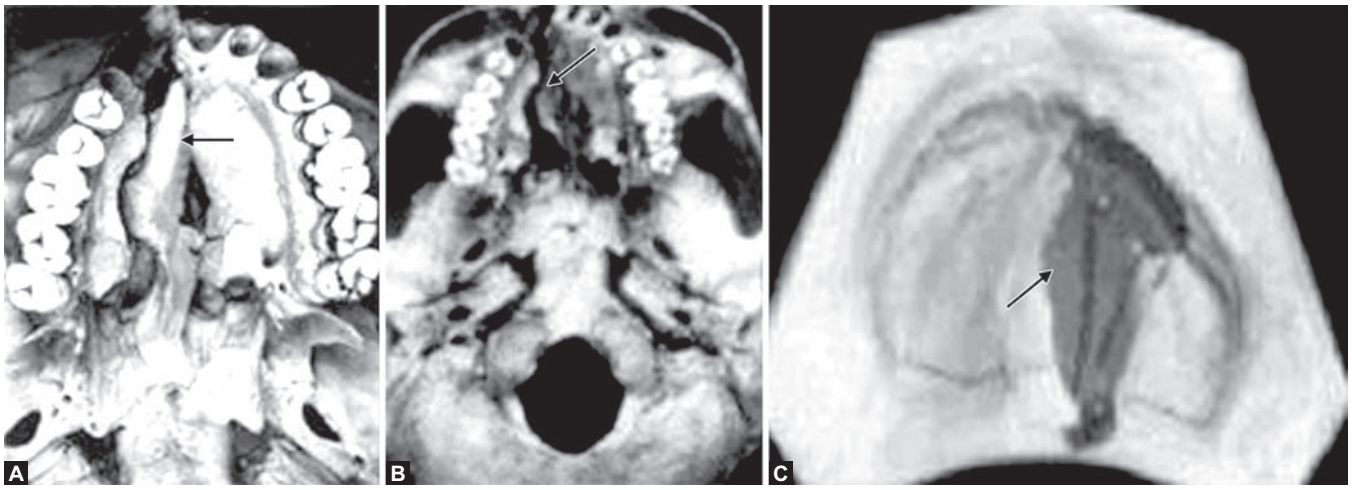
Formation of the Clefts

In the development of cleft lip and palate, intercontact and fusion between MXP and the MNP is normal. The critical problem is failure of LNP to make contact with MNP. The initial MXP-MNP fusion remains intact in early stages of cleft, but in 90% of cases, it ruptures later. Clefts of the secondary palate are due to failure of the palatine shelves to fuse together **(Figs 40.5 and 40.6)**.

Medial Nasal Processes (MNP)

Medial nasal processes form the following:

- Middle portion of the nose
- The middle portion of the upper lip (Philtrum)



Figs 40.6A to C: (A and B) Skull with unilateral cleft palate; (C) Model of cleft palate

- The middle portion of premaxilla, which carries four incisors
- The entire primary palate.

Lateral Nasal Processes (LNS)

Lateral nasal processes forms ala of the nose. Premaxillary segment is continuous with the nasal septum formed by frontal prominence.

Two maxillary processes—MXPs + MNPs complete the upper lip. 2 MNPs + 2 MXPs form the cheek, maxilla, zygoma and the secondary palate.

There are basically two theories forwarded for CLP formation.

1. **Theory of Dursy**-*His* (1931, San Francisco) put forward the hypothesis of failure of fusion of the various facial processes. In fact it sounded a very convincing theory to explain the formation of various degrees of unilateral and bilateral clefts and even the rare midline upper and lower lip clefts. This explained the presence of Simonart's band in an incomplete cleft lip.

   The fusion theory is no longer in vogue. The term "process" implies a finger like projection of tissue and "fusion" implies that the projections meet, their epithelial walls disappear and then they grow together. It has now been proved that this is not the case. It is realized that it is not a question of processes, but of localized prominences.
2. **Theory of failure of mesodermal migration**: Fleischmann, a zoology professor (Germany 1910), stated that "cleft palate is the arrest of the disappearance of the epithelial membrane, which remains intact, not penetrated by the adjacent mesoderm." This theory was further endorsed by Victor Veau (1935) and supported by Stark (1954).

Mesodermal migration theory proposes that, as the oral and nasal cavities deepen, there is an increase in the sizes of facial prominences due to the penetration of mesoderm. As more mesoderm enters the area, the bulging increases, so that what used to be a wall of tissue with ectoderm on one side and endoderm on the other side, is transformed into prominence and grooves depending on the amount of mesoderm between the two epithelial layers. Failure of sufficient mesoderm to migrate into a specific area is responsible for the persistence of a groove. With consequent epithelial breakdown, the persistent groove gives way to an established cleft.

It is now accepted that no theory enjoys universal acceptance.

CLASSIFICATIONS

Basic Classifications

- **Location**: Lip, alveolus, palate
- **Completeness**: Complete/incomplete or microform
- **Extent**: Unilateral/bilateral.

Spectrum of Cleft Lip Deformity

1. **Microform cleft lip:** There is a groove or furrow along the length of the lip, a vermillion notch and imperfections in the white roll. There can be varying degrees of vertical shortening of the lip. Associated nasal deformity may be seen.

2. **Unilateral incomplete cleft lip:** Varying degrees of vertical cleft of the lip with intact nasal seal or Simonart band. Simonart band connects the alar base to the footplates of the lower lateral cartilages of the nose.
3. **Unilateral complete cleft lip:** Disruption of the lip, nostril sill, and alveolus or complete primary palate.
4. **Complete bilateral cleft lip:** Protruding premaxilla on a vomerine stem, with or without rotation and angulation of the segment. Collapse of the lateral palatal shelves toward the midline.
5. **Incomplete bilateral cleft lip:** Incomplete bilateral cleft lips have a near normal nose, a normally positioned premaxilla, Simonart bands across the nasal floors. Clefts only involve the lip.

Spectrum of Cleft Palate

The primary palate components—the lip, alveolus and anterior palate till the incisive foramen.

The secondary palate—hard and soft palate from the incisive foramen, back till uvula.

Isolated cleft palate: may be associated with Pierre Robin syndrome. (Wide horseshoe cleft palate).

Submucous cleft palate and bifid uvula: A submucous cleft in the palate is a midline deficiency or lack of muscle tissue. Posterior nasal spine is almost always missing triad of deformity may be seen in some cases, including a bifid uvula, a notched posterior hard palate and a muscular diastasis of the velum. Speech problems are common. Otherwise patients may be asymptomatic. 15% may develop velopharyngeal insufficiency. A bifid uvula sometimes can occur without submucous cleft palate **(Fig. 40.7A)**

A. **Davis and Ritchie classification** *(1922), had anatomical basis:*
- Group I: Prealveolar clefts (unilateral, bilateral and median)
- Group II: Postalveolar clefts
- Group III: Complete alveolar clefts (unilateral, bilateral and median)

B. **Veau (1931)** *presented a very simple classification*
- Group I: Cleft of the soft palate only
- Group II: Cleft of hard and soft palate

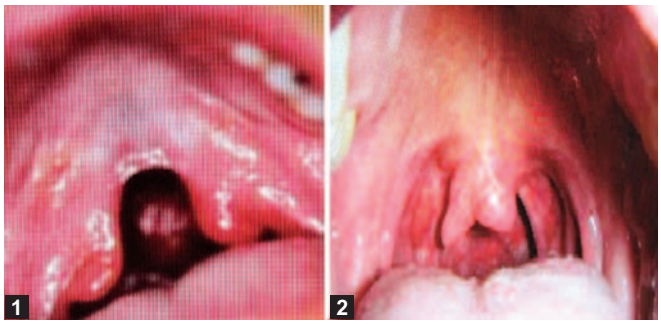


Fig. 40.7A: (1) Submucous cleft palate; (2) Bifid uvula

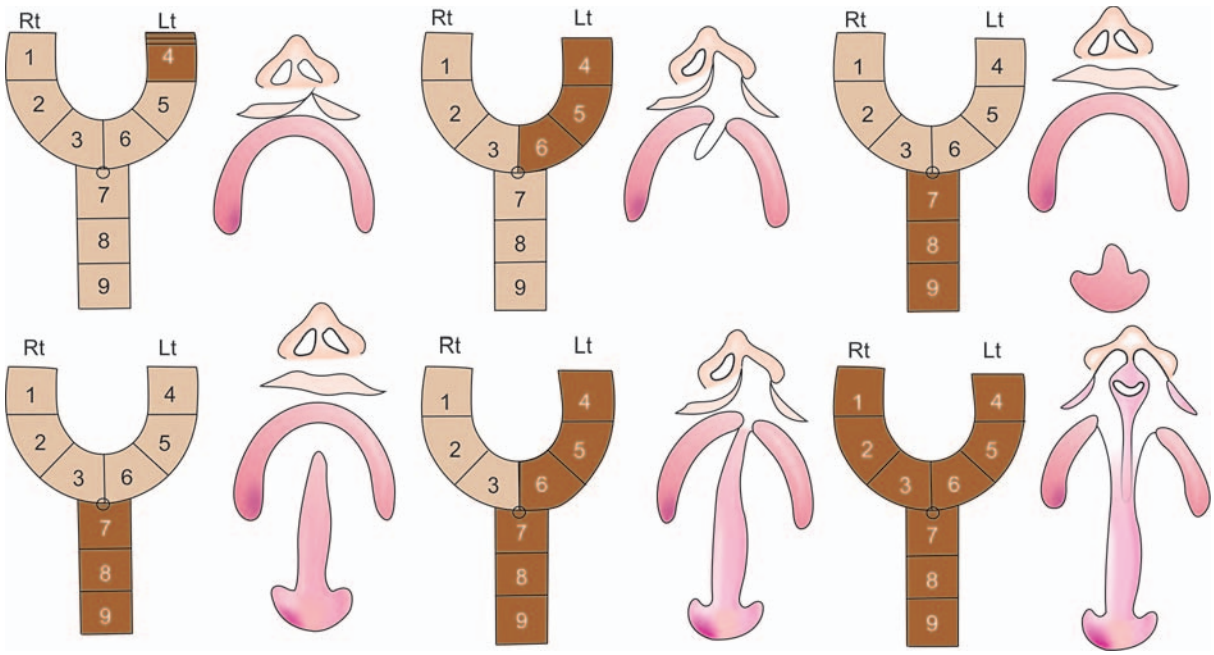


Fig. 40.7B: Diagrammatic representation of Kernahan's classification

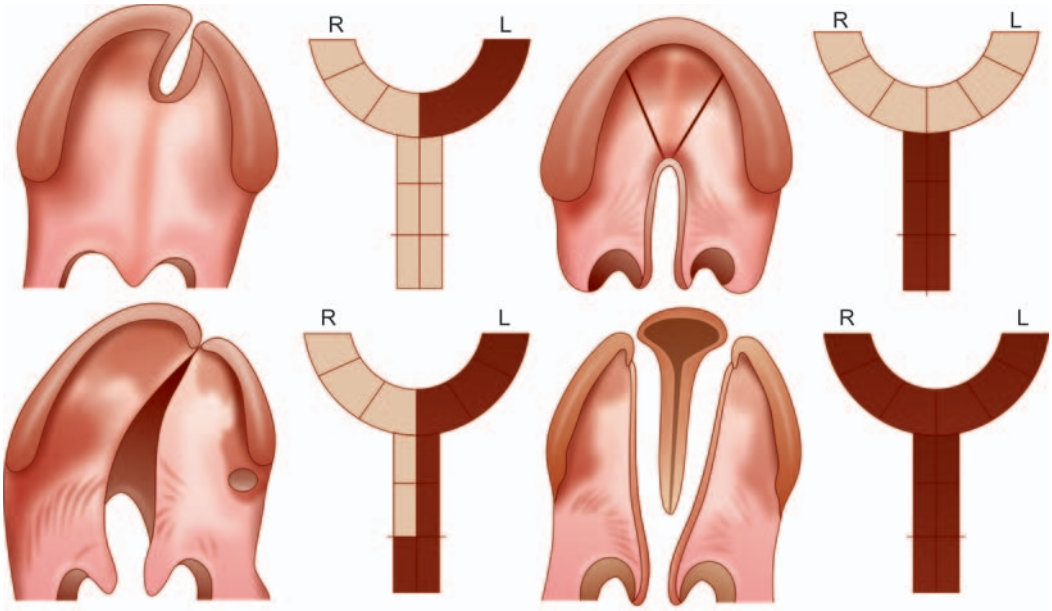
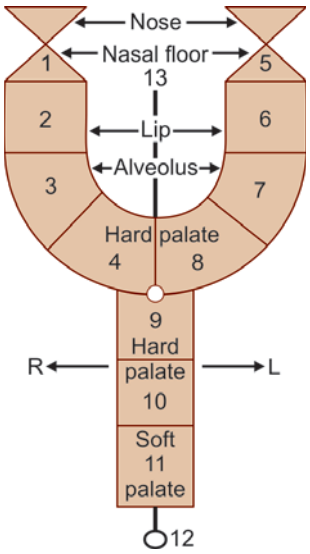


Fig. 40.7C: Kernahan's classification another diagram

- Group III: Complete unilateral cleft, extending from uvula to incisive foramen and then deviates to one side extending through the alveolus.
- Group IV: Complete bilateral alveolar cleft.

C. *Internationally approved classification (1967), following Rome Congress based on embryological principle:* This was the basis of the first classification advocated by Fogh-Andersen in 1942, confirmed by Kernahan and Stark (1958), and later put forward by V Spina (1972) and others. Landmark was the incisive foramen **(Table 40.2)(Figs 40.7B and 40.7C)**.

Kernahan has simplified it by representing various clefts in the form of a striped Y. The anterior portions of the Y depict the lip (1 and 4), the middle alveolus (2 and 5), incisive foramina and the posterior portion (the area of the hard palate from the alveolus back to the incisive foramen (3 and 6), posterior to the incisive foramen, the hard (7 and 8) and the soft (9) palate. This facilitates charting of the deformity by residents in a CLP clinic.



Figs 40.7D: Elsahy's modification of stripped Y Kernahan's classification

Elsahy's Modification

Millard modified Kernahan's classification, he added two triangles to Y, and numbered them 1 and 5, depicting nasal floor, rest of the numbering pattern was changed as shown in the diagram, which was further modified by Elsahy **(Fig. 40.7D)**. Elsahy modified the stripped ~Y~ further by double lining the blocks 9 and 10, in the hard palate area and used arrows to indicate the direction of deflection in complete clefts. He also placed a circle 12, under the stem of the Y to represent pharynx, and a dotted line from Y to circle to 12 reflecting the velopharyngeal competence. Another circle 13 was also added to represent premaxilla and the amount of its protrusion was indicated by the dotted line with an arrow **(Fig. 40.7D).**

Table 40.2: Internationally approved classification of cleft lip and palate

A.	*Group I: Cleft of the anterior (primary) palate*			
	a.	Lip	Unilateral/Bilateral	Right/Left—total or partial
	b.	Alveolus	Unilateral/Bilateral	Right/Left—total or partial
B.	*Group II: Cleft of anterior and posterior (primary and secondary) palate*			
	a.	Lip	Unilateral/Bilateral	Right/Left—total or partial
	b.	Alveolus	Unilateral/Bilateral	Right/Left—total or partial
	c.	Hard palate		Right/Left—total or partial
C.	*Group III: Clefts of posterior (secondary) palate*			
	a.	Hard palate: Right/Left		
	b.	Soft palate		
D.	*Group IV: Rare facial clefts [Figs 40.8A (1 to 7)]*			

Cleft Lip and Palate Syndromic Cases

- Down's syndrome
- Waardenburg's syndrome
- Van der Woude's syndrome—most common syndrome associated with CLP, with or without lower lip pits or blind sinuses
- Marphan's syndrome
- Edward's syndrome
- Stickler's syndrome
- Craniofacial digital syndrome
- Treacher Collin's syndrome
- Pierre Robin's syndrome
- Klippel-Feil's syndrome
- Crouzon's craniofacial dysostosis
- Apert's syndrome, Gorlin's syndrome and many more.

ASSOCIATED DEFORMITIES AND PROBLEMS

The cleft of the upper lip entails loss of the important orbicularis oris muscle complex. Without the control of



Figs 40.8A (1 to 7): Rare facial clefts: (1) Median mandibular cleft; (2) Proboscis nose—double nose with cleft lip-unilateral; (3) Coloboma of the eye with lateral facial cleft; (4) Oro-ocular cleft; (5) Oronaso-ocular cleft; (6) Postoperative view of the same child in above Fig. 5(7) Lip pits

this sphincter group of muscles, the developing parts of the cleft maxilla deviate to accentuate the alveolar ridge cleft, when it is seen at the time of birth. In all significant cleft lip cases nostril defect is present, which ranges from mild nostril asymmetry to absence of nasal floor and gross deformity of nasal cartilage and septum. In unilateral cases, the ala on the cleft side is hypoplastic, flared and at lower level than the normal side. The columella will be pulled towards noncleft side. Vertical and horizontal hypoplasia of the maxilla is also noticed on the cleft side. Premaxilla and prolabium are deviated away from the cleft. In bilateral cases, premaxilla and prolabium project anteriorly and the columella is extremely short. There is lack of underlying bony support to the base of the nose. Difference in the dynamics of the growth potential in midline structures as compared to the lateral structures will be evident. Clefts of the palate may be associated with marked underdevelopment of the mandible. In Pierre Robin syndrome along with cleft palate, there is mandibular micrognathia and glossoptosis. The underdeveloped mandible results in tongue fall in the oropharynx, airway obstruction in newborn child.

Structural defects of cleft lip and palate prevent negative oral pressure required for effective sucking. Feeding the child is a major problem in these patients. Palate function is necessary for swallowing and normal speech.

The hard palate provides the partition between oral and nasal cavities and soft palate functions with the pharynx in an important valve action referred to as velopharyngeal mechanism. In normal speech, this valve action is intermittent, rapid and variable to effect normal sounds and pressures by deflecting the air stream with its sound waves out of the mouth. Without this valve action, speech is hypernasal and deglutition is impaired. In addition to their actions in the elevation and tension of the soft palate, the levator and tensor muscles affect the opening of the auditory tube (equalization of pressure by swallowing). When this mechanism of tube opening is impaired, there is greater susceptibility to middle ear infections. There is additional hazard of lymphoid hyperplasia over the auditory tube orifice in the nasopharynx.

Thus, the cleft palate patient will be handicapped with multiple problems of hearing loss from middle ear infection plus defective mechanism of normal speech and deglutition. The growth of the maxilla will be affected in these patients resulting into functional and esthetics impairment and malocclusion. Recurrent otitis media and hearing loss is seen in 22–88% of patients.

Dental Problems

Cleft of the alveolus may affect the development of the primary and permanent teeth and the jaw itself. Teeth can be congenitally absent or supernumerary teeth may be seen or crowding or displacement of permanent teeth can be seen. Usually the cleft is seen extending between the lateral incisor and canine areas.

The teeth may be morphologically deformed or hypomineralized and the eruption can be seen at the cleft margin.

The hypoplastic maxilla will have common finding of pseudoprognathism or relative prognathism of the mandible. Early palatal closure will bring about scar contraction and may severely limit the growth and development of maxilla, which will be deficient in all three planes. Constriction of the maxillary dental arch will be seen with narrowing of the palatal vault.

Feeding

Often the complaint made by parents is about the poor nutritional status of the child due to cleft palate deformity. This is a total fallacy. Though the child is not able to suck like a normal child and tends to take in more air with every sip of the milk, a proper training to the mother can easily overcome this handicap. The babies can swallow normally, if they are fed directly towards the hypopharynx, sitting in an upright position. But, breast or bottle milk sucking is difficult for babies, as there is no necessary negative pressure in their mouth. The problem can be overcome through the use of specially designed nipples, that have elongated and bigger opening, which extend directly into the hypopharynx. Care should be taken to avoid aspiration or regurgitation.

Spoon feeding is preferred. It is more hygienic. Breast milk can be expressed and fed with a spoon. In addition the child should be burped frequently to take the air out, which it ingests with the milk (due to large velopharyngeal port) and feels full without taking in adequate quantity of feed.

Once the date of surgery is decided upon, the child should be weaned off the bottle/breastfeed and should be put on spoon feeding at least a week in advance to let him get adjusted to it.

Speech Problems

Communication problems are inherent with cleft patients. 80% of the patients born with CLP are nonsyndromic, who receive palatal repair by 18 months of age, can expect reasonably good speech without

intervention. Hypernasality is due to velopharyngeal incompetence (VPI).

Retardation of consonant sounds is the most common problem (p, b, t, d, k and g). Speech is affected, hypernasality can remain in these patients, even after the surgical correction. Dental malformation and abnormal tongue position may produce an articulation problem. Hearing impairment aggravates the speech problem further. The speech problem should be treated at earliest, to develop normal articulation skills. Several years of speech therapy may be necessary for acceptable speech level.

AIMS AND OBJECTIVES OF MANAGEMENT OF CLEFT LIP AND PALATE

- To correct the birth defect surgically, so that patient can have acceptable facial esthetics (**Fig. 40.8B**)
- To permit intelligible speech
- To correct the dentition to allow normal function and esthetics.

In order to meet medical, surgical, dental, psychological needs of the individual with orofacial cleft birth defect, a multidisciplinary approach is a must. All specialists must work in unison with their individual skill and expertise to enhance the optimum care for the patient. Several trained persons like geneticists, craniofacial surgeons, plastic surgeons, oral and maxillofacial surgeons, ENT/otolaryngologists, anesthesiologist, neurosurgeons, ophthalmologists, pediatrician, speech therapist, speech-language pathologists, child psychiatrists/psychologists, orthodontist, prosthodontist, pediatric dentists, periodontists, etc. are needed to be involved in the overall treatment plan. Allied healthcare workers also contribute towards the success, like trained nursing staff, audiologist, prosthetic laboratory technician, social workers, NGO workers, etc.

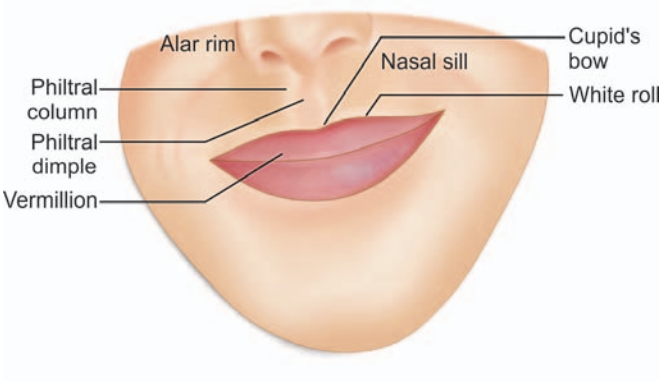


Fig. 40.8B: Normal anatomic landmarks considered during cleft lip surgery, the attempt is always towards establishing near normal esthetics

GENERAL MANAGEMENT PROTOCOL FOR THE CLEFT PATIENT (TABLE 40.3 AND TABLE 40.4)

Table 40.3: Modalities in the management based on chronological age

	Timing	*Procedure*
1.	After 16 weeks of pregnancy	Cleft lip diagnosis by ultrasound images **(Fig. 40.8C)**.
2.	Prenatal	Discussion with craniofacial surgeon/geneticist/ dysmorphologist.
3.	Neonatal/immediately after the birth	Pediatric consultation, counseling, feeding instructions, evaluation by geneticist to decide whether it is an isolated cleft or if the cleft is part of the syndrome, diagnosis of life expectancy of a child and diagnostic tests
4.	Within first few weeks of life	Team evaluation, including hearing testing
5.	0–3 months	Presurgical orthopedics—nasoalveolar molding (NAM), 10–12 weeks Primary Surgical repair of the lip, 3–6 months in India, and tip rhinoplasty
6.	Before age 6–12 months	Team evaluation and primary surgical repair of cleft palate, with intravelar veloplasty and placement of pressure equalization tubes for hearing impairment (bilateral myringotomy and tubes)
7.	3 months after palate repair	Team evaluation for speech and language assessment
8.	3–6 years	Team evaluation—medical, behavioral intervention as needed. Speech therapy, treatment for middle ear infection, fistula repair, soft palate lengthening, psychological evaluation
9.	5–7 years	Lip, nose revision if necessary, secondary rhinoplasty Pharyngeal surgery

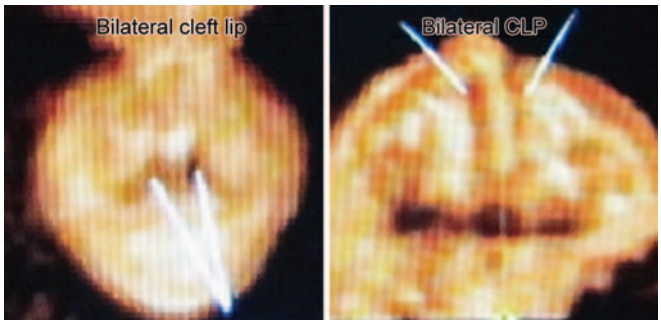


Fig. 40.8C: Prenatal ultrasound examination helps to reveal cleft lip and palate (CLP) deformity earlier, so that parental mental preparation along with necessary counseling and preplanning the further treatment is done. Prenatal surgical endoscopic repair is also possible at the specialized centers

Table 40.4: Modalities in the management based on dentofacial development

	Timing	*Procedure*
1.	Prior to cleft lip repair	Presurgical infant dentofacial orthopedics—strapping/ nasoalveolar molding
		NAM appliance **(Fig. 40.8D)**
2.	Primary dentition	Orthodontic treatment for maxillary expansion
3.	Mixed dentition maxillary	Orthodontic treatment for maxillary expansion and Protraction
4.	Before eruption of permanent dentition	Prealveolar bone grafting **(Fig. 40.8E and F)**
5.	Permanent dentition	Orthodontic treatment for dental arches alignment
6.	Complete eruption of permanent dentition	Dental arch alignment—full orthodontic phase II
7.	End of dentofacial growth	Orthognathic surgery/ distraction osteogenesis for maxillary. Advancement, if required
8.	After orthognathic surgery/distraction	Postsurgical detailing of occlusion
9.	After postorthodontic treatment	Placement of implants, fixed bridge, etc. for missing teeth
10.	After complete dental rehabilitation	Final nose and lip revision—rhinoplasty, after 21 years

Presurgical Dentofacial Orthopedics

Presurgical nasoalveolar molding protocol (NAM) was introduced by Grayson et al. in 1993 **(Fig. 40.8D)**. NAM is basically used to carry out active molding and repositioning of the nasal cartilages and alveolar processes and also lengthening of the deficient columella. The nasal changes by NAM are achieved by the use of nasal stents rising from the labial vestibular flange of the intraoral plate. As per the studies, there is high degree of plasticity and lack of elasticity in neonatal cartilage due to high levels of hyaluronic acid—an important component of proteoglycan intercellular matrix. Hyaluronic acid level increases with the increase in estrogen level. Immediately after the birth, neonatal levels of maternal estrogen levels are highest. Therefore, first 2–3 months after the birth, is the ideal period for active soft tissue/cartilage molding.

Aim of the Presurgical Nasoalveolar Molding

- **Unilateral CLP:** to align and approximate the alveolar segments, correct the malpositioned nasal cartilages and the alar base on the affected side and also try to normalize the position of the philtrum and columella in a controlled manner.
  Advantages: Decreased tension on the incision line and postoperative scar, controlling alveolar contact, creation of a natural curvature of the alar rim and most important to decrease the amount of surgical dissection required.
- **Bilateral CLP:** to lengthen the columella, elongate the prolabium, reposition the nasal cartilages toward the tip and align the alveolar segment including premaxilla.
  Advantages: The nasal stents advance the lateral alar cartilages into the nasal tip and provide stretch to the columellar skin. In bilateral CLP cases, the columella at birth is 0–2 mm in length, following NAM—it increases to 4–7 mm. The normal columella length at this age group is 3.2 mm. Overcorrection of columella is helpful to compensate the postsurgical relapse. The columellar base is stabilized by a horizontal prolabial band, attached to the two nasal stents. It serves as a fulcrum for the distracting forces of the nasal stents upwards on the columella envelop, and of the labial tapes downwards on the prolabium. This controlled elongation of the columella provides enough tissue for the surgery to create both nasal projection as well as central lip length.

Technique of NAM Plate Therapy

Immediately after birth, an impression of CLP defect is done in custom made acrylic tray, with an elastomeric material and conventional molding plate, as shown in **Fig. 40.8D**, is fabricated by using clear resin. The NAM is placed in CLP defect, offering compression over the lips and alveolus and is secured with the use of adhesive tapes

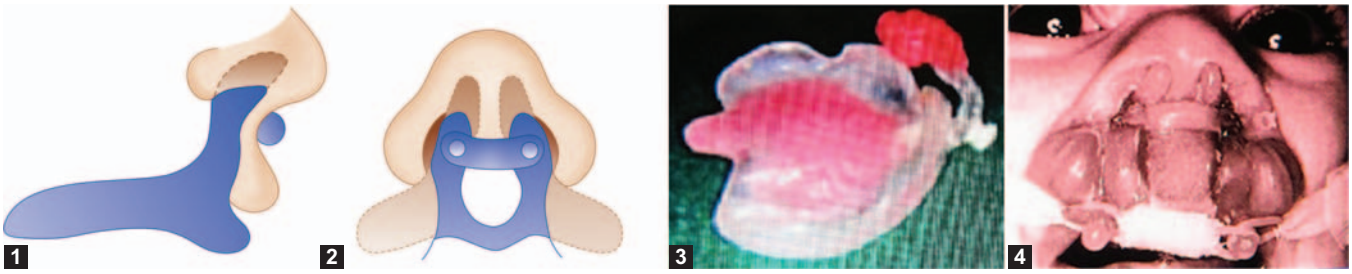


Fig. 40.8D: (1 and 2) Diagrammatic representation of design of nasoalveolar molding appliance—nasoalveolar molding (NAM) shown in blue color; (3) NAM appliance; (4) Clinical photo of a child wearing NAM appliance

applied externally to the cheeks and also elastic banding/taping the right and left lip segments together. The NAM is modified every week as the alveolar segments start getting molded and getting approximated. Soft denture liner is added to the plate in the region of desired alveolar molding, after selective grinding. The mesiolateral position of the nasal stents is also adjusted as it lifts the nasal tip. In bilateral cases NAM is done in stages. In first stage, repositioning of the everted premaxilla into the space between the lateral alveolar segments is carried out using sequential modifications of an acrylic intraoral plate in conjunction with elastic bands that are attached to the cheeks. In second stage, after the alveolar segments are approximated together, the nasal stents are built from the anterior rim of the oral plate and enter the nasal apertures. This will provide support to the nasal dome and also shape alar cartilages along with the dome.

Alveolar Bone Grafting

Seventy-five percent of the patients with CLP have an anterior alveolar bone defect, which can affect tooth development and contribute to the collapse of the alveolar segments. Surgical repair/reconstruction of the cleft is necessary for the eruption of adjacent teeth, orthodontic/prosthodontics treatment for rehabilitation and also for the closure of symptomatic oronasal fistulas. Currently bone grafting is the important step in the protocols of treatment of CLP. Earlier primary bone grafting was done before 3 years of age. But this had adverse effects, such as restriction of maxillary growth or deficient alveolar morphology with unerupted teeth or teeth with no support **(Figs 40.8E and 40.8F)**.

Advantages of Alveolar Bone Grafting

- To provide osseous support for the teeth, near the area of the cleft. To facilitate eruption of the teeth and to improve the success of further orthodontic treatment.

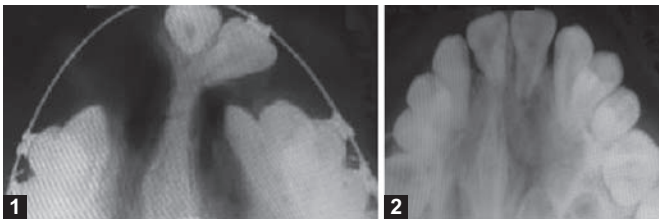


Fig. 40.8E: (1) Presurgical occlusal view of bilateral cleft lip and palate (CLP) case, during orthodontic expansion treatment; (2) Postorthodontic treatment occlusal view showing take of the alveolar bone grafting and alignment of teeth

- Uniform formation of the dental arch and alveolar ridge, along with optimum lip support. Improve the arch form.
- Closure of oronasal fistula—preventing regurgitation and frequent infection, improve speech.
- Improvement of facial esthetics—supports nasal structures and lifts the free portions of the nostrils in the area of the cleft, thus improving nasal and labial symmetry.
- Stabilization and partial repositioning of the premaxilla in patients with bilateral clefts. Decreases the incidence of maxillary collapse. Decrease need for orthognathic surgery.
- To provide adequate bone volume for subsequent eruption of canine through the graft and for implant based prosthetics. Preserves lateral incisor.

Timing of the Alveolar Bone Graft

It is highly variable. But currently performed between 9 years and 12 years of age—when the permanent canine is at the height of its eruptive process, located high in the alveolar process (with one-third or half completed root formation).

Surgical Protocol

Maxillary expansion, if needed, depending on maxillary collapse, is completed 6 months prior to bone grafting. Roots of the adjoining teeth near the clefts are adjusted



Courtesy: Dr Vidya Rattan

Fig. 40.8F: (1 to 12) Alveolar bone grafting procedure in 9-year-old girl with left unilateral cleft lip and alveolus (1 to 3—frontal, lateral and occlusal intraoral photographs showing left side alveolar cleft defect. 4, 5, 6—postoperative frontal, lateral and occlusal intraoral photographs at 6 months follow-up following alveolar bone grafting. 7 to 9—intraoperative photographs depicting exposure of alveolar cleft followed by bone grafting with iliac cancellous bone. 10—preoperative intraoral periapical X-ray. 11—intraoral periapical X-ray after 14 days of alveolar bone grafting. 12—intraoral periapical X-ray after 6 months of alveolar bone grafting showing uptake of bone graft and eruption of canine through grafted bone

away from the cleft, with preservation of some bone around it **(Fig. 40.8E)**. Anterior teeth with large rotations should not be corrected prior to grafting to avoid fenestration and dehiscence. Extractions of primary and supernumerary teeth adjacent to the cleft should be done at least 6 weeks prior to grafting. Application of chlorhexidine gel 3–4 times

a day at the cleft site for 2 days prior to surgery. Alveolar bone grafting from iliac crest-corticocancellous graft. Postoperative evaluation after 15 days, 1 month and 3 months with radiographs. Orthodontic treatment is resumed 6 weeks later. Treatment for aligning teeth is initiated and expansion achieved is retained for 6–12 months.

MANAGEMENT OF CLEFT LIP: UNILATERAL AND BILATERAL

Unilateral Cleft Lip: Timing of the Lip Surgery

The timing of the lip repair in infancy varies from first 48 hours of life to 6 months of age, depending on the surgeon's judgment. Although, there is always a debate as to when the surgery should be performed, most surgeons follow "Millard's rule of 10". 10 weeks of age with 10 g of hemoglobin and 10 pounds of weight. The trend is shifting toward early repair. In fact few centers like to repair the lip as early as 5–7 days postbirth. But in a country like India, where postoperative neonatal care is less than ideal, rule of safety should be applied. It should be safe to anesthetize the child and to look after postoperatively.

Preoperative Evaluation

Total pediatric and ENT checkup should be done for the child, though in a large number of cases, this can be done by the operating surgeon himself. Wherever the need be, help may be sought of other specialists. One should particularly look for the following:

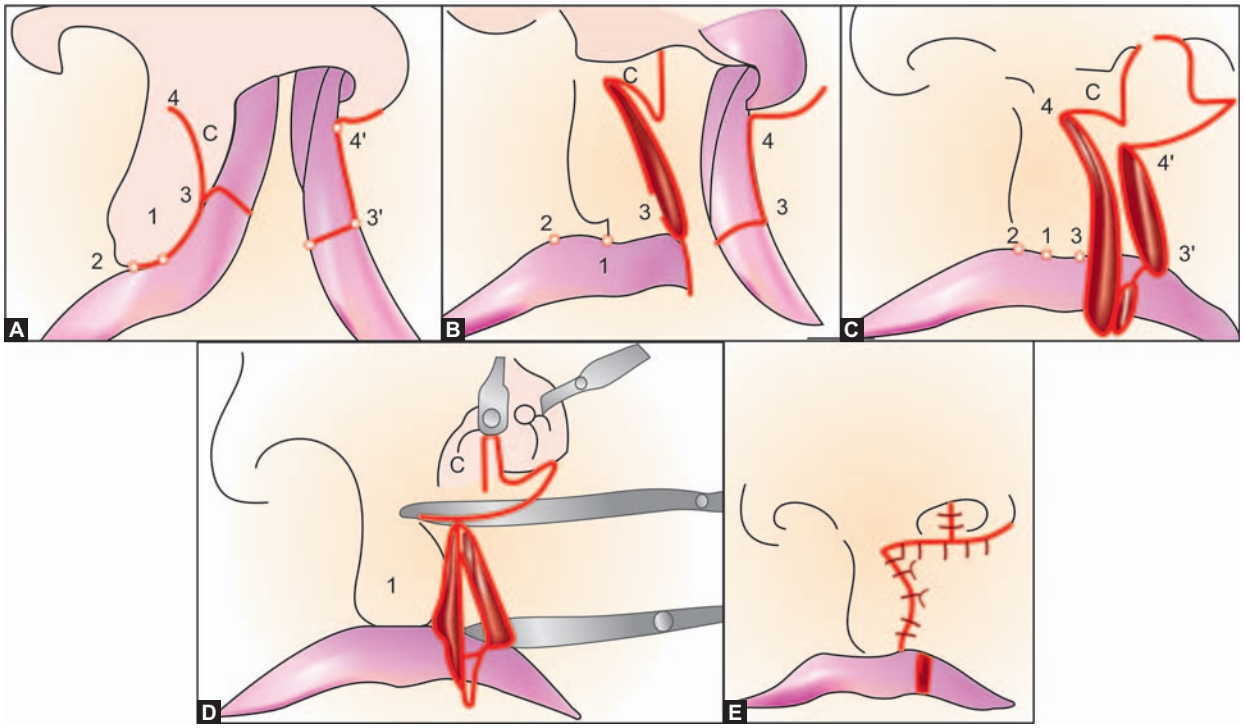
- Upper respiratory tract infection
- Ear infection
- Malnutrition
- Anemia
- Other congenital anomalies particularly cardiac
- Milestones
- Mental status of the child.

Parental counseling is extremely important and its role should never be underestimated.

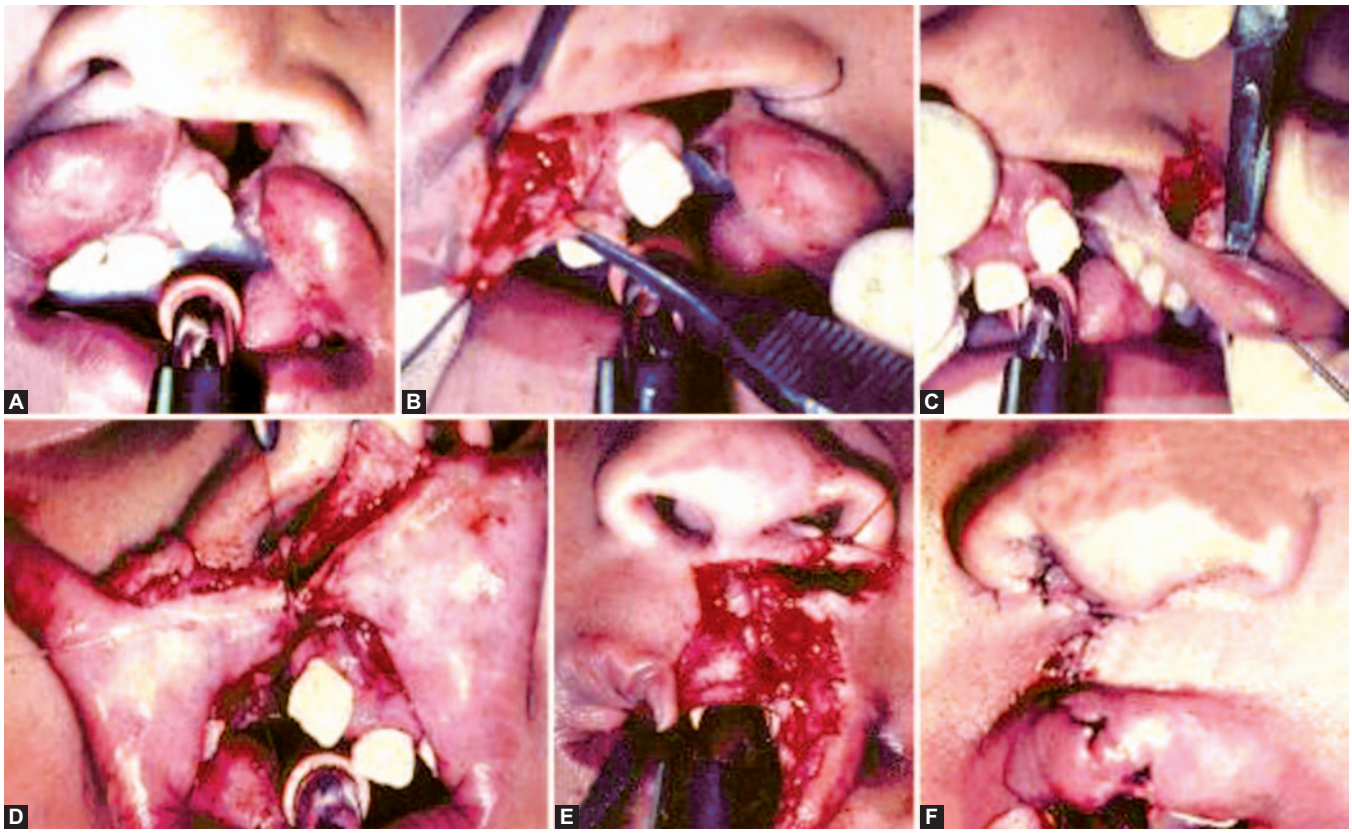
Operative Procedure

Unilateral Cleft Lip Repair: Millard's Rotation Advancement Principle

Cleft lip involves the vermilion border of the upper lip and may extend toward the nostril **(Figs 40.9 to 40.11)**.



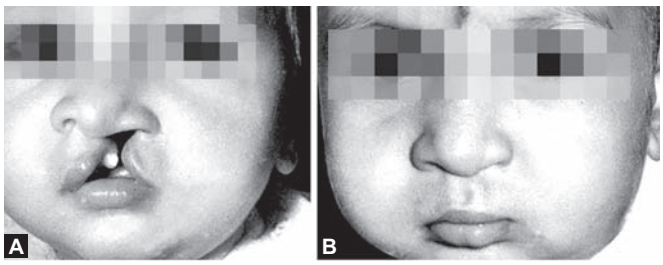
Figs 40.9A to E: Millard's rotation advancement operation for the repair of unilateral cleft lip. Points 2, 1, 3 mark Cupid's bow. Incision from 3 to 4 allows for downward rotation of lip. The distance between 3 and 4 should be equal to 3–4′. The incision between 3′ and 4′ creates the advancement flap. The incision from 4′ to 5′ mobilizes the flap to allow its advancement into the rotation gap. Closure is started by elevating the nostril, permitting small "C" flap to augment columella



Figs 40.10A to F: Surgical repair of unilateral cleft lip—Millard's procedure: (A) Initial markings; (B) Flap raised on the noncleft side; (C) Skin incision on the cleft side; (D) Intraoral mucosal suturing; (E) Muscular layer and skin suturing; (F) Cleft lip repair complete

In the repair of the cleft lip, the most critical process is the reconstruction of the orbicularis oris muscle into a continuous sphincter. Basic aim of the repair is to create a three-layered closure of skin, muscle, mucosa that approximates the normal tissue after excision of hypoplastic marginal cleft tissue.

In 1955, Millard put forward the concept of advancing a lateral flap into the upper portion of the lip, along with downward rotation of the medial segment. The technique preserves both the Cupid's bow and the philtral dimple. It also places the tension of closure under the alar base, so it reduces the nasal flare and promotes better molding of underlying alveolar process.



Figs 40.11A to B: Unilateral cleft lip: (A) Preoperative front view in a 4-month-old child; (B) Postoperative front view

The operation is performed under general anesthesia. For endotracheal intubation, an oxford tube is preferred. It is then fixed with a stitch to the lower lip in its middle to prevent distortion. Head is placed on a rubber ring. Having draped the patient, the markings are done with pen and ink, usually a sterile toothpick is used dipped in ink (surgical grade). The important landmarks, which are usually present in unilateral cleft lip, are then tattooed with a no. 26 gauge needle.

The lip, ala and the adjoining cheeks are infiltrated with 1:100,000 saline-adrenaline solution, 1 cc or 5–10 mg per kg body weight can safely be injected. 5 minutes wait after injection is desirable. For greater accuracy in incising and suturing and proper alignment of anatomical landmarks, use of magnification loops 1.5–2.5 is desirable. Skin incisions are then made with no. 15 blade. Incisions are completed through the muscle and the mucosa.

Simply put, the difference in the height of two peaks of the Cupid's bow on the medial element is the exact distance that the higher peak must be lowered into normal position. This is also the exact distance that the interdigitation flap must measure across its widest point, so as to supply a mathematically sufficient amount of tissue to complete the release. The rotation incision provides flap "C" which is cut free from the lip base attached to the columella. It is freed from the membranous septum to allow columellar advancement. This provides extra length to short columella and also reduces defect at backcut.

The difference in the vertical height of 2 and 3 = amount of release necessary from incision 3–5 + x = width of the point of flap 8–9 = 10, necessary to fill the rotation gap. To achieve requisite rotation, the incision may be carried well past the midbase of the columella. If rotation is still not sufficient, the incision can be carried further across toward the normal side. A "backcut" assures adequate closure without causing obliqueness of the scar or abnormal vertical lengthening of the lip and is a standard feature of all cleft lip repairs. Realignment of vertically attached muscle fibers is very important. Changing their direction from oblique to horizontal enables them to present their ends to the muscle of the lateral element. Wide undermining of the muscles on the noncleft side should not be encouraged as such action will destroy the natural philtral dimple and philtral column. Freeing the muscle from its skin and mucosa along the edge, offers an advantage in the three-layer suturing.

Primary Nasal Correction

There is great controversy in regards to primary nasal correction at such an early age that it may interfere with the nasal growth. But the release of underdeveloped alar cartilage, correction of the wrongly directed ala and rotating it medially, upward and inward, bringing into its normal anatomical configuration does not interfere with the growth; in fact restoration of normal anatomy allows it to grow in more normal manner **(Figs 40.12 to 40.14)**.

Introduction of flap "C" into the short side of the columella adds length and contour bringing better symmetry to the central column. Lateral side of flap "C" still serves as a portion of the nostril sill. The next step is to free the nasal and lip attachments to the maxilla on the cleft side. The extent of freeing depends on the width of the cleft. It must be quite radical in wide complete clefts. An incision along the upper labial sulcus on either side of the cleft with wide undermining and medial advancement of the mucosa depending upon the severity of the cleft, helps to bring the two lip elements (medial and lateral) together and suturing without tension with good buccal sulcus.



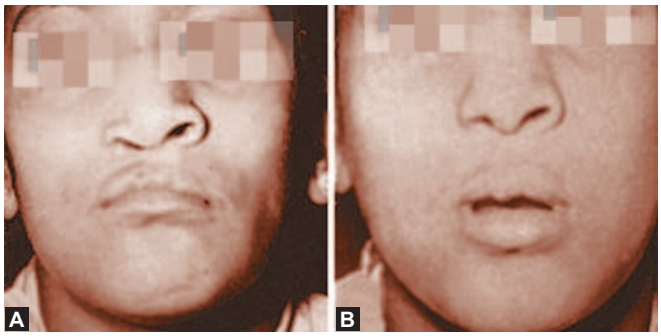
Figs 40.12A and B: (A) Unilateral cleft lip with typical nose deformity; (B) Cleft lip repair without primary nose correction



Figs 40.13A to D: (A) Unilateral cleft lip with typical nasal deformity; (B) Repair of the cleft lip along with primary correction of nose; (C) Immediate postoperative results; (D) Nose and lip contour 6 months postoperatively

Suturing

Flap "C" is advanced into the columella on the cleft side and fixed with skin sutures of 6/0 ethilon. Then the vermilion pairings are sutured with 4/0 catgut or vicryl to line the sulcus by covering the raw area of the alveolus. Simultaneously the lip elements are advanced medially by suturing their upper lining edge to the maxillary mucosa along the labial sulcus on both sides.



Figs 40.14A and B: Primary correction of the nose: (A) Preoperative view; (B) Postoperative view

Then the key stitch is taken to suture the advancement into the depth of rotation backcut. Muscles on both the sides are then sutured carefully across the cleft. This should be done without tension and in such a manner that skin edges approximate automatically. Skin edges are then trimmed for perfect fit and sutured with 6/0 ethilon. If possible a small "z" introduced at the mucocutaneous junction helps to prevent peaking, when the scar has healed. Suture line care—regular cleaning with diluted hydrogen peroxide and topical application of antibiotic ointment is useful. Sutures are usually removed after 5–7 days. Postsuture removal taping can be done and silicone scar gel can be applied.

Postoperative Management

Though the author personally has never used Logan's bow in last 30 years, but surgeons swear by it and if nothing else it protects the lip from external trauma.

Soft arm restrains/elbow splints are a must for 2 weeks postoperatively.

The child is maintained on spoon feeds of full strength formula or breast milk for 5–7 days and then can use a *wati* or a glass.

BILATERAL CLEFT LIP

A complete and accurate assessment of the bilateral cleft lip is required before embarking on its surgical correction:

- Whether the cleft is complete or incomplete
- The size and portion of the prolabium and the premaxilla
- Presence of anomalies, i.e. lower lip pits, absence of the associated bifid nose, etc.

In bilateral cleft lip repair, there is a lack of quality tissue and segments are widely displaced. It is a major challenge to repair such a defect. Adequate mobilization of the tissues with excellent technique yields good results.

Principles and Objectives of the Surgical Correction

1. Prolabium should be used to form the full vertical length of the middle of the lip.
2. The vermilion ridge or white line of the inferior border of the prolabium should be preserved.
3. The thin prolabial vermilion is turned down for lining.
4. The thin central prolabial vermilion is immediately built-up with the vermilion muscle flaps from the lateral lip segment.
5. Vermilion ridge should come from the lateral lip segments.
6. Upper buccal sulcus should be adequate and at no stage should the central portion of the lip look adherent and tethered to the alveolus.
7. No lateral lip skin should be used below the prolabium.
8. Lengthen the short columella.
9. Premeditated adequate columella planning will avoid the need for later lip re-entry.
10. The creation of continuity of the prolabium with the lateral lip elements joining mucosa for sulcus extension for muscles function. Scar is camouflaged within the philtrum column.
11. Early and permanent alar base positioning.
12. Correct disparity between premaxillary and maxillary segments of the alveolar arch.
13. Repositioning of the severely protruding premaxilla must be done to avoid undue push on the lip.
14. Prevention of collapse of maxillary processes behind the premaxilla.
15. Orthodontia.
16. Bone grafting to stabilize the premaxilla.

Repair Both Sides Simultaneously

Earlier thinking of repairing one side of the lip at one time to convert bilateral lip into a unilateral one is almost outdated today. Simultaneous correction of the lip as well as the nose is done as it obviates the second anesthesia and rehabilitation is faster. Repair in two stages should be reserved only in a small number of cases, where the general health of the child and anesthesia risk overshadows the single stage repair.

1. Freeing of the prolabium from premaxilla.
2. Freeing of lateral lip elements from the maxilla.
3. Forked flaps from the prolabium.
4. Joining of mucosa and muscle to each other behind the prolabium.
5. Lateral vermilion flaps to overlap prolabial vermilion.
6. Banking of forked flaps in subalar incision.

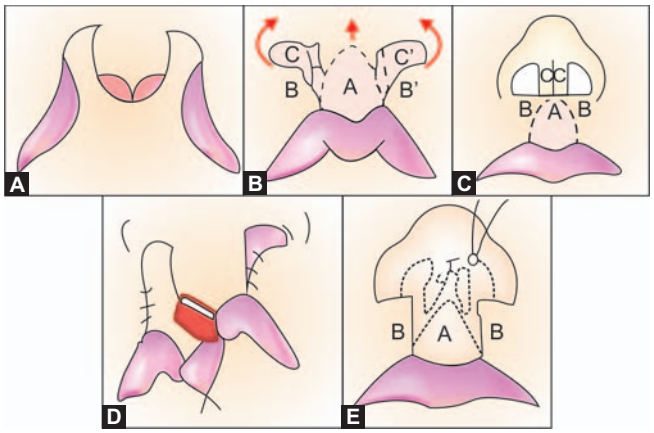
Join alar bases tip to tip. Correction of large defect is achieved by muscle to muscle union in the midline.

Technique of Bilateral Lip Repair (Figs 40.15 to 40.20)

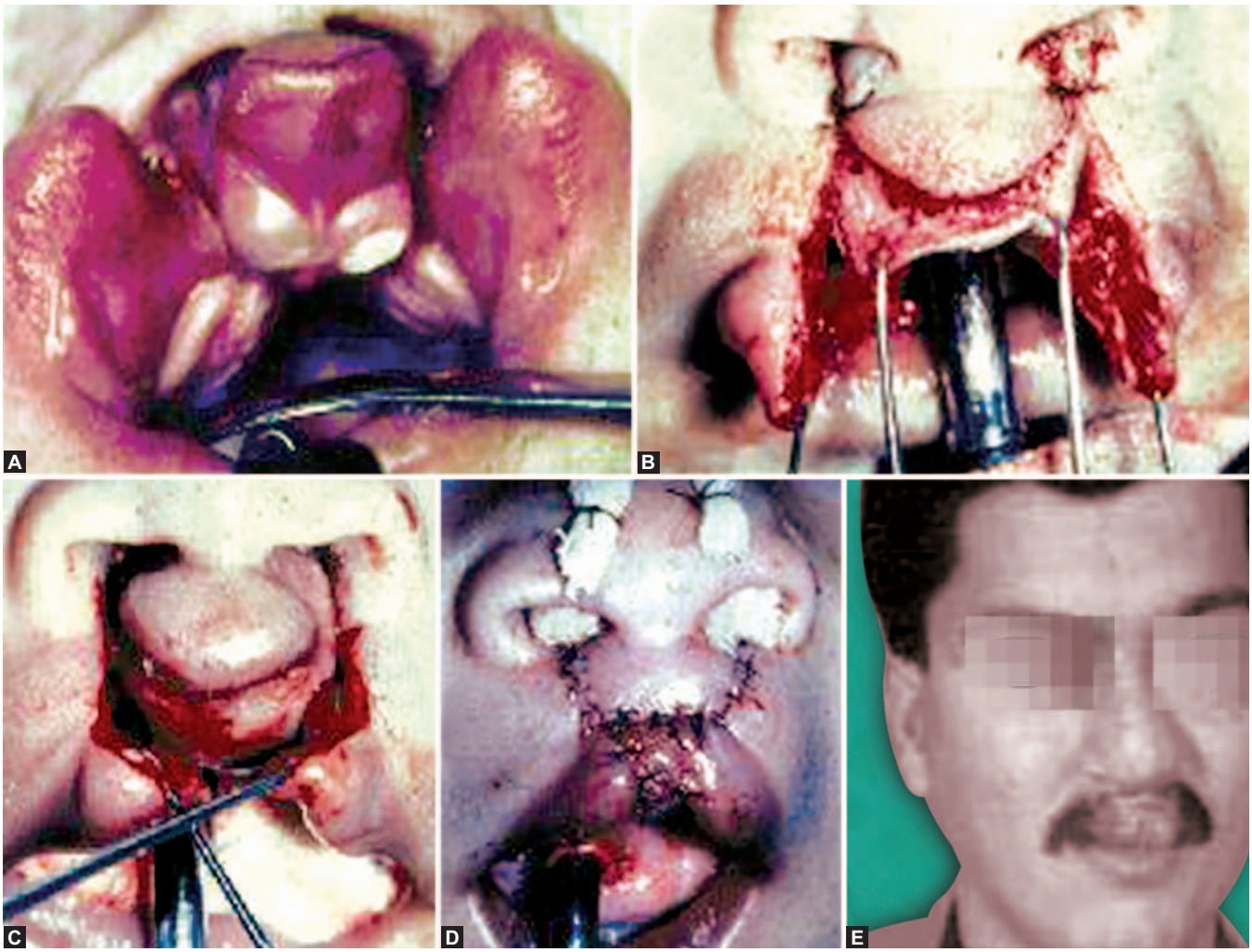
Almost all the methods of lip repair used in a unilateral cleft lip deformity can be used in bilateral lip repair as well.

The simplest is essentially a straight-line closure and it can produce a satisfactory result. The most popular method for lateral lip repair with older generation surgeons has been the Veau's technique, but the results achieved with Millard's repair have been more pleasing.

While correcting a bilateral cleft lip with Millard's rotation advancement, the only difference, but an important one, is that the flap "C" is never allowed to cross the midline of the columella. This is to preserve the blood



Figs 40.15A to E: Diagram for repair procedure for bilateral cleft lip



Figs 40.16A to E: Surgical correction of bilateral cleft lip deformity: (A to D) Intraoperative pictures; (E) The same patient 23 years later



Figs 40.17A and B: Bilateral cleft lip deformity in a 4-month-old child and immediate postoperative results



Fig. 40.18: Residual occlusal deformity in a 16-year-old male, who underwent surgery for closure of bilateral cleft lip and palate at younger age. Note the premaxilla is unattached to either maxilla and protruding forward unhindered

supply to columella. Point "A" is located medial to lip of the alar base. Point "C" is placed in the midline of the valley of the Cupid's bow on the vermilion ridge. Point "B" is placed 3 mm lateral to point "C" on vermilion ridge. If prolabium is wide, forked flaps can be developed and banked in nasal floor to be used later for columellar lengthening. Points A, B are marked on the lateral segments. After marking is completed, saline adrenaline infiltration is used and the operation is proceeded as described for the repair of the unilateral lip.

In the complete bilateral cleft, the premaxilla is unattached to either maxilla. Hence, there are three components—two maxilla usually equal to each other in size and position and the third central premaxillary element protruding forward unhindered **(Fig. 40.18)**. The complete separation of the central component of prolabium and premaxilla influences the nose, philtrum, musculature, vascularity, nerve supply, growth and the development of all the three elements.

No matter which method of repair is used, certain basic principles remain the same:

- Observe symmetry of the lip.
- However small the prolabium, its vermilion must be retained. It should be used to form central part of the lip.
- Bring muscles into the prolabium. Release muscles in both the segments and try to suture these in the midline, if possible, if not at least bring these into the prolabium, so that the children with repaired bilateral lips can smile normally.
- Have adequate buccal sulcus. Prolabial lip or the central portion of the lip must be adherent to the alveolus.
- If for some reason, only one side of the lip is repaired at a time, the second side should be repaired 3–4 months later. In such a case one must try to match the previously repaired side.

Columellar Lengthening

In a unilateral cleft lip repair cleft-sided columella is lengthened with the use of the "C" flap. In a bilateral cleft lip, vertical height of the columella always poses a problem unless the prolabium is quite ample. In such cases, if Millard's rotation advancement is used then the banked flaps in the nostril floors are used at second stage at the age of 2–3 years to lengthen the columella. If there are no banked flaps, then bilateral forked flaps as described by Millard is used, to lengthen the columella. This improves the lip scars of the previous operation as well.

CLEFT PALATE AND MANAGEMENT

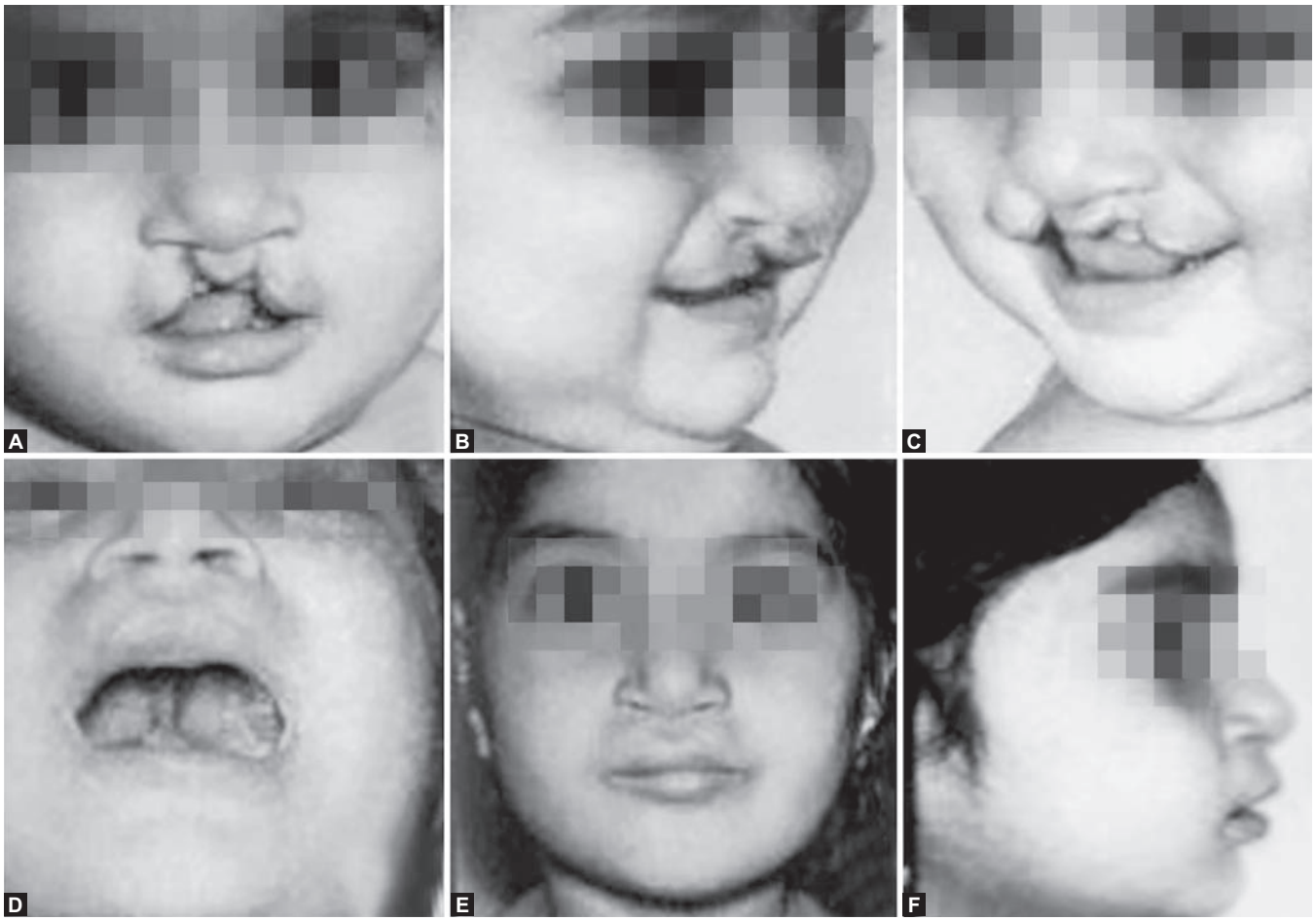
Basic Functions of Palate

Sucking

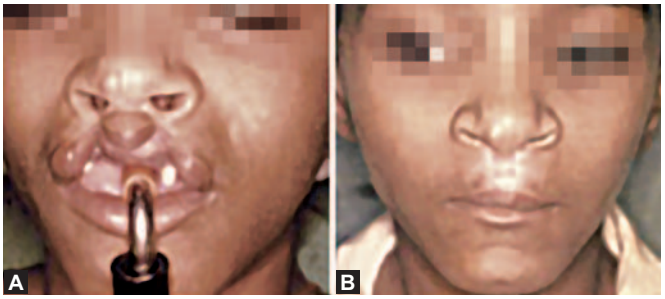
Sucking is effected by an intraoral negative pressure. Lips grasp the object tightly, soft palate moves upward, simultaneously contraction by the buccal muscles and closure of the glottis affects closure of the oral cavity from the nasopharynx.

Swallowing

Swallowing starts as a voluntary movement. Bolus of food is taken to the posterior part of the tongue, then the



Figs 40.19A to F: (A to C) Preoperative views of bilateral cleft lip in a child of 6-month-old; (D) Immediate postoperative result; (E and F) Postoperative result 3 years later



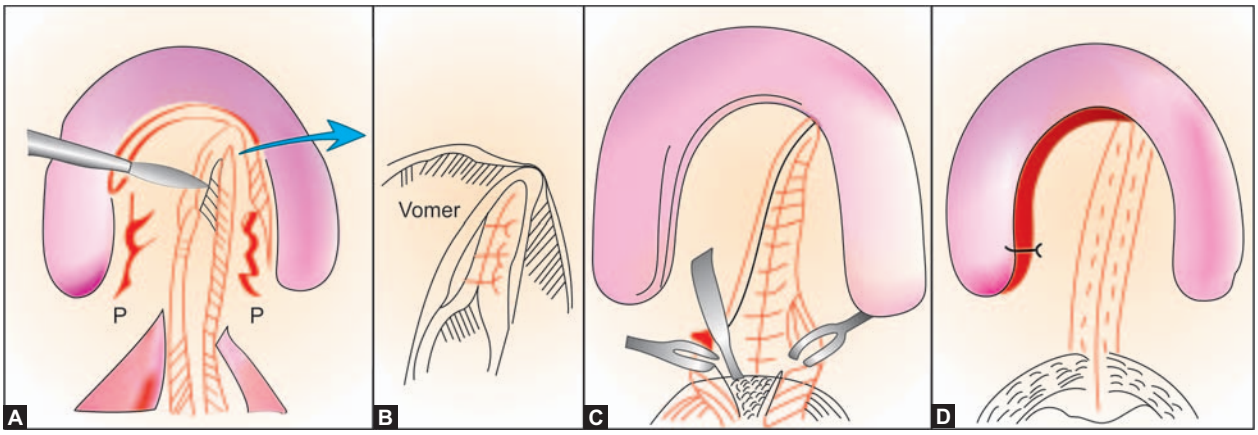
Figs 40.20A and B: (A) Preoperative view of 10-year-old boy, with bilateral cleft lip deformity; (B) Immediate postoperative results

involuntary movement begins and this helps to take the food into the pharynx. Retroflux of the food into the nasal cavity is prevented by the contraction of palatopharyngeal muscles, which narrow the nasopharyngeal isthmus and the levator palatini muscles draw the soft palate upward and backward to press it against the posterior pharyngeal wall. At the same time tensor palatini muscles open the eustachian tubes to equalize the pressure. Hence, the food is not allowed to go back into the oral cavity.

Speech

Speech is produced by the expired air, which is used to vibrate the vocal cords to produce a sound. The sound produced is thus modified by the voluntary changes in the size and shape of the oral and nasal passages. These passages act as a dynamic resonating chamber, e.g. soundbox. The outgoing air may be almost completely stopped in the oral cavity to produce the plosive sounds or may be allowed to go into the nose to produce nasal sounds.

In cleft palate deformity, oral and nasal cavities are not separated from each other, hence the main purpose of repair of the cleft palate is to improve these functions of sucking, swallowing and speech, which are greatly affected.



Figs 40.21A to D: Langenback's palatoplasty technique: (A) Bilateral, unipedicled mucoperiosteal flaps based on the greater palatine (P) arteries are elevated; (B) The nasal mucosa is transected and detached from the nasal side of the palatal shelves. Anteriorly, the nasal floor is repaired by suturing the vomerine mucosa to the nasal mucosa on the cleft side; (C) The soft palate is closed in three layers—nasal, muscular, oral. The levator muscles are dissected free from the oral and nasal mucosa and released from the posterior edge of the hard palate. The levator muscles are approximated to each other in the midline; (D) The oral mucosa is reapproximated in the midline with interrupted horizontal mattress sutures

Repair of the Cleft Palate

From earlier attempts of stitching together the raw edges to the present day concept of lengthening the palate and repositioning of the palatine muscles, the surgery of palate has attained the more functional concept **(Figs 40.21 and 4.22)**.

According to Swedish school only soft palate is first closed at 6–12 months of age. Hard palate is not repaired till 6–8 years of age, lest it may interfere with the growth. Early repair between 9 months to 18 months results into hypoplastic maxilla in 25% of cases.

Veau (1931) modified the Langenback's operation of pushback. Wardill (1933–37) evolved four-flap method of repair.

Treatment Guidelines

1. Proper preoperative evaluation is desired.
2. Timing of surgery must be related to the assets and deficits of an individual case.
3. The same surgical procedure can yield different results.
4. The surgeon does not always have complete control of the rehabilitative outcome.
5. Velopharyngeal capability is related to the pharyngeal architecture and to the size and activity of the velum, rather than to the cleft type.

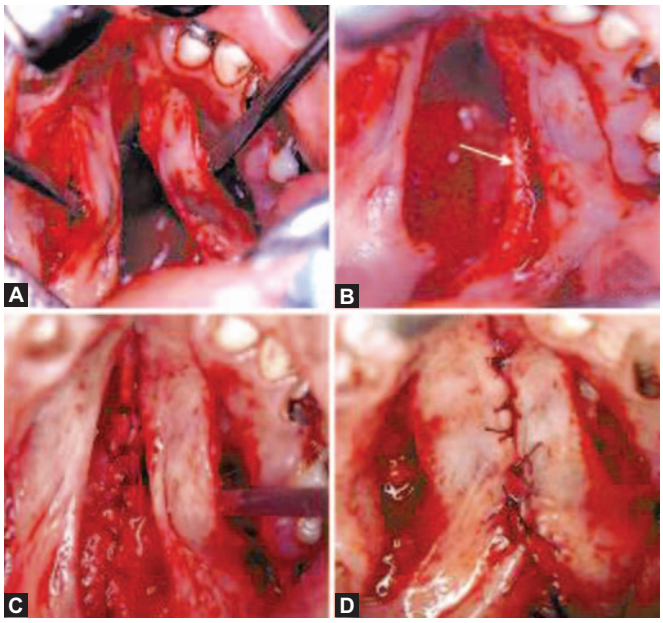
The object of operation is to provide for a mechanism to close the pharyngeal isthmus during speaking and swallowing. Hence the objective of surgery is to obtain a long and mobile palate.



Figs 40.22A to D: Cleft palate repair: (A) Preoperative intraoral view of a 12-year-old girl; (B) Immediate postoperative result; (C) Preoperative intraoral view of 14 years boy; and (D) Immediate postoperative result

Anterior palate is usually closed along with the lip in first stage of the cleft lip repair surgery. A single layer closure of the anterior palate is well accepted. However, a mucosal flap is raised from the cleft side buccal mucosa as described by Muir (1966) can provide buccal layer closure.

Cleft in the alveolar gap is usually closed by a single nasal layer. Buccal side is left with raw area which



Figs 40.23A to D: Surgical procedure of cleft palate repair: (A) Bilateral unipedicled mucoperiosteal flaps are raised based on the greater palatine arteries; (B) The nasal mucosa is transected; (C) The nasal floor is repaired by suturing the vomerine mucosa to the nasal mucosa on the cleft side; (D) The oral mucosa is reapproximated in the midline

granulates. Skoog used a mucoperiosteal flap to cover this raw surface and later proved radiologically not only bony fusion of the alveolar cleft is seen, but also the growth of tooth in this segment is observed.

Operative Procedure

Having anesthetized the patient, neck extension is given with the sandbags placed under the shoulders to visualize the palate **(Figs 40.23A to D)**. A mouth gag—Dott-Kilner or East Grinstead with cheek blades is used to retract the palate. Then saline adrenaline solution 1:1 lac is used to infiltrate proposed lines of incision of the mucoperiosteum and the margins of the cleft. Mucoperiosteal flaps are then raised one from either side. These are island flaps based on greater palatine vessels.

The flaps are elevated to the posterior bony margin. The greater palatine vessels are teased from the foramen and off the palatal flaps for the distance. Next the elevator is passed laterally and posteriorly separating the soft tissues from the medial plate of the pterygoid bone. The palatal muscles are dissected from posterior edge of the hard palate. The free edge of the soft palate is slit open. The amount of posterior displacement of soft palate varies from 1 cm to 2 cm. Nasal mucosa is separated on the nasal side. Levator muscle aponeurosis and nasal mucosa are carefully separated from the posterior bony margin.

To achieve adequate pushback not only the oral layer, but the nasal layer is also lengthened. It is detached from its attachment to the posterior margin of the hard palate allowing it to move back posteriorly.

Soft palate is sutured using vertical mattress sutures. Suture knots of nasal layer are placed on the nasal side, while that of oral layer, on the oral side. Absorbable suture material (either chromic catgut or vicryl 4/0 in small children and 4/0 in older children and adults, on a Dennis Brown needle) is used. A majority of surgeons still use two layer closure—nasal and oral. But as the functional importance of palate is being recognized more and more, dissection of palatine muscles under magnification and then their suturing in normal anatomical configuration is being preferred. Thus, a three-layer closure—first nasal mucosa, second muscle and then the oral mucosa may hold some advantage. Fracture of the hamulus to release tensor palatini is debatable. Often in older children, when the soft palate musculature does not move centrally without tension, hamulus should be fractured and the palatine muscles brought medially and sutured to that from the other side. A cleft uvula must be dissected and muscle uvulae sutured together. Palatine shelves laterally (from where mucoperiosteal flaps are raised) can be left as such. Their surface granulates quite fast.

In very wide clefts with limited tissue, it may not be possible to achieve full closure. Under these conditions, pushback must never be sacrificed at the cost of complete closure of the cleft. If flaps do not reach till right anterior region, it is quite acceptable to leave a fistula anteriorly for which an obturator can be used.

Postoperative Management

Elbows are splinted in extension. Spoon feeding with only strained liquids (the food particles stick in the oral cavity and become a residue for bacterial growth) is done for 10 days. It is essential that suction with sterile catheters be kept by the bedside at least for first 24 hours. Child should be nursed on his side to avoid the danger of tongue falling back. It is preferable to keep the child following palate surgery in the hospital for 10 days or at least under observation.

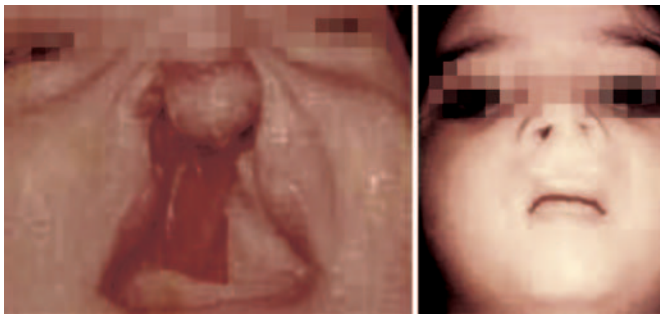


Fig. 40.24: Complete cleft lip and palate deformity and postoperative results

COMPLETE CLEFT LIP AND PALATE DEFORMITY

Anterior palate is repaired usually along with the lip. Closure of alveolar cleft provides stability to the maxillary arch. It also helps in closing the oronasal fistula. In infancy, this gap can be successfully closed with mucosal or Skoog's mucoperiosteal flap, but in later years a bone graft is required **(Fig. 40.24)**. This provides better periodontal support for teeth bordering the cleft. Most of the centers now favor bone grafting during period of mixed dentition, that is, between ages of 9 years and 11 years. Since sagittal and transverse growth of anterior maxilla is completed by 8 years and lateral incisor erupts at 7–8 years of age and canine by 11–12 years of age. The attached gingiva is used as flaps for alveolar cleft after filling the gap with cancellous bone graft obtained from the iliac crest.

ORTHODONTICS IN CLEFT LIP AND PALATE

One of the major clinical features common to cleft lip and palate is constricted and distorted maxillary arch. The severe the cleft, more severe the arch deformity due to collapse. Following lip surgery due to molding action, the cleft segment moves medially and arch further collapses. Added to this underdevelopment or severe hypoplasia of the maxilla on the affected side further accentuates the deformity. This leads to malocclusion. Orthodontic treatment is necessary to correct the deformity.

Orthodontic therapy should be started during mixed dentition, and continued through the permanent dentition. Permanent teeth especially, those adjacent to cleft, are malposed, often severely rotated and poorly calcified. They certainly need to be corrected by orthodontia. If necessary, unwanted tooth/teeth can be extracted, especially the supernumerary ones.

Even with complete orthodontic treatment, there is maxillomandibular discrepancy which may need surgical correction in the form of maxillary advancement with or without mandibular pushback, with or without genioplasty. More information in orthognathic surgery and distraction osteogenesis chapters is given.

Points to Remember

- Introduction
- Incidence
- Etiology
- Embryological aspects
- Classification
- Associated deformities and problems
- Aims and objectives of management of cleft lip and palate
- General management protocol for the cleft patient
- Management of cleft lip, unilateral and bilateral
- Cleft palate and management
- Orthodontics in cleft lip and palate.

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Section 12

Maxillary Sinus and its Implications

41. Management of Maxillary Sinus Afflictions

CHAPTER 41 Management of Maxillary Sinus Afflictions

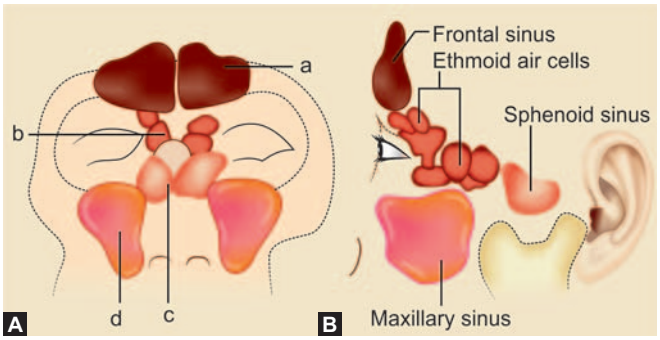
GENERAL CONSIDERATIONS

Anatomy

The maxillary sinus was first described in 1651, by Nathaniel Highmore. Therefore, it is also known as *antrum of Highmore*. Maxillary sinuses are two in number, one on either side of the maxilla, and they are the largest of the paranasal air sinuses **(Figs 41.1A and B)**. They communicate with the other paranasal sinuses through the lateral wall of the nose. They may be identical or asymmetrical in size and shape. The average dimensions of the sinus are approximately 3.5 (anteroposterior) × 3.2 (height) × 2.5 cm (width) (Turner 1902). Its volume is 15–30 mL. The ostium (3–6 mm diameter) opens into middle meatus **(Fig. 41.2)**. It can be described as pyramidal in shape, consisting of a base, an apex and four sides. The base is formed by the lateral wall of the nose. The apex projects laterally into zygomatic process of maxilla; and it may extend into zygomatic bone when the sinus is very large.

The four walls of pyramid are formed by: (1) The roof of antrum or the floor of orbit, (2) The anterior, and (3) Infratemporal surfaces of body of maxilla, and (4) The alveolar process of maxilla which is the floor of sinus.

The roof is formed by thin orbital plate; separating it from orbital contents. The infraorbital canal, containing the vessels and nerves, runs down along the roof. The floor is formed by the lateral hard palate; alveolar process of maxilla carrying the roots of premolars and molars. The posterior wall separates the sinus from infratemporal and pterygopalatine fossae. It is pierced by posterior-superior alveolar nerves which travel to molar teeth. The anterior wall is the facial surface of maxilla.



Figs 41.1A and B: (A) Frontal view of paranasal sinuses: (a) frontal sinus, (b) ethmoid air cells, (c) sphenoid sinus, (d) maxillary sinus; (B) Lateral view of paranasal sinuses

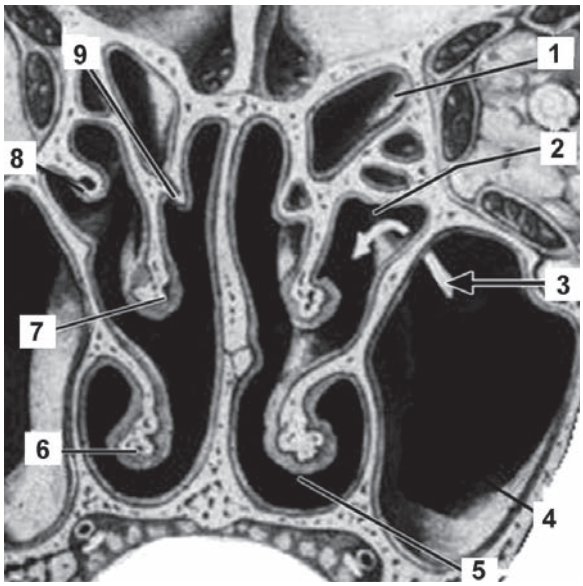


Fig. 41.2: Coronal section through the nasal cavities: (1) Ethmoidal air cells, (2) Middle meatus, (3) Opening of the maxillary sinus, (4) maxillary sinus, (5) Inferior meatus, (6) Inferior concha, (7) Middle concha, (8) Bulla ethmoidalis, (9) Superior concha

Blood Supply

Blood supply to the mucous membrane is from arteries which pierce the bone, and are derived from facial, maxillary, infraorbital and greater palatine arteries. The veins accompany the arteries, and drain into anterior facial vein and then to pterygoid plexus of veins. The lymphatic drainage of maxillary sinus is through the infraorbital foramen or through the ostium and then to submandibular and deep cervical lymph nodes.

Nerve Supply

Last (1959) described that nerve supply to maxillary sinus is from superior dental nerves (anterior, middle and posterior), and the greater palatine nerve. These are branches of maxillary division of trigeminal nerve. Their pathways are of surgical importance; as there is a possibility of damage to any of these nerves, while doing surgical procedures on anterior and posterior walls of antrum. The anterior superior dental nerve is given off from the infraorbital nerve about 15 mm from infraorbital foramen; and courses down the anterior wall of sinus. The middle superior dental nerve is probably present in more than 50% of the cases; and when present it arises from the lateral aspect of infraorbital nerve.

Harrison (1971) described his view, and that it may run in posterior lateral or anterior wall of antrum. The posterosuperior dental nerve, the same author writes that there are two main offshoots of importance—the superior branch tunnels the lateral wall of the antrum and runs at the level of malar tuberosity; while the larger inferior branch is below, and courses parallel to transverse facial part of anterior nerve.

Embryology (Growth of Maxillary Sinus)

In early stages, maxillary sinus is high in maxilla. Later gradually grows downward, by a process of pneumatization **(Table 41.1)**.

The expansion of the sinuses normally ceases after eruption of permanent teeth. However, occasionally, the sinuses pneumatize further, after removal of one or more of maxillary posterior teeth, and extend into the residual alveolar process. In adults, the apices of the posterior teeth may extend into the sinus cavity.

Physiology

The sinuses are lined by respiratory epithelium; namely, the mucus secreting; pseudostratified, ciliated, columnar epithelium. It is also known as *schneiderian membrane*.

Table 41.1: Stages of the growth of maxillary sinus

Time	*Growth*	*Shape*
3/12 IU	Outpouching in middle meatus	—
Birth	Tubular: 2 cm × 1 cm × 1 cm	
	3 mm per year × 2 mm × 2 mm	Tubular
9 years	60% of adult size	Ovoid
12 years	Antral floor parallels nasal floor	—
18 years	Adult size	Pyramidal

The mucociliary mechanism is useful means for removal of particulate matter, bacteria, etc. The cilia move the mucus and other debris towards the ostium, and subsequently discharged in the middle meatus.

Functions

- Impart resonance to the voice
- Increase the surface area and lighten the skull
- Moisten and warm the inspired air
- Filter the debris from the inspired air
- Sinuses are located in front of the forebrain, olfactory region, etc. They create "air padding" to provide thermal insulation to the important tissues mentioned above.

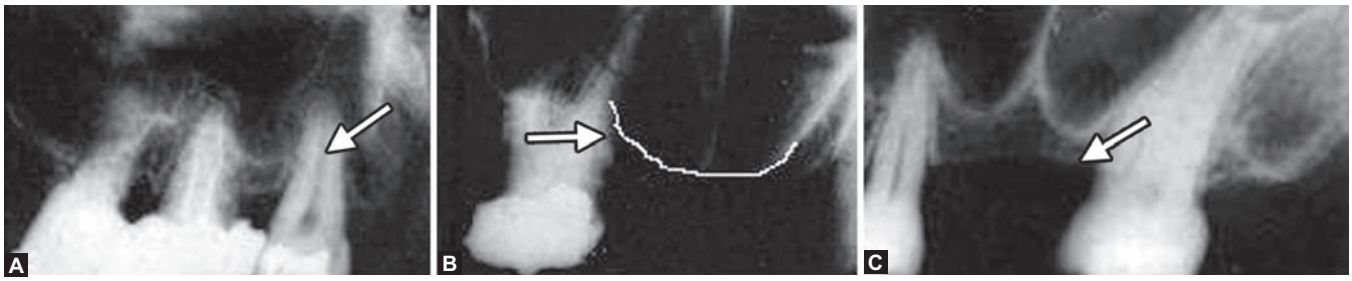
Applied Surgical Anatomy

Relation of the Root Apices with the Floor of the Sinus

In adults, there is a distance of approximately, 1–1.25 cm between the floor of the sinus and the root apices of maxillary posterior teeth. Sometimes, the floor of the sinus is in close proximity with the roots of these teeth. The teeth, in close proximity with the sinus vary from study-to-study. Von Bornsdorff (1925) found in his series, that the roots of second molar were closest to the floor. Paatero (1939) also confirmed this finding; with the next in order of frequency were; the first molar, third molar, second premolar, first premolar, and canine **(Figs 41.3A to C)**.

Low Incidence of Oroantral Fistula in Children under 15 Years

The maxillary sinus reaches its normal adult size by the age of 15 years. Hence, the risk of creating oroantral fistula



Figs 41.3A to C: Periapical intraoral X-rays showing close proximity of the roots of upper posterior teeth to the floor of the maxillary sinus

is less in children and young adults. In adults, the roots are usually in proximity to floor of sinus. The incidence of inadvertent displacement of teeth or roots into the antrum is also less in young adults (Killey and Kay 1972).

Circumstances with Increased Likelihood of Oroantral Fistula

- **Large sinuses:**
  - When sinuses are very large, and the floor gets thinned out, there is a risk of fracture when force is applied during extraction of maxillary posterior teeth. This may result in oroantral fistula.
  - Sometimes, the floor of sinus descends down between the adjacent teeth, and also in between the roots of the individual tooth; so that their root apices; especially, the palatal root may cause elevations in antral floor.
- **Unerupted or partially erupted maxillary third molar;** such a tooth lies in close proximity to the maxillary sinus. This may lead to its inadvertent displacement into the sinus cavity, especially, if the tooth has conical roots **(Fig. 41.4)**. In such circumstances, attempts to remove the broken root apices, may cause its displacement into maxillary sinus, if extreme care is not taken. The presence of an unerupted third molar in tuberosity constitutes a potential line of weakness. In such cases, if adjacent second molar is extracted, it may result in fracture of the tuberosity.

Lining of Maxillary Sinus

It does not get torn, unless the force of extraction is undue; and the clinician carries out inadvertent postextraction manipulation in the socket. The confirmation of breach in the continuity of maxillary antrum, can be obtained by carrying out routine occipitomental (OM) radiographs. These radiographs show radiopacity of maxillary sinus; which persists for 10 days to 2 weeks. Further, in case, there is breach in continuity of lining, there is collection of blood in the maxillary sinus, and which may escape from ostium and may present clinically as unilateral epistaxis.



Fig. 41.4: Inadvertent displacement of tooth during extraction into the maxillary sinus

Cracks and Fractures in the Bony Floor of Maxillary Sinus

These usually heal even if there is accompanying tear in sinus lining. In case, where the clot breaks down, it results in oroantral communication; which, if not noted at the time of extraction either by the patient or by the clinician, evidences itself within 10 days, leading to establishment of oroantral fistula and evidences as foul-smelling discharge of pus.

Fracture of floor of maxillary sinus, may sometimes occur, following the extraction of upper molars. It is sometimes more easier to extract these teeth in adults than in children aged 7–8 years, where the three divergent roots of first molar may be completely embedded in alveolar bone.

Periapical Involvement

Periapical involvement, in the form of acute or chronic abscess in teeth related to floor of sinus, may secondarily involve maxillary sinus. The pus may discharge into sinus producing a fluid level. The extraction of such a tooth, results in blood clot getting infected, and results in creation of oroantral fistula.

Pressure on the Nerves within the Antrum

It may occur in acute sinusitis. The pus formed is unable to escape from ostium into nose, because of its occlusion, caused by inflammation of adjoining mucosal lining.

Tumors Developing in Maxillary Antrum

The anterior and infratemporal walls of maxillary sinus are very thin. The tumors which develop in maxillary sinus may erode these walls and present as swellings of cheek. Tumors may also penetrate floor of maxillary sinus and present as a palatal lump or a swelling in buccal sulcus. The teeth present in the vicinity may get loosened due to bone destruction. The interference with the blood supply to these teeth lead to pulp necrosis which further lead to development of acute apical abscess. In case, the tumor erodes the posterior wall, the posterior-superior alveolar nerves may be destroyed, and patient may complain of anesthesia of gingiva or teeth in maxillary molar area.

Involvement of roof of sinus is as good as involvement of orbital floor. This leads to anesthesia in the distribution of infraorbital nerve; as it lies in a canal in the roof of the sinus and emerges at infraorbital foramen. Further involvement of orbit, the tumor encroaching on the orbit, may lead to alteration of pupillary level; the eye is lifted up and proptosis may occur. When the orbital muscles or nerves innervating them are involved, it will lead to strabismus with diplopia. The tumor after occluding the nostril may protrude through nostril.

Paresthesia in Maxillary Teeth Following Surgical Procedures

The incidence of paresthesia in maxillary teeth following surgical procedures of the lateral wall of the antrum, varies from study to study. In a larger percentage, the sensation gradually returns to normal over a period of time. Very few cases of permanent anesthesia are reported in literature.

Mucous Membrane Lining of Antrum Affected by Infection

If left *in situ*, the normal ciliated columnar epithelium may regenerate, once the infection is taken care of. When the lining is stripped, the nasal mucosa extends through the ostium.

Antral Puncture

Whenever antral puncture is to be carried out; the puncture into the sinus cavity should be made through the middle meatus in children; and in the inferior meatus in adults. The antral puncture or intranasal antrostomy, in the inferior meatus then becomes a point of dependent drainage for maxillary sinus. The floor of maxillary sinus is about 1.25 cm below the floor of the nose.

Canine Fossa

The wall of the sinus is very thin in this area. This area is used for following: (1) Diagnostic aspiration, and (2) The site for Caldwell-Luc operation; that is, the antral exploration with or without an intraoral antrostomy.

Fractures of the Middle Third of Face

The thin walls of maxillary sinus get easily fractured as a result of trauma. The fractures of middle third of face involve maxillary sinus. Fractures of zygomatic bone show the zygomatic buttress pushed into the sinus; while fractures of middle third of the maxilla—LeFort I, II and III—show disturbance in the walls of maxillary sinus.

Foreign Bodies in the Sinus

The presence of a foreign body, such as a tooth or root fragment or any other things, it changes its position with movement of head. This change in position can be confirmed by serial radiographs. In case, the foreign

body does not move in consecutive radiographs, then it is (1) Either trapped into polyps or thick mucosa; or (2) present between the antral lining membrane and the bony wall **(Figs 41.5 and 41.6)**.

CLINICAL EXAMINATION OF MAXILLARY SINUS

- **Extraoral examination:** Pain and tenderness, swelling over the prominence of cheek bones
- **Intraoral examination:**
  - Pain and tenderness, swelling over the maxilla between the canine fossa and the zygomatic buttress
- **Transillumination**: The affected sinus shows decreased transmission of light; due to accumulation of fluid, debris, pus and thickening of the sinus mucosa.

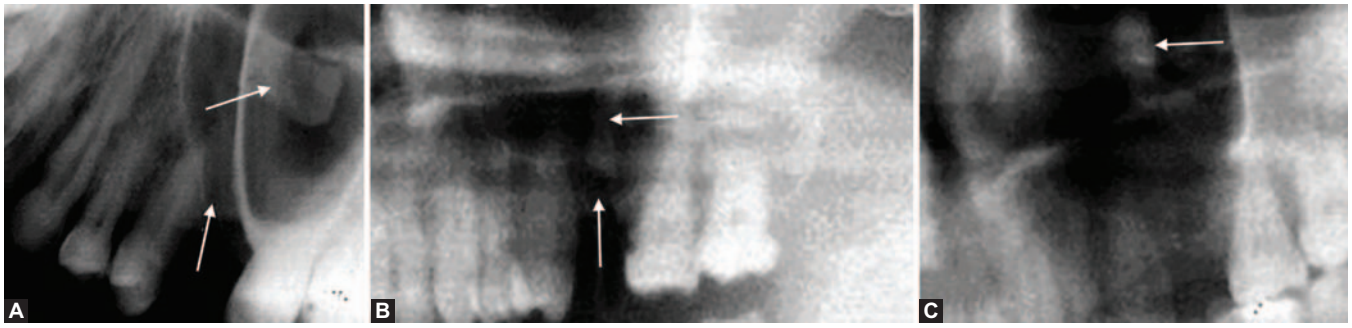
RADIOLOGY OF MAXILLARY SINUS

The radiological examination is an important aid to clinical examination of maxillary sinus. It provides adequate information to either confirm or rule out various pathological processes involving maxillary sinus. The various radiographs useful are as follows:

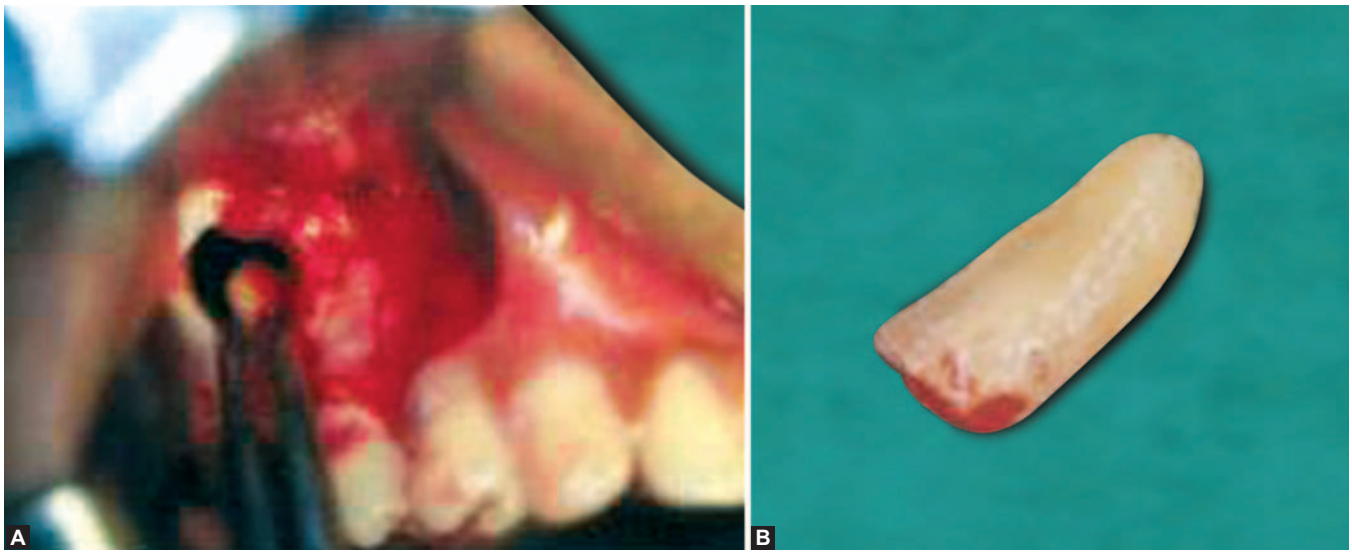
- **Extraoral views:** (1) Occipitomental (OM); (2) Lateral skull; (3) Submentovertex (SMV); (4) Linear tomography; (5) Orthopantomography; and (6) Computed axial tomography (CAT).
- **Intraoral views:** (1) Occlusal; (2) Lateral occlusal and (3) Periapical.

Extraoral Views

The knowledge of appearance of a normal radiograph is of a great help in interpretation of radiographs of maxillary



Figs 41.5A to C: Root fragment in the maxillary sinus: (A to C) Presence of broken root piece, which was pushed up in the maxillary sinus. Note the change in the level of the root position in serial radiographs



Figs 41.6A and B: (A) Removal of the root piece, which was pushed up in the maxillary sinus, through Caldwell-Luc approach, (B) Root piece recovered

sinus. A normal antrum appears as a large air-filled cavity surrounded by various bony structures and dentoalveolar component. The sinus cavity appears radiolucent and is outlined in all peripheral areas by well-demarcated layer of cortical bone. It is always useful to compare the other side in the radiographs. The abnormalities to be looked for include: evidence of thickening of mucosa on the bony walls (caused by chronic sinus disease), Air-fluid levels (caused by accumulation of mucus, pus, or blood), or foreign bodies.

Occasionally, the apices of the roots of maxillary posterior teeth and impacted third molars are seen projecting into the sinus. In edentulous areas, because of pneumatization of the sinus into the alveolar process, it leads to extension almost to the level of the alveolar crest.

Complete opacification of the sinus can occur by: (1) Mucosal hypertrophy; (2) Accumulation of fluid; (3) Filling of the sinus with blood, secondary to trauma; and (4) Neoplasia.

Disruption of cortical outline may be due to: (1) Trauma; (2) Formation of tumors, and (3) Surgical procedures involving the walls of the sinus.

Odontogenic conditions, such as granulomas and cysts, may produce radiolucent areas and extend into the sinus cavity. These conditions should be differentiated by their association with the tooth apex, clinical correlation with the dental examination, and the presence of cortical bony margin on the radiograph.

Occipitomental View

The maxillary sinuses can be demonstrated by 15° OM view radiographs. This view was first described by Water's and Waldron (1915). The presence of pus will produce a horizontal fluid level in this view, provided that there is air above it. As a measure of confirmation of the diagnosis, the view is repeated with the head tilted towards the side of pathology. The fluid level remains horizontal. In case, the fluid is very viscous, the surface may not be completely straight and level **(Figs 41.7A to C)**.

Lateral Skull

This view is helpful (1) in confirming the presence of fluid level and cyst, and (2) in localizing a foreign body, e.g. root; particularly when the foreign body is located higher up in the sinus.

Submentovertex View

This view is helpful in visualizing the posterior walls of maxillary sinus. The three views together show most of the bony margins of the two antra.

Occipitofrontal View

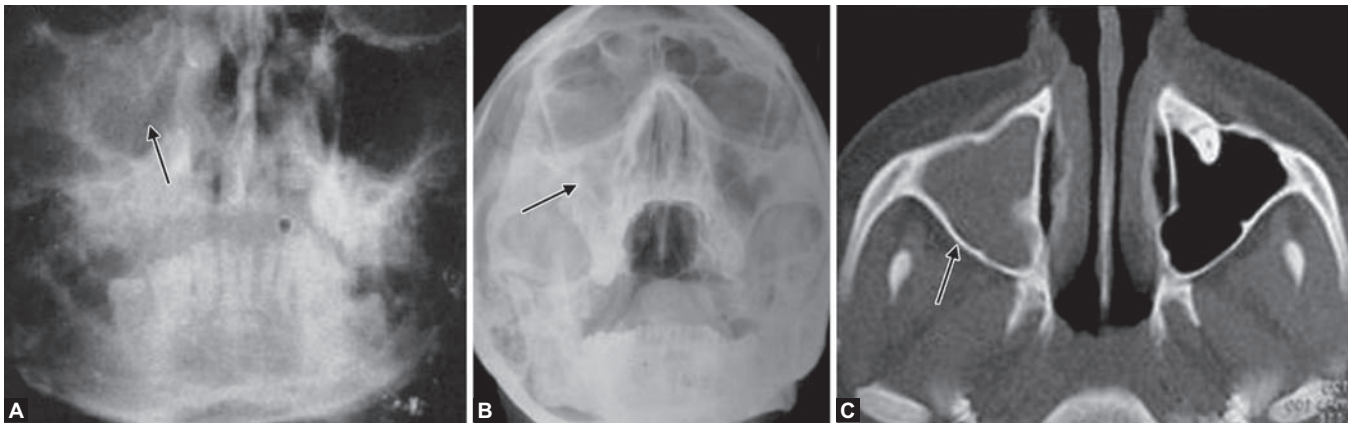
Occipitofrontal view is recommended to detect multi-sinusitis, pansinusitis, if present.

Tomography

This technique provides details of sinus structure; and is indicated for demonstration of following: (1) Solid masses within maxillary sinus such as osteoma; and antroliths, and (2) Early erosion of walls of maxillary sinus from malignant diseases.

Orthopantograph

Orthopantograph is helpful in routine detection of lesions such as odontogenic and mucosal cysts of maxillary sinus **(Fig. 41.8)**.



Figs 41.7A to C: (A) PA view of Water's position showing haziness of the (R) maxillary sinus, following extraction of upper right first molar 3 months back. Chronic maxillary sinusitis with oroantral fistula; (B) PA view Water's position; and (C) CT scan picture of another patient showing complete haziness of (R) maxillary sinus, indicating chronic maxillary sinusitis

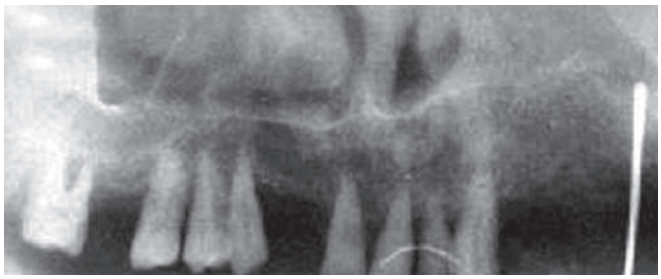


Fig. 41.8: Maxillary panogram showing sinus probe into the maxillary sinus indicating the oroantral communication

Intraoral Views

The intraoral radiographs are of great value in: (1) locating and retrieving foreign bodies in the sinus such as: teeth, roots, osseous fragments, and also for (2) careful planning of their surgical removal. These films are useful in demonstration of root fragments in sinus cavity; and also in differentiating the root apices which are intra-antral, but extramucosal.

Interpretations

The interpretation of the opacities found in maxillary sinus cannot be specific. In view of the fact that the following structures produce a similar shadow on the radiograph: (1) Transudates, exudates and blood; (2) Gross mucosal thickening; or sinus entirely filled with blood, or pus, or mass of polyp; all produce complete opacity of maxillary sinus. It is impossible to differentiate between them by purely radiological means.

Under normal circumstances, the mucous membrane lining of sinus is about 1–2 mm in thickness. The lining in sinusitis may increase 10–15 times. The thickness of antral mucosa also produces a shadow on the walls of maxillary sinus; of a similar density to the substances described earlier.

It is worth noting that thickening of antral mucosa is often seen on routine radiological examination in individuals who are otherwise healthy and asymptomatic. As a matter of fact, 25–30% of a group of asymptomatic subjects revealed abnormalities ranging from thickening of mucous membrane or polyposis to cyst.

INFECTIONS OF MAXILLARY SINUS

Odontogenic Sinusitis

Definition

Odontogenic sinusitis is the inflammation of mucosa of any of the paranasal sinuses. Inflammation of most or all of the paranasal air sinuses simultaneously is known as pansinusitis.

The maxillary sinusitis is usually odontogenic in origin, because of its close proximity with the maxillary teeth. The condition, if not treated, may spread to involve other sinuses.

Etiology

It can be caused by: (1) Infection; periapical abscess spreading into maxillary sinus. Other infections following common cold, upper respiratory tract infection, etc. also can lead to maxillary sinusitis, (2) Trauma; fracture of antral floor and walls, (3) Allergy, and (4) Neoplasms and infected cyst of odontogenic origin (5) Oroantral communication and fistula (6) Displaced tooth or root.

In case the ostium of maxillary sinus gets blocked, the mucus secreted by secretory cells of the walls gets collected, and the bacterial growth then produces an infection.

Maxillary sinusitis can be classified into: (1) Acute and (2) Chronic.

The maxillary sinusitis or inflammation of the antral mucosa is modified due to following factors:

- Sinus lining is for the air chamber.
- Ostium is situated in the middle meatus, higher than the sinus floor. Sinusitis is aggravated, whenever the ostium becomes edematous (Because the drainage of the maxillary sinus gets affected).
- Vascularity of the maxillary sinus is very high.
- Because of the close relation to the roots of the teeth, there may be referred symptoms to the teeth.

The odontogenic conditions causing sinusitis include: chronic suppuration from granuloma, from an acute abscess, and also from periodontal abscess.

Spread of Infection to Maxillary Sinus, from Apical Abscess

The most common cause of spread of oral infection to maxillary sinus that can be attributed is a periapical abscess (15–20%). The maxillary teeth with roots in close proximity to the floor of antrum, most likely involved in causing such an infection are first molars, second molars, etc. (The teeth vary in different studies). In these areas, antral floor intrudes in between the roots of these teeth.

Clinical Features

Involvement through periapical pathology: The teeth which are involved are first premolars, first molars, and second molars. The presence of abscess causes

characteristic signs and symptoms: (1) Severe throbbing pain; when the pus remains confined within bone in apical region. The intensity reduces after 12–24 hours as the pus is discharged into antral cavity; (2) There is only slight swelling of cheek. Patient complains of foul pus running down a nostril; or presence of unpleasant taste or smell; (3) In case, the tooth is periodontally involved, it may feel loose.

Diagnosis

Appropriate radiographs will reveal either a totally opaque sinus or a fluid level.

Management

The extraction of the offending teeth carries a risk of perforation and a persistent fistula. In cases of extraction, some authors recommend that the socket be covered with complete soft tissue closure: (1) With antibiotic prophylaxis and taken for at least 5 days postoperatively; (2) Decongestants: in the forms of nasal inhalations and drops.

Acute Maxillary Sinusitis

Acute maxillary sinusitis may be suppurative or nonsuppurative (Catarrhal) inflammation of the antral mucosa.

Signs

Extraoral Examination

(1) Tenderness over the cheek; (2) Anesthesia of the cheek in the area of distribution of infraorbital nerve; (3) Severe infection may lead to mild swelling of the cheek.

Percussion of maxillary teeth, related to maxillary sinus show tenderness.

Intraoral Examination

(1) Existence of oroantral fistula with or without polypoid mass extruding from the orifice into the socket; (2) Patient complains of fetor oris, especially when blowing the nose; (3) Discharge of pus into the mouth from fistula; if opening is obstructed by polyps, the discharge is prevented.

Rhinoscopy: Anterior rhinoscopy may reveal pus draining downwards: Edema and erythema of mucosa and pus discharge flowing onto inferior turbinate bone.

Symptoms

Patient may give history of cold 3–4 days prior to the acute attack. There may be nasal blocking following rhinitis. Thick, mucopurulent, foul smelling, discolored nasal discharge may follow. Postnasal discharge with constant irritation requiring clearing of the throat and cough secondary to the nasal discharge may lead to pharyngitis: (1) Heavy feeling in the head; (2) Constant throbbing pain in upper part of cheek or entire side of the face, which is exacerbated by lowering or bending down. Pain is more severe in the morning and evening; (3) Maxillary teeth in relation with maxillary sinus on the affected side may be painful. Pain in the teeth often precedes pain in the cheek; (4) Unilateral foul nasal discharge, which becomes more profuse with lowering down of head; (5) Unilateral nasal obstruction on affected side. There can be occlusion of ostium of maxillary sinus; (6) The generalized constitutional symptoms are present but in milder form, like chills, fever, sweating, nausea, difficulty in breathing. Anorexia may be due to swallowed pus.

Other Special Examinations

Other special examinations include: (1) Transillumination of maxillary sinus will confirm radiopacity on the affected side. The sinuses when full of pus do not transmit the light through them. (2) Fiberoptic light probe. This has a source of intense light without production of heat.

Radiography: Water's view (OM 15°) is the most valuable radiograph.

- **Acute sinusitis:** The affected antrum shows uniform opacity. Sometimes, a fluid level is discernible.
- **Chronic sinusitis:** The radiograph shows pansinusitis. Fluid level, thickened lining is also seen.

Management

Classical antral regimen includes—bed rest, plenty of fluids, maintenance of oral hygiene. The regimen should be carried out for at least 5–7 days.

Antimicrobials: The most suitable against common antral pathogens are: (1) Macrolides: Erythromycin 250–500 mg 6 hourly for 5 days. (2) Broad-spectrum group: Amoxicillin 250–500 mg 8 hourly for 5 days.

Decongestants: These take care of nasal congestion. These drugs reduce the excessive vascularity of lateral nasal wall, thereby improving the opening of the ostium.

1. Nasal drops or sprays, e.g. ephedrine sulfate—0.5 to 1% in normal saline, 6 hourly.
2. Xylometazoline hydrochloride 0.1%. The decongestant drops not only shrink the swollen and inflamed mucosa, but also help to minimize and eliminate the mucosal discharge. The ostium may now open up and permit free ciliary drainage.

Mucolytic agents: These are used to reduce the viscosity to produce thin mucous secretion. Drugs used—volatile oil preparations are used, benzoin tincture, camphor, menthol, chlorbutol, etc. or simple steam inhalation every 8 hourly can be used. Inhalations of 2–3 tablespoons full of benzoin tincture in a bowl of steaming water for 5–10 minutes, 3–5 times a day, followed 10 minutes later by 1–2 nasal decongestant drops in each nostril. Inhalation is given to maintain or to improve the drainage by the ciliary pathways of the antral lining through the ostium. The steam inhalation tends not only to thin the mucous congestion, and nasal discharges, but also helps to lay down an antiseptic blanket all over the involved antral lining.

Nonsteroidal anti-inflammatory analgesic agents: (1) aspirin, (2) paracetamol and (3) ibuprofen.

Chronic Maxillary Sinusitis

Chronic maxillary sinusitis may be due to a persistent dental focus, chronic rhinitis, chronic infection in the frontal or ethmoidal sinuses, allergic conditions, etc.

Pathophysiology

The mucous membrane of the maxillary sinus, due to chronic inflammation may undergo changes like hyperplasia or atrophy. Multiple polyps formation or degeneration of epithelium, where the cilia are lost can be seen. The ostium shows edematous changes causing a complete blocking. The drainage of the sinus will be affected.

The condition sometimes is asymptomatic.

- Pain and tenderness in the area of antrum is found usually in acute exacerbations.
- Unilateral foul discharge through posterior nares.
- Cacosmia—a fetid odor with bad taste in the mouth.

Diagnosis

Diagnosis is based on:

- **History of**: (1) Repeated attacks of acute mucopurulent rhinitis, (2) Long-standing nasal or postnasal discharge
- **Anterior rhinoscopy**: It shows nasal congestion and mucopurulent material in middle meatus
- Inspection of oropharynx reveals descending pharyngeal exudates
- Presence of an obvious oroantral fistula may be there
- Prolapse of polypoidal mass into the mouth forming a lump may be seen.

Transillumination: The sinus reveals radiopacity on the affected side.

Radiography: The findings are: (1) Presence of fluid level, (2) Thickened lining membrane, (3) Opaque air space may enclose polyps associated with mucosal thickening, (5) In case of presence of tooth or root, the characteristic outline is seen within the sinus.

Management

The management requires eradication of related dental complications. If the chronic sinusitis is caused by chronic periapical infection, then affected tooth must be extracted and the socket closed surgically completely as there is a risk of oroantral fistula formation. If there is already a communication with maxillary sinus; if the blood clot fails to organize; and the socket gets infected, then there will be persistent chronic maxillary sinusitis.

There are some factors to be considered in management of chronic maxillary sinusitis, or oroantral fistula:

- The longer the management is deferred, the greater is the risk of inflammatory changes in lining membrane. The transition to chronic form occurs after a period of 2 weeks. At this stage, the condition is curable, belated therapeutic intervention adversely affects the prognosis. The lining membrane may get permanently injured and deprived of its capacity for functional recovery. The other irreversible changes, in addition to mucosal thickening and polyposis, include: marked fibrosis, squamous metaplasia and destruction of mucous secreting elements. The ciliary epithelium, which normally acts as a scavenger of debris, is destroyed and is no longer capable of its "brushing-up" role. The antrum serves as a factory of massive mucus.
- There are various grades of chronicity, unless all conservative measures are tried; it is not justified in regarding the case to be irreversible. However, patients with a familial trait for vasomotor or allergic rhinitis are likely to succumb to irreversible disease.
- In case, the cause is the foreign body, such as tooth or root in the sinus, it is necessary to retrieve these foreign bodies prior to considering any other form of treatment. Concurrent presence of antralpolyps should also be removed. The antral air space is gently irrigated and closure of wound is affected. Routine postoperative treatment with an antibiotic, decongestant and analgesics to be given.
- The presence of a chronic pyogenic sinusitis subsequent to an oroantral fistula requires surgical closure of fistula. The polyps found at operation should also be removed. Preoperatively, if the antrum is found to be full of pus: (1) It should be irrigated through the

fistula, on a daily basis, with a warm normal saline or betadine, or (2) In certain circumstances, the fistulous orifice needs to be enlarged surgically to enable efficient antral lavage. When the antral washouts appear to be clear, the fistula should be repaired and routine postoperative measures instituted; (3) In cases, where there is no oroantral fistula present, but there is chronic maxillary sinus nonresponsive to other conservative regime, then a surgical drainage should be considered.

Procedure for Surgical Drainage (Fig. 41.9)

A topical anesthesia ointment is applied to the cotton wool, which is inserted along the nasal floor adjacent to the lateral wall of the nose near the inferior turbinate. A sharp trocar and cannula is then introduced along the floor of the nasal cavity inferior to inferior turbinate. The thin medial wall of the antrum is punctured. The trocar is withdrawn and the pus can be drained under pressure through the suction tip. Warm saline irrigation should be carried out daily, till the symptoms settle down.

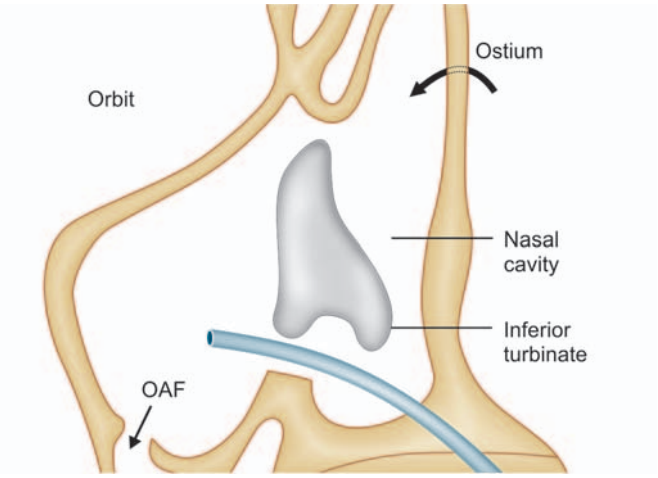


Fig. 41.9: Trocar introduced through nostril into maxillary sinus for surgical drainage and irrigation

OROANTRAL COMMUNICATION AND FISTULA

Definition

- An oroantral perforation is an unnatural communication between the oral cavity and maxillary sinus.
- An oroantral fistula is an epithelialized, pathological, unnatural communication between these two cavities.

The proximity of maxillary second premolar and first molar to maxillary antrum is of great importance. At times, the antral cavity dips down in between the roots of maxillary molars resulting in no bone between the roots and the lining of the antrum.

Etiology

Oroantral fistula can result from several causes:

- Extraction of teeth
- Destruction of the portion of the floor of the sinus by periapical lesions
- Perforation of the floor of the sinus and sinus membrane with injudicious use of instruments
- Forcing a tooth or a root into the sinus during attempted removal
- Extensive trauma to face
- Surgery of maxillary sinus; removal of large cystic lesions encroaching on the sinus cavity
- Chronic infection of maxillary sinus, such as osteomyelitis
- Teratomatous destruction of maxilla, such as gumma involving palate
- Infected maxillary implant dentures
- Malignant diseases such as malignant granuloma.

Extractions

The most common cause of an oroantral fistula is the inadvertent opening of maxillary sinus during extraction of maxillary tooth. The root apices of canines, premolars and molars may be also in close proximity to the floor of sinus. At times, the apices of these teeth intrude into the antral cavity and are separated by the socket from the sinus lining membrane. Sometimes the root loses its lamina dura due to chronic periapical infection; so that the apex is then in direct contact with the sinus lining. Rarely, the extraction of posterior teeth associated with periapical disease, for example acute periapical abscess, chronic granuloma, or periapical sclerosis is at risk of causing oroantral perforation. But, paradoxically it is the palatal root of the maxillary first molar, which is when broken during extraction, brings about the most frequent creation of an oroantral communication. Also a conical maxillary third molar, which when grasped with the forceps during extraction, slips into the maxillary antrum along with fracture of the tuberosity, and creates an oroantral communication.

A previous history of fistula would necessitate careful radiological assessment of remaining maxillary posterior teeth at the time of removal. Forceps extraction of solitary

isolated posterior teeth in an edentulous arch is also at risk of causing disruption of floor of sinus.

Surgical removal of impacted teeth (e.g. maxillary third molar, supernumerary), submerged, or geminated or hypercementosis, divergent root teeth also carries risk of inadvertent breach in continuity of antrum. Fracture of the maxillary tuberosity during such extraction is the likely possibility.

Apicoectomy on roots of teeth, adjoining the sinus lining will also result in maxillary sinus communication.

"Blind" instrumentation, without adequate surgical exposure, in an attempt to retrieve retained apices of posterior teeth is also hazardous, and may result in the root displaced into maxillary sinus through antral perforation.

- **Facial trauma:** Extensive trauma to middle third of face skeleton, especially if the trauma is due to missiles or sharp objects driven through the mouth into sinus will lead to oroantral fistula. The penetrating injuries, as in gunshot wounds, may result in huge defects of sinus walls.
- **Surgery:** The various major surgical procedures that would lead to formation of large fistulae are as follows:
  - Partial maxillectomy, which is performed for eradication of malignancy or antral neoplasm. This procedure, usually, involves removal of alveolus, part of the palate and antral and medial walls.
  - Surgical treatment of large abscess or maxillary cyst may lead to formation of fistula.
  - Wrong diagnosis: Marsupialization done for defects in alveolar antral wall.
  - Improper planning of incision for Caldwell-Luc operation (The opening in canine fossa will heal if the incision should lie on sound bone).
  - In cases of fractures of zygomatic complex, where the fractures of orbital floor are supported by an antral pack. The pack is kept protruding from the Caldwell-Luc incision and is sutured to buccal sulcus mucosa. At the conclusion of treatment, the pack is pulled out through the opening in buccal sulcus. The orifice, at times, fails to heal and leads to fistula.
- **Malignant tumors:** Malignant tumors involving maxillary sinus may produce symptoms related to oral cavity, including oroantral communication or fistula in the following ways to produce the symptoms:
  - By penetration of lateral walls of sinus into mouth.
  - By erosion of floor of sinus into mouth.

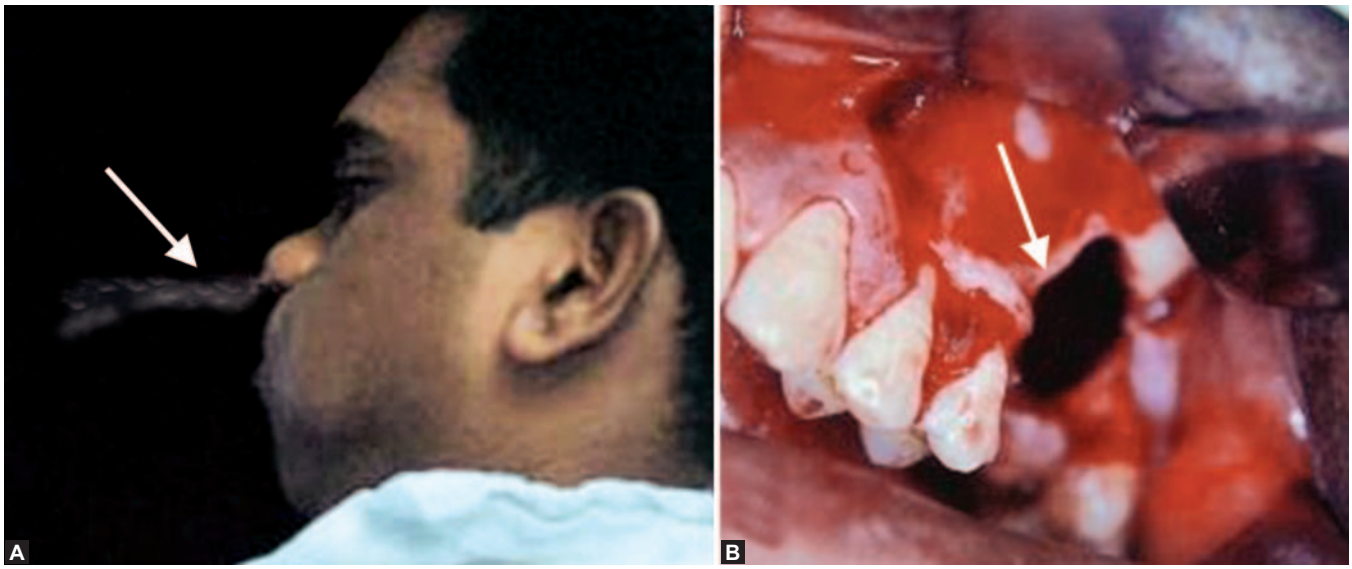
  In a similar way, neoplasms arising in upper jaw extend into the sinus and lead to fistula formation.
- **Osteomyelitis:** Osteomyelitis of maxilla is rare, unless, (1) There is underlying systemic disease, such as leukemia, diabetes, uremia, due to kidney disorders, etc. or (2) Maxillary region has been subjected to irradiation, or (3) Severe osteitis with bone loss.
- **Syphilis:** (1) Gummatous lesions of palate may result in an extensive oroantral fistula, as there is the destruction of bone. (2) Congenital syphilis: The lesions associated with secondary and tertiary forms of syphilis involving nose can arise and extend into mouth.
- **Implant dentures:** There can be considerable destruction of antral floor in patients with maxillary implant denture. This can be avoided by using sinus lift operation.

Symptoms: Fresh Oroantral Communication: Remember 5 Es

1. **Escape of fluids:** From mouth to the nose on the side of extraction. This happens when the patient rinses or gargles the mouth following extraction of a tooth **(Figs 41.10A and B)**.
2. **Epistaxis (unilateral):** It is due to blood in the sinus escaping through osteum into the nostril. It may or may not be associated with frothing at the nostril on the affected side.
3. **Escape of air:** From mouth into the nose, on sucking, inhaling or drawing on a cigarette, or puffing the cheeks (inability to blow cheeks. Passage of air into mouth on sucking).
4. **Enhanced column of air:** Causes alteration in vocal resonance and subsequently change in the voice.
5. **Excruciating pain:** In and around the region of the affected sinus, as the local anesthesia begins to wear off.

In Late Stage, Symptoms of Established Oroantral Fistula: Remember 5 Ps

1. **Pain**: Previously a dominant feature is now negligible, as the fistula is established, it allows free escape of fluids.
2. **Persistent, purulent or mucopurulent, foul, unilateral nasal discharge** from the affected nostril, especially when head is lowered down. Unilateral foul or foetid taste and smell.
3. **Postnasal drip**: The trickling of the nasal discharge from the posterior nares, down the pharynx. The continuous



Figs 41.10A and B: (A) Regurgitation of water through nostril. Patient gave history of extraction of upper left first molar 2 months back, (B) Surgical exposure of oroantral communication (Big bony defect)

swallowing of the foul mucopurulent discharge may lead to unpleasant taste. This is accompanied by nocturnal cough, hoarseness, ear ache or catarrhal deafness.

4. **Possible sequelae of general systemic toxemic condition**: Fever, malaise, morning anorexia, frontal and parietal headaches and in extreme cases anosmia and cacosmia.
5. **Popping out of an antral polyp**: The persistent infection in the antrum may lead to establishment of chronic long standing oroantral fistula, which may be occluded by an antral polyp. This can be seen as a bluish red lump extruding through the fistula **(Figs 41.11A and B)**.

Fate of Clot

In normal circumstances, penetration of antrum during simple extraction of maxillary teeth, there is formation of a blood clot, which occludes the oral end of the perforation. This usually undergoes organization and the perforation heals uneventfully. Infection of the blood clot from extension from pre-existing periapical infection or as a consequence of maxillary sinusitis, or as a sequel to alveolar osteitis, results in recreation of the fistula.

- Once infected, the blood clot gets disintegrated and the communication becomes patent.
- Sometimes, the clot blocking a fistula may be dislodged and blown into mouth as a result of violent nose blowing, or
- Blood clot may get washed away by vigorous rinsing of mouth.

Persistence of Fistula

Persistence of fistula can result in various problems such as: Inadvertent entry into antrum of food particles, chewing gum, fluids, impression materials, dressings, packs, etc. These substances may result in acute or subacute exacerbation of sinusitis.

Physical signs of oroantral communication can be divided into:

1. Those signs presenting immediately after the formation of communication, and
2. Those relevant to an established oroantral fistula.

Recently created communication: Surgery in the immediate vicinity of maxillary sinus such as extraction of maxillary posterior teeth.

If the extraction demanded more force, however, the extraction was straight forward, and the examination of roots of the tooth revealed that a part of bony floor of antrum is seen adherent to the tooth, then the operator must examine the socket to establish any tear in the lining of sinus.

- Attempted extraction of maxillary molar root which disappears as soon as force is applied with an elevator also denotes its inadvertent displacement into maxillary sinus and the presence of coexistent communication.



Figs 41.11A and B: Popping of an antral polyp through long-standing oroantral fistula

- Attempted extraction of a partially erupted upper third molar. The root(s) of such a tooth are adjacent to maxillary sinus, and the application of extraction force results in its displacement into maxillary sinus. This is more likely to occur if the roots of the partially erupted third molar are conical.

Confirmation of the presence of oroantral communication/fistula: If the fistula is large, it can be assessed from inspection; in case, its patency is not obvious, the nose blowing test is useful. Compression of anterior nares, followed by gentle blowing of nose (with mouth open), causes a rise in intranasal pressure exhibited by the whistling sound as air passes down the open passage. Escape of air bubbles, blood or pus, etc. may appear at the oral orifice. A wisp of cotton-wool held just below the alveolar opening will usually be deflected by the air stream. However, it is important that a suspected antral defect at a site of recent extraction should not be explored with an instrument. Such a maneuver could lead to breakdown of the blood clot and the seal, and result in a fistula.

Physical Signs of Established Oroantral Fistula

- **Early signs**: The early signs are seen when the blood clot gets disintegrated, so that the breach in the continuity of antral lining remains patent (and seal is unbroken): (1) As a result of infection, (2) Forceful nose blowing, and (3) Excessive rinsing of mouth.
- **Late signs and symptoms:** Due to involvement of sinusitis or established oroantral fistula with or without rhinitis: (1) Signs and symptoms of sinusitis and rhinitis, (2) Escape of air or fluid through nostril, and (3) Development of a lump (polyp).
- **On examination**: Inspection—(1) Discharge of foul smelling pus from the orifice (occlude patient's nose and ask him to blow). Sometimes, the pus does not descend freely, may be due to occlusion of sinus orifice by polyps.

Careful insertion of an instrument into the antrum, the mass gets pushed to one side and then the flow of pus can be seen with blowing the nose.

Signs of Acute Sinusitis

- Tenderness over the maxilla, especially in the infraorbital region.
- Mild edema of cheek in infraorbital soft tissues.
- Rarely, patient gets earache as a referred pain from antrum. This is attributed to acute otitis media.
- Percussion of maxillary premolars and molars related to affected sinus will lead to pain.
- Examination of nose with a speculum shows nasal congestion (red, shiny and swollen mucous membrane around ostium).
- Presence of pus or mucopurulent discharge in middle meatus. This comes from sinus, through ostium, from over inferior conchae onto floor of nose.
- **Oropharynx**: Mucopurulent discharge trackling down posterior wall of pharynx.

Signs and symptoms of chronic sinusitis associated with OAF: (1) Impairment of sense of smell, (2) Foul smelling of mucopurulent discharge seen under middle conchae or in postnasal space, (3) Mild tenderness over infraorbital region.

Intraoral examination: (1) Descending postnasal flow of mucopurulent discharge, (2) Herniation of polyp into middle meatus, and (3) Prolapse of polyp through the fistula.

Sometimes, the oroantral fistula remains asymptomatic; in case, where the oral orifice is large and permits free drainage from antral cavity. The signs and symptoms of acute and chronic sinusitis occur usually, if the fistulous tract is narrow and does not permit free drainage.

Possible Sequelae

- A newly created fistula is likely to persist, if one or more of the following contingencies apply:
  - Interference with normal healing process of the orifice by: (1) Instrument, or probing of orifice, and (2) Indiscriminate packing, (3) Exploration of socket, (4) Vigourous rinsing, (5) Injudicious use of caustic substances, or (6) Introduction of hemostatic agents.
  - Traumatic extraction which resulted in: (1) Soft tissue loss or, (2) Gross damage to gingival margins peripheral to the gap.
  - Secondary infection of a postextraction or a pre-existing sinusitis.
  - When the diameter of the perforation is greater than 4 mm, or the depth of socket is more than 5 mm. Forcible dislodgement of an infected clot through the antral floor.
  - The presence in the wall of the fistula of denuded root of an adjacent tooth.
- Sometimes, the sinus lining membrane remains intact despite a break in the bony antral floor during an extraction. Under such circumstances, immediate measures should be taken. As a precautionary measure, strenuous nose blowing should be avoided. Such an act may rupture the antral lining and convert the minor defect into a fistula.
- Extrusion of a dislocated root into nasal passage or nasopharynx and sometimes larynx with pulmonary inhalation. The various factors that play a role in these situations are: posture, effects of gravity, the fragment getting sneezed out can be ingested. Foreign bodies may get dropped into mouth via the fistula. They either get thrown out or ingested or aspirated.

Management

Purpose

The closure of oroantral fistula should be performed: (1) To protect the sinus from oral microbial flora; (2) To prevent escape of fluids and other contents across the communication; (3) To eliminate existing antral pathology; (4) To establish drainage through inferior meatus. A fistulous tract present for more than 14 days should be considered as a chronic fistula.

Treatment of Early Cases

Cases where oroantral communication is recent and formation of fistula is not established.

- Ideal treatment (1) is immediate surgery repair to achieve primary closure, and (2) simultaneous antibiotic prophylaxis to prevent sinus infection **(Figs 41.12 and 41.13)**.

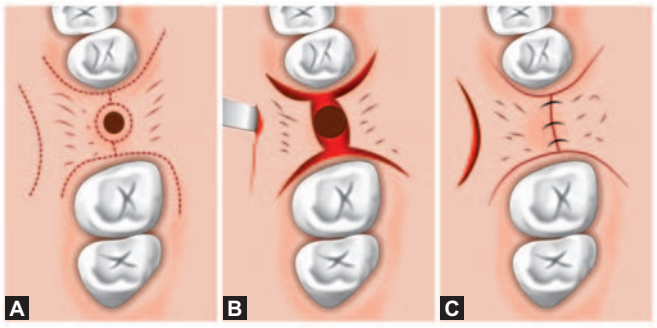
The immediate primary closure is done by a simple reduction of the buccal and palatal socket walls to allow coaptation of buccal and palatal soft tissue flaps to close over the defect. A protective acrylic denture or splint can be used to provide a barrier to the inadvertent entry of food particles.

The result of such a treatment would depend upon: (1) Skill and experience of the clinician, (2) Surgical facilities available, (3) Whether the communication is complicated by the presence of a tooth or root in maxillary sinus or not.

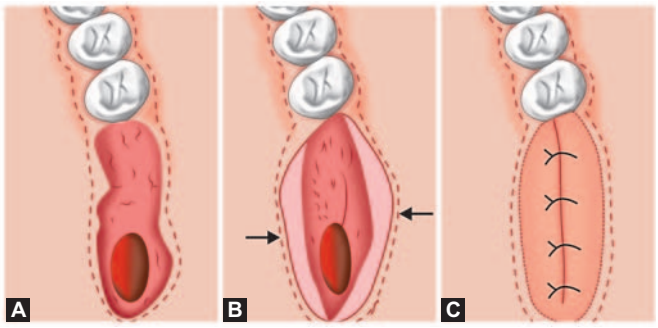
- **Ideal circumstances**: That is where patient is under GA, a surgical procedure can be carried out in operation theater, a tooth or a root can be easily removed from the antrum via the orifice; even if the procedure would entail a slight enlargement of the orifice.

While the similar procedure is to be performed under LA, in a dental chair; regardless of the operator's skill and experience; and the facilities available; it is not advisable to explore the antrum for the recovery of the tooth or the root. Moreover, the patient may not give consent for such a procedure.

The various procedures that can be employed are: (1) Complete closure of socket by careful approximation of buccal and palatal gingival margins, (2) Additional procedures may be required, such as: (a) Reduction in height of underlying alveolar bone, and (b) Relieving incisions in adjacent tissues, and (c) Referral of the patient to an oral and maxillofacial surgeon.



Figs 41.12A to C: Closure of accidental oro-antral communication in the dentulous arch: (A) Incisions are made around the teeth and antral opening. A relaxing incision is made on the palate; (B) Mucoperiosteal flaps raised and the buccal and palatal alveolar walls are reduced with Rongeur; (C) Interrupted suturing done



Figs 41.13A to C: Closure after large defect due to tuberosity fracture along with extraction of teeth and oroantral communication: (A) Large defect; (B) Reduction of buccal and lingual walls permits the approximation of flaps; (C) Flaps sutured

Supportive Measures

- **Antibiotics:** The prime objective is: (1) Prevention of secondary infection at the site of wound, and (2) Control of coexisting or pre-existing infection of antrum, if any. The selection of antibiotic should be done on the basis of culture and sensitivity testing:
  - **Penicillin and its derivatives**: These are used until symptoms begin to subside. It can be started with IV route, and later switched over to oral route. Penicillin V 250 to 500 mg six hourly is adequate.
  - In case, the organisms are resistant to penicillin, a broad spectrum antibiotic is prescribed.
- **Nasal decongestants**: This term applies to vaso-constrictor nasal drops and sprays and inhalations. These encourage the drainage of pus and secretions. These do not interfere with ciliary action; however, produce shrinkage of nasoantral mucous membrane and aeration of sinus.

The available preparations are: (1) Ephedrine nasal drops (0.5%), instilled intranasally every 2–3 hours. The correct method of using is the recumbent position with the head inclined to the affected side, (2) Steam inhalations: when the nose is clear subsequent to the use of decongestant drops or sprays; steam inhalations are helpful in encouraging drainage. It also helps in thinning down the mucous, pus and has a soothing effect, (3) Benzoin and menthol inhalations: a teaspoonful is added to a pint of hot (not boiling) water and the vapors are inhaled for 10 minutes twice a day, after covering the head.

- **Analgesics:** Nonsteroidal anti-inflammatory agents: (1) Aspirin 500 mg 1–3 tablets 4 times daily. (2) Paracetamol 500 mg three times daily, (3) Ibuprofen 400 mg three times daily.

Temporary Therapeutic Measures before Surgical Closure

The ideal treatment is immediate surgical repair combined with supportive measures; because: (1) Success of closure is more likely and (2) Infection is unlikely and (3) Easier to recover the displaced tooth or root fragment.

Delay in treatment carries risk of displacement of a root fragment, to a less accessible area of antrum, e.g. tuberosity, recess, lodgment in the inter-radicular areas of molar teeth or even in between the roots of single tooth; which form invaginations of antral floor.

Provisional or temporary measures which effect satisfactory repair include: (1) Whitehead's varnish pack, or (2) Denture plate.

- **Pack**: A strip gauze or ribbon gauze is used to pack over the socket and secured with sutures. Superficially, the pack is further supported by a horizontal mattress suture.
- **Denture plate**: It is indicated when surgical repair of fistula is to be deferred. The purpose of the appliance is to provide a barrier to prevent entry of food particles into the antrum. The orifice in the socket is covered with a piece of gauze or tulle grass; a well-fitting denture plate is constructed to entirely cover the opening.

Whitehead's varnish

- Benzoin 10 parts 44 g
- Storax 7.5 parts 33 g
- Balsam of tolu 5 parts 22 g
- Iodoform 10 parts 44 g
- Solvent—ether to 1 floz or 100 parts.

Treatment of oroantral communication seen within 24 hours of accident: If the case of oroantral communication is seen within 24 hours of its occurrence, and if the edges of the wound are clean; it should be closed immediately. The usual postoperative treatment of antibiotics, nasal drops and inhalations prescribed. In a situation where the case is not complicated by displacement of a tooth or a root into the antrum, it can be closed by a buccal flap and sutured under local anesthesia.

If the situation is complicated by displacement, the case is best treated by immediate surgery in the operation theater under GA.

Treatment of Delayed Cases

Treatment of cases seen more than 24 hours after accident: When a period of 24 hours has elapsed, the soft tissue margins of fistula often get infected. It is preferable to defer the surgical closure until gingival edges show sound healing, i.e. approximately 3 weeks.

As a prophylactic measure, antibiotics, analgesics and decongestant should be prescribed. Killey and Kay reported that a large percentage of cases with a small oroantral fistula heal in response to this form of treatment.

In case, (1) there is purulent discharge from fistula; or (2) the patient develops signs of acute or chronic sinusitis; then the maxillary sinus should be gently irrigated with warm normal saline.

Treatment of oroantral fistula of long duration (more than a month): In these cases, the fistulous tract is usually well epithelialized. Surgical closure is required, (1) patient presents 2–3 weeks after extraction, (2) complaint of foul taste in the mouth, (3) pus discharge from fistula into the mouth, which is increased with nose-blowing.

Management

The drainage of maxillary sinus is established through the fistula by enlarging it surgically, and the sinus should be gently irrigated daily with normal saline until it is clear.

Supportive medical treatment is instituted. When the acute condition subsides, surgical repair is undertaken.

Surgical Procedures Used in Closure of Oroantral Fistula

The surgical procedures can be divided into three groups: depending upon the type of flap used: (1) buccal, or (2) palatal flap, and (3) combination of both.

Essential Features of the Procedure

- The free end of the flap should have an adequate blood supply. The buccal flap is so designed, that the base should be wider than the apex; to ensure adequate vascularization at the apex. The palatal flap should be so designed that the greater palatine vessels are incorporated in the transposed tissues; and should be long enough to swing across the fistulous opening without tension or twisting at the base.
- Suture line is well-supported by sound bone.
- Mobilization of either buccal or palatal flap should be done in such a manner that there is no tension on the suture line.

There is a theoretical objection to buccal flap operation. It tends to obliterate the buccal sulcus, and renders the subsequent prosthodontic procedures more difficult. In reality, this does not occur, because of undermining of the flap by releasing incisions.

The palatal mucosa tends to produce some deformity, i.e. ridging, but this tends to regress in due course of time. When the palatal flap is rotated over the fistula, an area of denuded bone is left in the anterior part of palate. This is temporarily covered by gauze pack soaked in Whitehead's varnish. This dressing is secured across the defect with sutures and gets gradually covered with granulation tissue.

Buccal Flap Advancement Operation

It was originally described by Von Rehrmann in 1936. It is the most satisfactory method of closing oroantral fistula. This is according to the principle of periosteal release described by Berger in 1939.

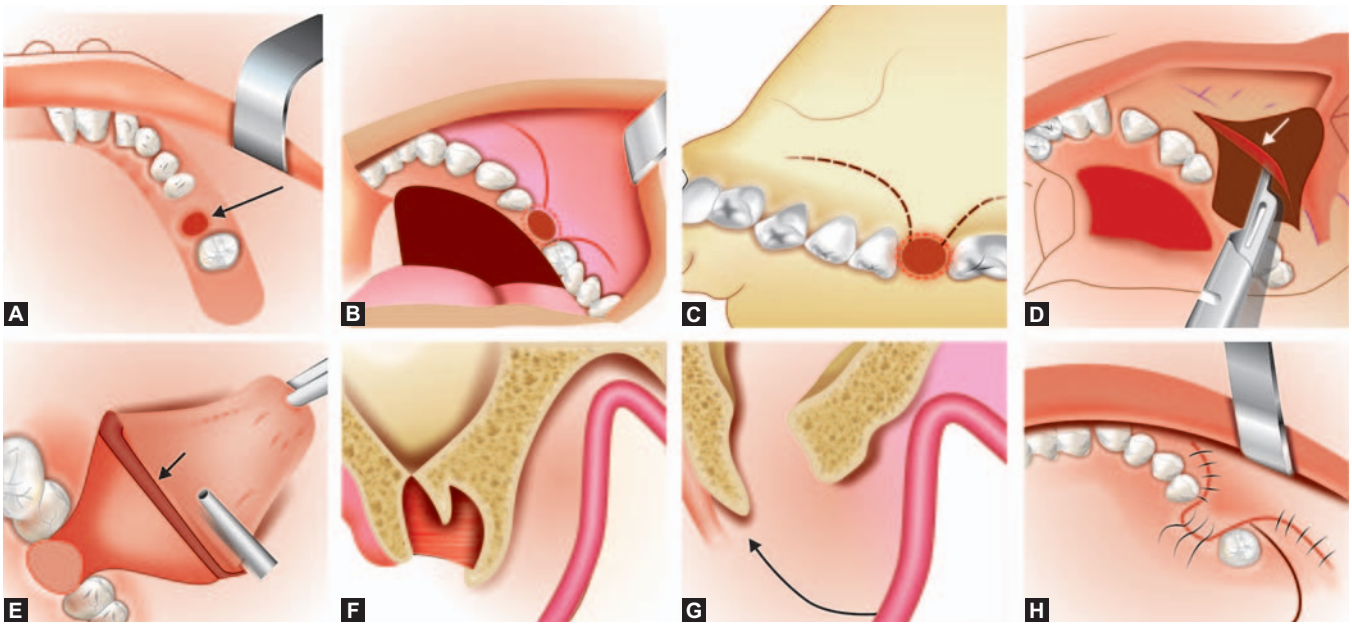
Procedure

- **Injection of LA in the mucobuccal fold**: It reduces local capillary bleeding by vasoconstriction at the time of operation, reduces the risk of formation of postoperative hematoma.
- **Excision of fistulous tract**: An incision is made around the fistulous tract 3–4 mm marginal to the orifice. As the soft tissue aperture of the communication is almost always smaller, than the diameter of bony defect. The entire epithelialized tract along with associated antral polyps is dissected out and excised gum margins are freshened with blade no. 11.
- Two divergent incisions are taken with blade no. 15, from each side of orifice into buccal sulcus for a distance of 2.5 cm. These incisions are made down till the bone. While extending the incisions towards cheek, care must be taken to avoid injury to papillae and duct of parotid salivary gland. Mucoperiosteal flap is reflected carefully. Inspection of bony margins of the alveolar ridge is done. Reduction and smoothening of the same is carried out.

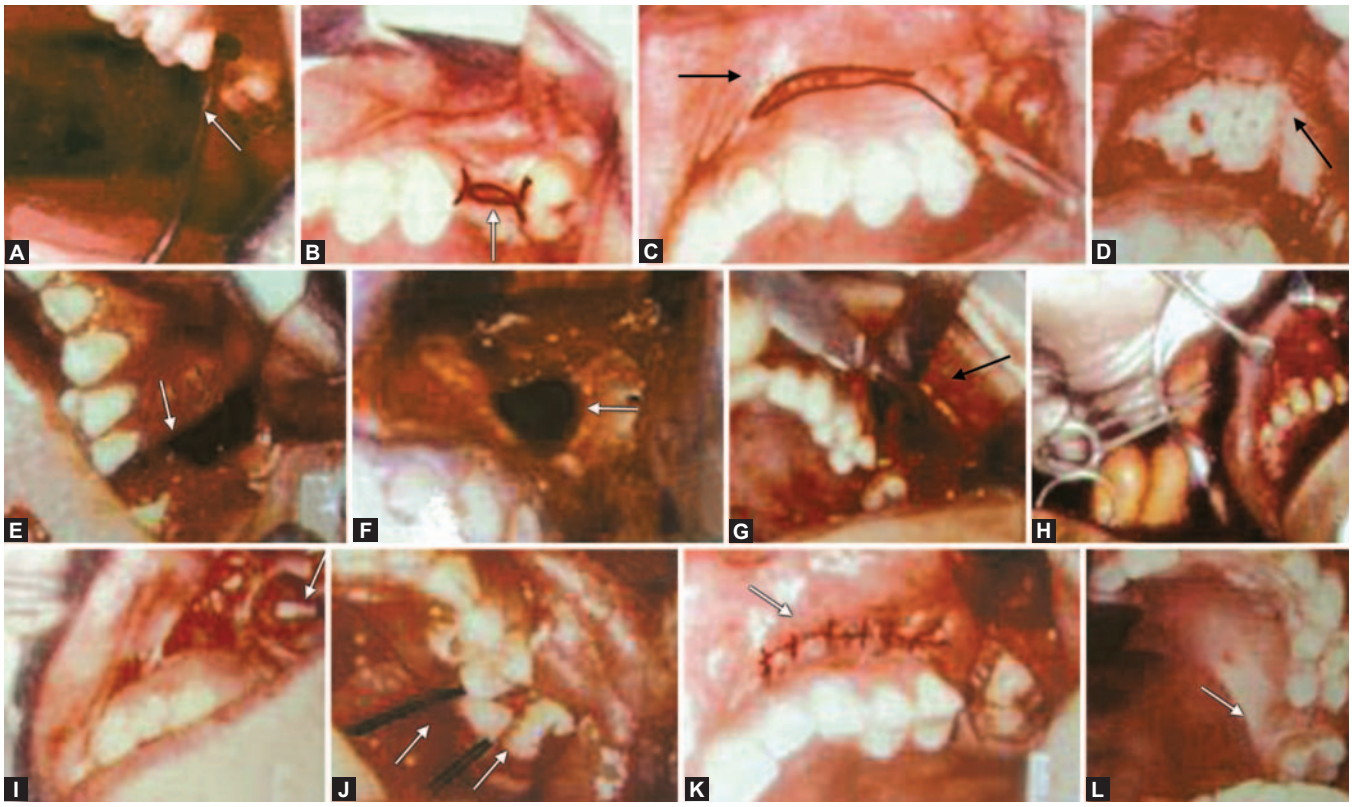
- **Advancement of buccal flap:** In situations, where the buccal mucoperiosteal flap falls short of covering the fistula; the flap can be advanced. A horizontal incision is made in the periosteum, as high as possible. This will allow advancement of buccal flap. It is advisable only to cut those areas in periosteum which are preventing its advancement. There is no need to cut through the periosteum at the entire base of flap.
- **Inspection of maxillary sinus:** Maxillary sinus should be carefully inspected for evidence of infection, either through fistula or by illumination, or with a fiberoptic light. Any polypoidal masses or other diseased tissue should be removed. Antrum gently irrigated with warm normal saline.
- In case, if antral pathology is present, Caldwell-Luc procedure should be carried out before the final closure of fistula.
- **Arrest of hemorrhage:** Complete arrest of hemorrhage to avoid formation of hematoma.
- **Closure of wound:** The mucoperiosteal flap is sutured into position across fistula with interrupted sutures.
- Postoperative medications: (1) Antibiotics, (2) Analgesics, and (3) Nasal decongestants and inhalations.
- Restriction to soft diet.
- Instructions to patients: (1) to avoid sneezing, (2) not to explore the wound with tongue, or deliberately sucking air or fluid through it.
- To avoid nose blowing in early stages: (1) it creates back pressure on sutures before consolidation is complete, and (2) causes surgical emphysema through mucoperiosteal flap into soft tissue of cheek.
- Removal of sutures 7–10 days postoperatively.
- **Review:** Patient is reviewed regularly to observe progress, clinically and radiologically.

Modified Rehrmann's Buccal Advancement Flap (Figs 41.14 and 41.15)

Here, after mobilization of the buccal flap and after taking the releasing periosteal incision, the free end of the flap which is to be sutured to the palatal mucosa is modified. A step is created along the entire length of the free end of the buccal flap in the submucosal area, by removal of 1–2 mm of mucosal layer, keeping the submucosal layer intact (de-epithelialization). This denuded flap margin is then pulled below the palatal mucosal edge by few vertical mattress sutures. By this procedure, the step in the submucosa will come in approximation with palatal edge, which is closed by means of interrupted sutures. This ensures double layer closure.



Figs 41.14A to H: Oroantral fistula closure by buccal advancement flap. Modified Rehrmann's procedure: (A) OAF; (B and C) Outline of buccal flap; (D and E) Reflection of buccal mucoperiosteal flap. Relieving incision high up through the periosteum; (F) Sagittal section—Rehrmann buccal flap; (G) Modified Rehrmann flap with de-epithelialization of the margin of the buccal flap, which is tucked under the palatal flap over the periosteum. This ensures double layer closure. Buccal and some palatal alveolar bones are reduced with Rongeurs; (H) Initial mattress suturing to pull the margin of the flap and then interrupted suturing is carried out



Figs 41.15A to L: Surgical procedure for closure of OAF by modified Rehrmann's buccal advancement flap: (A) Probe in OAF; (B) Circular excision of the margins of OAF; (C) Outline of buccal flap, (D) Reflection of mucoperiosteal flap and exposure of anterolateral wall of the maxillary sinus; (E) Bony defect due to traumatic extraction, seen communicating with the antrum; (F) Window made to access maxillary sinus; (G) Periosteal cut to mobilise the buccal flap; (H and I) Nasal antrostomy procedure; (J) Initial mattress suturing to pull the buccal deepithelialized margin underneath the palatal mucosa; (K) Complete suturing; and (L) Satisfactory healing

Intranasal Antrostomy

It is performed to facilitate the drainage at the conclusion of an operation performed: (1) To close an oro-antral fistula, or (2) To remove a tooth or a root from sinus.

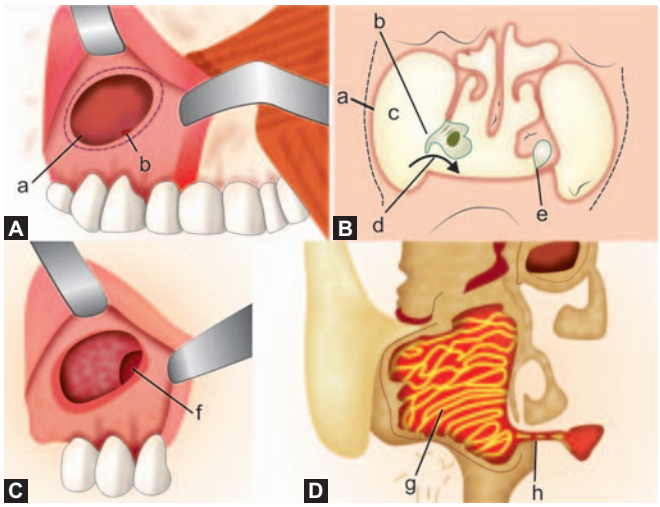
Drawbacks: It is a controversial surgical procedure for the following reasons: (1) It cannot drain the sinus, satisfactorily; as the point created for drainage is not at the point of dependent drainage; due to the fact that antral floor is about 1.5 cm below nasal floor, (2) It also interferes with ciliary pathways: thus impedes normal physiological drainage of sinus.

Surgical Procedure for Intranasal Antrostomy (Figs. 41.16A to D)

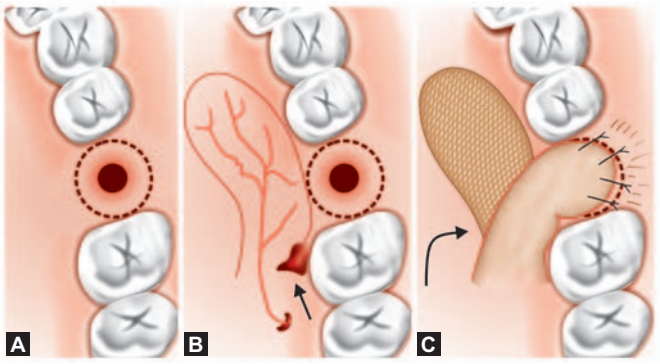
- A small-sized osteotome or gouge is pushed through the inferior meatus in the nasal cavity, into the maxillary sinus. Then a big curved artery forceps is passed through this opening and iodoform impregnated ribbon gauze pack's end is grasped into its beak and pulled out into the nostril. Here a single knot, which is put in the ribbon gauze will help to keep it secured in the nostril. The other end of the ribbon gauze is then used to systematically pack the maxillary sinus cavity in multiple folds, after achieving proper hemostasis (after Caldwell-Luc operation).
- An antrostomy can be performed by removing approximately 1 cm of the medial wall of the antrum, which bulges into the sinus below the level of the inferior turbinate. This antrostomy should be extended to the level of the floor of the nose. The nasal mucosa is then incised from the antral surface on three sides and the nasal mucosal flap thus created is reflected into the antrum.

Palatal Pedicled Flap: Rotational Advancement Flap Operation

Technically slightly more difficult than buccal flap operation. The palate gets its blood supply from greater



Figs 41.16A to D: Intranasal antrostomy: (a) Posterior wall of antrum, (b) Medial wall of sinus bulges into antrum below inferior nasal meatus, (c) Maxillary sinus, (d) Arrow—antrostomy to the level of floor of the nose, (e) Inferior meatus, (f) Antrostomy complete, (g) Antral packing with ribbon iodoform gauze, (h) End of the ribbon gauze brought out through the nasal antrostomy into the nostril



Figs 41.17A to C: Ashley's palatal pedicled rotational advancement flap for closure of oroantral fistula: (A) Circular excision of tissue around the fistula; (B) Palatal rotational advancement flap based on the greater palatine vessels. The kinking of the flap may be minimized by excision at the lesser curvature of the flap (dark area) Kruger's modification; (C) Final closure. Raw palatal area can be protected by placing iodoform gauze pack

palatine arteries, which emerge from greater palatine foramen; and run forwards in the palate, somewhat midway between gingival margin and the midline of the palate. Ashley (1939) devised the palatal flap operation, where a palatal flap is rotated across fistula, so that the suture line rests on sound bone on buccal side of the orifice. Although palatal tissue is less elastic, it is thicker than the buccal tissue. The abundant blood supply in the palatal tissue promotes satisfactory healing. Procedures involving palatal flaps do not affect the buccal vestibular height. Palatal rotational-advancement flap provides adequate mobility and tissue bulk to the flap. However, it requires the mobilization of large amount of palatal tissue, and it often kinks following the rotation of the flap, which may predispose to venous congestion. Kruger suggested a V-shaped excision of the lesser curvature of the flap to minimize folding.

Ashley's Operation

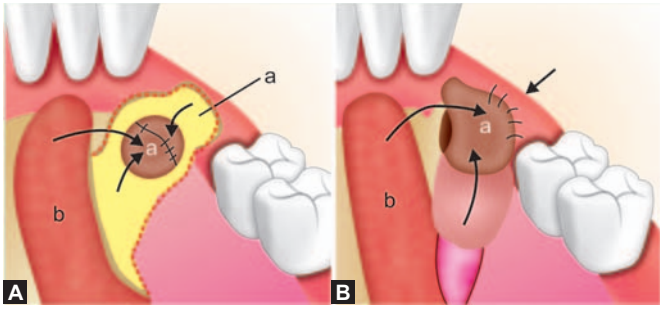
(i) Local anesthesia: It is also given to reduce bleeding. (ii) Excision of fistulous tract: The tract is dissected out by taking an incision around fistula, about 2 mm away from epithelialized edge. (iii) Marking out of proposed palatal flap: This is done with Bonney's blue ink before operation, (iv) Raising a palatal mucoperiosteal flap: Care is taken not to damage greater palatine artery, (v) Maxillary sinus is inspected and cleared of polyps; and irrigated with normal saline or betadine, (vi) Trimming of buccal mucoperiosteum: This is done in order to give bony support to suture line, (vii) Rotational advancement of the palatal pedicled flap to approximate the buccal margin with interrupted sutures **(Figs 41.17A to C)**.

Combination of Buccal and Palatal Flaps (Figs 41.18A and B)

An attempt to close larger defects by local flaps often leads to failure. Mobilization of both palatal and buccal flaps helps to have two layered closure. Used only in selected cases or where there is history of earlier repair with failure. The combination of inversion and rotational advancement flaps or hinged and palatal rotational advancement flaps can be used. A double layer closure not only improves the strength of the flaps, but also minimizes contraction and risk of infection.

Caldwell-Luc Operation

George Caldwell in 1893, from New York described a method of gaining entry into the maxillary sinus via canine fossa with nasal antrostomy. Henri Luc in 1897,



Figs 41.18A and B: Combined local flaps for closure of OAF (A) Hinged buccal and palatal rotational advancement flap—a and b; (B) Inversion flap-a and palatal rotational advancement flap—b. The hatched area is excised to facilitate the rotation of the palatal flap (arrow)

from Paris also reported the same procedure as his own. Later on the procedure was accepted as Caldwell-Luc operation worldwide.

Indications

- Open procedure for removal of root fragments, teeth or foreign body or an antrolith (stone) from the maxillary sinus
- To treat chronic maxillary sinusitis with hyperplastic lining and polypoid degeneration of the mucosa
- Removal of cysts or benign growths from the maxillary sinus
- Management of hematoma in the maxillary sinus and to control post-traumatic hemorrhage in the sinus
- Zygomaticomaxillary complex fractures involving floor of the orbit and anterior wall of the maxillary sinus
- Removal of impacted canine or impacted third molar
- Along with closure of chronic oroantral fistula, associated with chronic maxillary sinusitis.

Caldwell-Luc Surgical Procedure (Figs 41.19A to D)

- The surgical procedure can be performed under LA with sedation or under GA—which is the preferred method
- A semilunar incision is planned in the buccal vestibule from canine to second molar area, just above the gingival attachment
- A mucoperiosteal flap is elevated with the help of periosteal elevator till the infraorbital ridge. Care is taken to prevent injury to infraorbital nerve
- An opening or window is created in the anterior wall of the maxillary sinus with the help of chisels, gouges or dental drills. The opening is enlarged carefully in all directions with Rongeur forceps, to permit the inspection of the sinus cavity. The size obtained should be about the size of the index finger. This is to facilitate the palpation of the sinus lining with the introduction of index finger into the sinus cavity. The opening or window created should be well away from the apices of the roots of the maxillary teeth.
- Pus should be sucked away from the sinus and a thorough irrigation of the maxillary sinus is carried out with copious saline wash.
- Inspection of the maxillary sinus is done and removal of root, tooth gauze, cotton or stone or bone wax, etc. can be done at this stage.
- The thickened, infected lining of the maxillary sinus can be elevated with Howarth's periosteal elevator and removed and sent for histopathological examination
- If there is profuse bleeding, then the sinus can be packed with ribbon gauze soaked in adrenaline 1:1000 for 1 or 2 minutes
- The antral cavity again is irrigated and can be packed with iodoform ribbon gauze. The end of the same can be removed through the nasal antrostomy or through the small incision in the buccal vestibule.
- The incision is closed with 3-0 silk.

Postoperative management: Antibiotics, analgesics, anti-inflammatory drugs for 5 days. Pack removal on the 5th day. Benzoin tincture inhalation three times a day, followed by nasal drops. Patient is instructed not to blow the nose, have soft diet and no vigorous gargling.

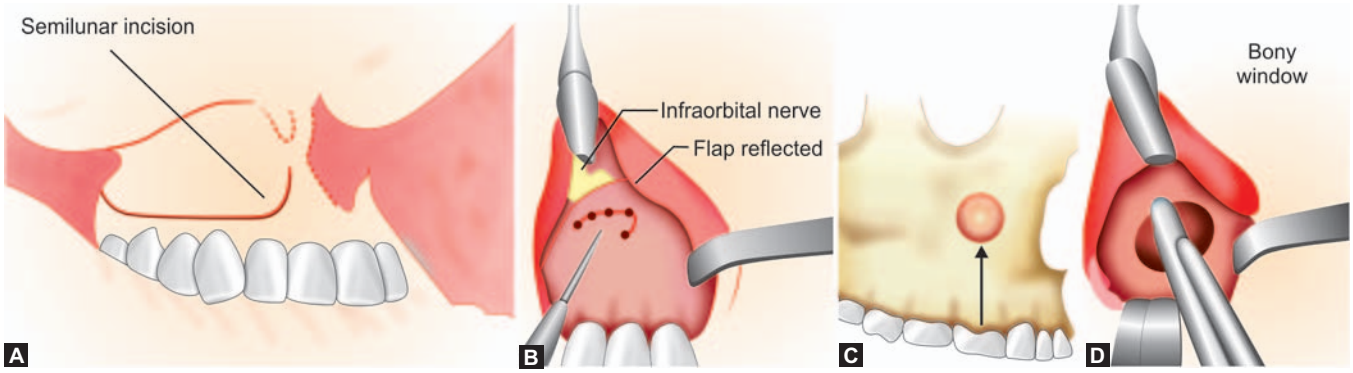
FUNCTIONAL ENDOSCOPIC SINUS SURGERY

Purpose

The purpose of functional endoscopic sinus surgery (FESS) is to restore normal paranasal air sinuses mucociliary function.

Historical Background

Hirschmann has been credited as the first surgeon to have attempted nasal and sinus endoscopy with a modified cystoscope in 1901. There are various reports in German literature on endoscopic treatment for sinusitis. The surgical landmarks were initially described in detail by Mosher with his principles of ethmoidal and frontal sinus surgery (1912, 1929). Later, Van Alyea, in 1939, described the anatomy of ethmoidal sinus in great details.



Figs 41.19A to D: (A) Intraoral incision for Caldwell-Luc operation; (B) Creation of bony window with drill; (C) Perforation area for window; (D) Enlarging the bony window at the anterior maxillary wall with Rongeur or bur

The first description of endoscopically examining nasal cavity and the antrum of Highmore was published by Maxwell and Maltz in 1925. They suggested that sinuscopy should be utilized for diagnosis, and described methods for maxillary endoscopic sinusotomy via the inferior meatal and canine fossa routes.

The functional endoscopic surgical dissections of the osteomeatal unit of ethmoidal and frontal sinusitis were described in English literature, simultaneously, by Messerklinger and Wigand in 1978, in independent publications. Stamberger and Kennedy, with the help of CT scans and pluridirectional tomograms, improved upon the original description of the technique as described by Messerklinger.

Endoscopic Sinus Surgery

There are four complementary developments which have contributed to the advancement of FESS.

1. Antibiotics: Antibiotics are credited as the first significant discovery that opened way for development of limited sinus surgery.
2. The substantiation that the anterior ethmoid sinus is the underlying key anatomical cause for frequent sinusitis. Infection that begins in the anterior ethmoidal sinus frequently spreads into the maxillary and frontal sinuses. Once ventilation and drainage is established, the sinus can return to normal function.
3. High-resolution computed tomographic (CT) examination of the paranasal sinuses has allowed for more precise identification and localization of sinus disease.
4. Advanced endoscopic instrumentation has markedly improved paranasal air sinus visualization and contributed improvement in surgical techniques.

Indications

(1) Recurrent sinusitis with stenosis at the osteomeatal unit which have been refractory to medical treatment. (2) Chronic hyperplastic sinusitis with obstructive nasal polyps. (3) Chronic sinusitis with mucocele formation. Patients with frontal sinus mucocele which are laterally placed are not good candidates for this type of surgery. (4) Fungal sinusitis in patients with diabetes or immunocompromised status are candidates for this type of surgery. (v) Neoplasms. (vi) Orbital cellulitis/abscess unresponsiveness to medical treatment.

Relative Indications

(1) Repair of cerebral spinal fluid leaks. (2) Selected nasofrontal recess/frontal sinus mucoceles. (3) Orbital decompression in bilateral exophthalmos. (4) Sinus-mediated cephalagia.

Diagnosis

The success of FESS depends upon an accurate diagnosis of osteomeatal complex disease; either in the form of mucus, or polypoid changes in the area of hiatus semilunaris or infundibulum.

The various factors employed are:

- **Routine sinus radiographs:** They are not of much value in revealing early paranasal sinusitis
- **Anterior rhinoscopy with a speculum:** It only provides a partial examination of nasal cavity
- **Nasal endoscopy**: It reveals a complete examination of nasal cavity and the osteomeatal complex
- **Computed axial tomography (CAT)**: It is used to confirm disease of osteomeatal complex and paranasal sinusitis. However, it is relatively expensive and requires radiation exposure.

Endoscopy of Maxillary Sinus

The topical anesthesia (4% cocaine soaked cotton) is applied to the sublabial area over the canine fossa. Then 1% lignocaine with 100,000 adrenaline is injected in this area. A small stab incision is made with Bard-Parker blade no. 11 or 15, a 5 mm mucous membrane trocar is used to enter the upper lateral part of canine fossa. The orbital rim should be palpated and the eye protected by keeping a finger on the rim during the puncture of the sinus. The trocar and the cannula are slowly rotated while entering the sinus in a posterior direction. The sinus, then can be examined with a telescope. A biopsy can be taken with an optical biopsy forceps through the cannula. The patient should avoid blowing nose for at least a week postoperatively, to avoid subcutaneous emphysema.

Types of Functional Endoscopic Sinus Surgery

The classification is based on the extent of disease involvement of sinuses prior to surgery, and the underlying medical condition. Anand and Panje's classification is as follows:

Type I: Nasal endoscopy and uncinectomy with or without aggernasi cell exenteration.

Indications: (1) Isolated osteomeatal thickening of mucous membrane; (2) Infundibular disease; (3) Patent maxillary sinus ostia without maxillary sinus membrane thickening and/or cysts; (4) Unsuccessful prior inferior maxillary sinus antrostomy and/or antrostomy with irrigation; (5) Prior septoplasty/adenoidectomy with continued paranasal sinus symptoms; (6) Anterior aggernasi cell infection presenting as dacrocystitis or erythema at the medial fornix of the eye.

Type II: Nasal endoscopy, uncinectomy, bulla ethmoidectomy, removal of sinus lateralis mucous membrane and exposure of frontal recess/frontal sinus. **Indications:** (1) Osteomeatal thickening of mucous membrane; (2) Evidence of anterior ethmoid sinus opacification, including obstruction of infundibulum; (3) Limited frontal sinus recess disease; (4) Unsuccesful prior inferior maxillary sinus antrostomy and/or antrostomy with irrigation; (5) Prior septoplasty/adenoidectomy with continued paranasal sinus symptoms.

Type III: Type II plus maxillary sinus antrostomy through the natural sinus ostium.

Indications: Type II with—(1) Evidence of maxillary sinusitis as evidenced by membrane thickening and/or opacification; (2) Stenotic or edematous maxillary sinus ostium.

Type IV: Type III surgical technique with complete posterior ethmoidectomy.

Indications: As per type III with: (1) Total ethmoid involvement; (2) Nasal polyposis with extensive ethmoidal and maxillary sinus disease; (3) Unresponsive to therapy for underlying systemic medical causes, e.g. persistent nasal sinus polyps despite steroid and antibiotic therapy; (4) Prior type I or type II FESS without response or progression of sinus disease.

Type V: Type IV surgical technique with sphenoidectomy and stripping of mucous membrane.
Indications: As per type IV with: (1) Evidence of sphenoid sinusitis; and (2) Pansinusitis and rhinitis.

Surgical Technique

Functional endoscopic sinus surgery (FESS) can be performed under local or general anesthesia. General endotracheal anesthesia is preferred by some otorhinolaryngologist.

The patient is placed in supine position at 15º reverse Trendelenburg. The nose is additionally anesthetized with 4% cocaine-soaked cotton pledgets placed in middle meatus and along the entire length of middle turbinate. One percent lignocaine with 1:1000 epinephrine is used for injection of greater palatine foramen. Additional injection in the middle meatus perimeter (uncinate, middle turbinate) are also done.

Endoscopies of maxillary sinus may be performed either via canine fossa or through a maxillary sinus antrostomy. Polyps or cysts may be biopsied or removed through either approach. The middle turbinate is reflected medially as the initial step of the surgery. In case, the nasal septum interferes with adequate visualization of osteomeatal unit, a septoplasty or, submucous resection of septum, should be performed before continuing with endoscopic ethmoidectomy.

An infundibulectomy is then performed using Freer elevator or sickle knife. Palpation of the uncinate process with cutting instruments will determine the limits of the uncinate process before reaching the denser bone of pyriform process. The uncinate process is relatively soft, while the pyriform process is hard. The Freer elevator or sickle knife is inserted immediately anterior and inferior to insertion of middle turbinate. This incision is carried inferiorly toward the natural ostium of maxillary sinus

(Kennedy, 1985). This exposes the base of infundibulum and anterior wall of bulla ethmoidalis. The uncinate process is then removed with a Blakesley-Wilde forward biting forceps.

Points to Remember

- General considerations and applied anatomy of maxillary sinus
- Clinical examination of maxillary sinus
- Radiology of maxillary sinus
- Infections of maxillary sinus
- Oroantral communication and fistula and management
- Functional endoscopic sinus surgery.

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Section 13

Orofacial and Neck Infections

42. Orofacial and Neck Infections and their Management
43. Osteomyelitis and Osteoradionecrosis of the Jaw Bones

CHAPTER 42 Orofacial and Neck Infections and their Management

INTRODUCTION

Infections of orofacial and neck region, particularly those of odontogenic origin, have been one of the most common diseases in human beings. Despite great advances in healthcare, these infections remain a major problem; quite often faced by oral and maxillofacial surgeons. These infections range from periapical abscess to superficial and deep neck infections. The infections generally spread by following the path of least resistance through connective tissue and along fascial planes. The infections spread to such an extent, distant from the site of origin, causing considerable morbidity and occasional death.

Early recognition of orofacial infection and prompt, appropriate therapy are absolutely essential. A thorough knowledge of anatomy of the face and neck is necessary to predict pathways of spread of these infections and to drain these spaces adequately.

This chapter deals with various types of orofacial and neck infections, with necessary description of numerous fascial spaces; with special reference to their involvement, surgical anatomy, clinical features, principles of their management with the surgical techniques used for drainage or decompression of the infections by intraoral or extraoral routes, and finally modes of their spread and the complications that would be encountered if these cases are left untreated, are also discussed.

ETIOLOGY

Infections in the orofacial and neck region usually originate from following sources:

A. General classification: It is based on the origin of the infection.

- **Odontogenic:** The majority of infections in orofacial and neck regions belong to this group. Odontogenic infections arise within the jaw bones, and can be classified as those arising from:
  (i) Pulp disease, (ii) Periodontal disease,
  (iii) Secondarily infected cysts or odontomes,
  (iv) Remaining root fragment, (v) Residual infection, and (vi) Pericoronal infection.
  These manifest in the following forms:
  (i) Periapical abscess, (ii) Periodontal abscess,
  (iii) Infected cyst, (iv) Residual abscess, and
  (v) Pericoronal abscess.
- **Traumatic:** Occasionally, trauma from penetrating wounds of soft and hard tissues of the face can lead to orofacial infections.
- **Implant surgery**
- **Reconstructive surgery**
- Infections arising from contaminated needle punctures.
- **Others:** This group includes instances of orofacial infections arising from other factors such as infected antrum, salivary gland afflictions, etc.
- Secondary to oral malignancies.

B. On the basis of causative organisms: Orofacial infections can be classified as:

- **Bacterial infections:**
  - The odontogenic infections encountered in orofacial region are mostly bacterial infections.
  - Nonodontogenic infections: (i) Tonsillar, and (ii) Nasal infections which are more common in children, and (iii) Furuncle of overlying skin.
- **Fungal infections:** These infections have slow rate of spread. These are difficult to diagnose in early stages.
- **Viral infections:** The literature does not show sufficient reports about these conditions of odontogenic origin.

Irrespective of the original source of infection, once it has been established within the soft tissues, its further spread tends to occur in uniform fashion.

PATHWAYS OF ODONTOGENIC INFECTION

Serious dental infection, spreading beyond the tooth socket, is more common due to the pulpal infection than the periodontal infection ***(Fig. 42.1).***

Invasion of the dental pulp by bacteria after decay of a tooth
↓
Inflammation, edema and lack of collateral blood supply
↓
Venous congestion or avascular necrosis
(pulpal tissue death)
↓
Reservoir for bacterial growth (anaerobic)
↓
Periodic egress of bacteria into surrounding
alveolar bone

The periapical infection progress can vary according to the:

- The number and virulence of the organism.
- Host resistance.
- Anatomy of the involved area.

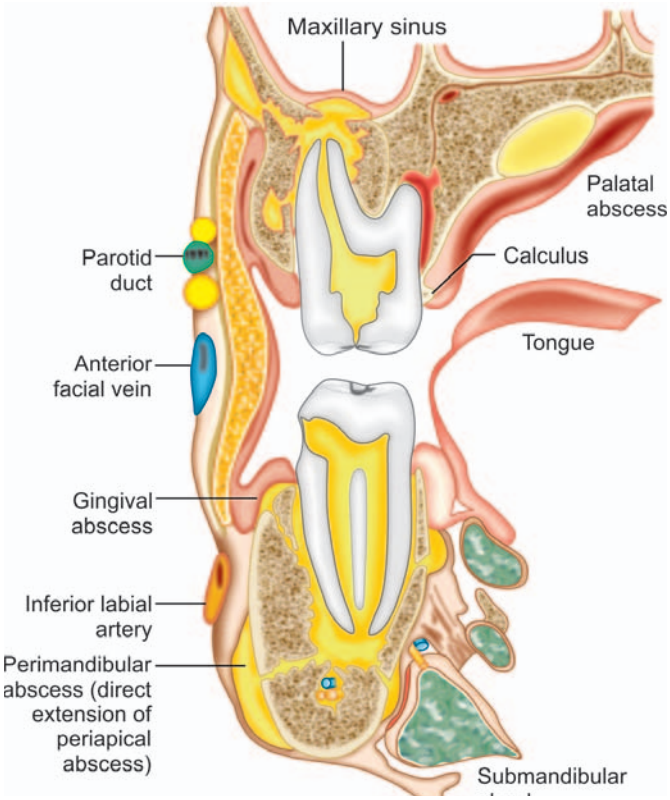


Fig. 42.1: Frontal section of oral cavity at the level of second molar. Possible spread of infection starting with simple caries and calculus. Abscess formation at various sites

Odontogenic Infections

Types of infection:

- Acute
- Chronic.

Acute Stage

In the acute stage, the infection spreading in the soft tissues can take the following forms in the clinical situations—abscess, cellulitis, and fulminating infections.

Abscess: It is a circumscribed collection of pus in a pathological tissue space. A true abscess is a thick-walled cavity containing pus. The suppurative infections are characteristic of staphylococci, often with anaerobes, such as bacteroides, and are usually associated with large accumulation of pus, which require immediate drainage. These microorganisms produce coagulase, an enzyme, that may cause fibrin deposition in citrated or oxalated blood.

Cellulitis: It is spreading infection of loose connective tissues. It is a diffuse, erythematous, mucosal or cutaneous infection. It is characteristically the result of streptococci infection; and does not normally result in large accumulation of pus **(Table 42.1).**

Streptococci produce enzymes such as streptokinase (fibrinolysin), hyaluronidase, and streptodornase. These enzymes break down fibrin and connective tissue ground substance and lyse cellular debris, thus facilitate rapid spread of bacteria along the tissue planes.

Antibiotics may arrest the spread of infection; and may bring about complete resolution of the condition. However, in cases refractory to antibiotic coverage, pus pockets should be suspected; and in such cases, exploration and drainage should be done.

Table 42.1: Differences between cellulitis and abscess

Characteristics	*Cellulitis*	*Abscess*
Duration	Acute phase	Chronic phase
Pain	Severe and generalized	Localized
Size	Large	Small
Localization	Diffuse borders	Well-circumscribed
Palpation	Doughy to indurated	Fluctuant
Presence of pus	No	Yes
Degree of seriousness	Greater	Less
Bacteria	Aerobic	Anaerobic/mixed

Fulminating infections of the various spaces in the orofacial region. Here, the infection involves the secondary spaces involving vital structures, along the pathway of least resistance.

Acute Infection

The odontogenic abscesses present in the following forms:

- **Acute periapical abscess:** An odontogenic abscess usually arises and remains in the confines of alveolar bone. This is referred to as acute periapical abscess.
- **Acute dentoalveolar abscess:** Once the infection has crossed the confines of alveolar bone and comes to lie in the neighboring soft tissues, and if it gets localized, it is referred to as acute dentoalveolar abscess **(Figs 42.2A to C)**.
- Acute periodontal abscess.
- Acute pericoronal abscess.

The infection follows the path of least resistance. The important and the deciding factor, in the involvement of the fascial spaces, is the relationship of root apices of molars with the mylohyoid line. The abscess related to mandibular second and third molars, usually, perforates the lingual cortex and spreads to the submandibular space; as the root apices of these teeth lie below the mylohyoid line. The abscess related to premolars and first molars, involves the sublingual space, as the root apices of these teeth are situated above the mylohyoid line.

Chronic Stage

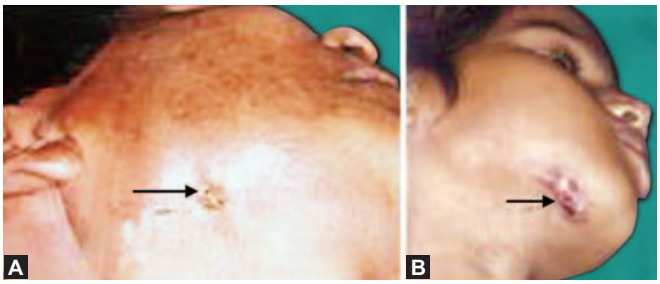
In the chronic stage, the odontogenic infection can present itself in the following forms:

1. **Chronic fistulous tract or sinus formation:** Abscesses neglected for a long time discharge intraorally or extraorally. When the abscess discharges through the skin; the sinus may appear in a location unfavorable for drainage; and the resulting scar is always thickened, puckered, and depressed and more esthetically prominent **(Figs 42.3A and B)**.
2. Chronic osteomyelitis
3. Cervicofacial actinomycosis.

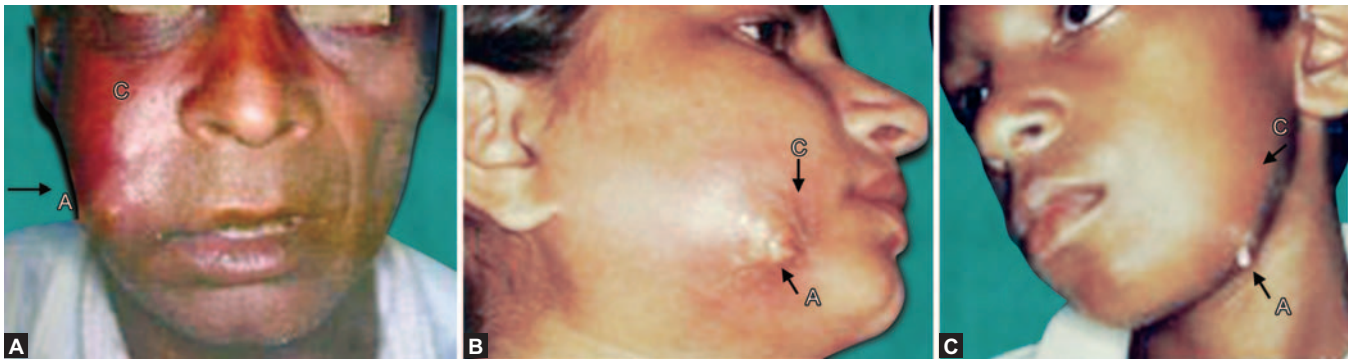
(2) and (3) are described in the next chapter.

General Course of an Odontogenic Abscess

- **Early stage:** There is intrabony collection of pus. The adjoining soft tissues do not undergo any necrosis.
- **Intermediate stage:** Perforation of cortex—with perforation of the cortex, the infection progresses; soft tissues become indurated and brawny. Subsequently, a small area of central softening can be palpated. This represents the central necrosis due to bacterial propagation and loss of blood supply. At this stage, sometimes, it is really difficult to judge whether or not to do an incision and drainage. However, if there is firm, brawny swelling, suppuration usually occurs unless the causative microorganisms are streptococci. Some clinicians feel that this is the time to intervene surgically either by,
  (i) doing incision and drainage, or



Figs 42.3A and B: Chronic odontogenic infection. Clinical extraoral pictures: (A) Chronic extraoral draining sinus tract; (B) Chronic fistula and exposed bone due to chronic odontogenic osteomyelitis



Figs 42.2A to C: Acute odontogenic infection: Clinical extraoral picture of (A) Acute abscess due to periapical lesion. Note the multiple pointing areas, (C) Cellulitis

(ii) extraction of the offending tooth; while the soft tissues are still soft and doughy to touch.

In such circumstances, the surgical intervention results in removal of the source of infection; and the soft tissues may not progress to suppuration and may undergo resolution.

If untreated or improperly treated, acute/chronic infection can lead to:

- Focal osteomyelitis
- Widespread osteomyelitis
- Fistulous tract (intraoral or extraoral) formation
- Intraoral or cutaneous soft tissue abscess
- Cellulitis
- Bacteremia-septicemia
- Deep facial space infection
- Ascending facial cerebral infection.

Acute Periapical Abscess

Etiology

The main cause is infective necrosis of pulp.

Causes of infective necrosis of pulp include—(i) carious involvement, (ii) contamination of traumatic exposure of pulp, (iii) sterile necrosis, where apical vessels are torn by blow on the teeth, or (iv) following inadvertent chemical or thermal damage to pulp.

Microorganisms from infected pulp invade periapical tissues. The entry to periapical tissues is gained usually through (i) apical foramina; and in such circumstances, the infection is truly periapical. Occasionally, the entry is through (ii) accessory canals, (iii) an endodontic perforation, (iv) an opening in the floor of the pulp chamber of a primary molar, (v) from an area of surface resorption, or (vi) root fracture. In these circumstances, the abscess develops on the lateral aspect of root or at the root furcation or in the vicinity of root fracture, as the case may be.

Clinical Features

Severe throbbing pain in the affected tooth. The offending tooth may show carious involvement, and may be sensitive to percussion. Mobility may or may not be present.

Radiographic presentation: The involved tooth shows carious lesion with periapical pathology, root fracture, erosion or absorption as the case may be. It also shows periapical radiolucency, areas of resorption; and the different types of radiolucencies involving the root fracture.

Treatment: The treatment modalities comprise of the following—(1) antibiotics, (2) analgesics, (3) drainage through the pulp chamber, (4) extraction of the offending tooth, or (5) endodontic treatment.

Acute Dentoalveolar Abscess

This disease entity is a continuation of periapical abscess.

Clinical Features

- **Pain:** The severity of pain depends upon the stage of the disease process.
- Submucosal swelling in the sulcus, usually on the outer aspect of alveolar process. Fluctuation may be elicited after a few days. If left untreated, the swelling bursts and produces sinus tract discharging pus.

Radiographic presentation: There is no appreciable difference in the presentation of the two entities radiographically, except that the area of radiolucency may be more marked in dentoalveolar abscess **(Table 42.2).**

Treatment: The same treatment modalities hold true for dentoalveolar abscess. In addition, intra or extraoral incision and drainage may be required.

Table 42.2: Differential clinical features between acute periapical and acute periodontal abscesses

	Features	*Acute periapical abscess*	*Acute periodontal abscess*
1.	Pain	Severe and throbbing	Severe and throbbing
2.	Age	Common in adults	Uncommon in children
3.	Pulp	Necrotic and infected	Vital
4.	Swelling	Usually, over the apex	Usually, over the gingival third of the alveolar process
5.	Sinus discharge	May be present	May be present
6.	Tenderness to percussion	Present	Present
7.	Mobility	Later stages	Early stage
8.	Origin	Arises from pulp	Arises in relation to periodontal pocket

Acute Periodontal Abscess

Etiology

It arises in periodontal membrane adjacent to a periodontal pocket.

Clinical Features

Dull pain, rarely severe, and variable in intensity. Pus discharges via gingival pocket. It may produce a sinus on either inner or outer aspect of alveolar process; and rarely tracks through the skin.

Periodontal abscesses are uncommon in children and an acute swelling close to gingival margin of a primary molar is usually a periapical abscess.

MICROBIOLOGY

The aerobic bacteria found in odontogenic infection are primarily gram-positive cocci, most are viridans streptococci species, include *Streptococcus milleri, S. sanguis, S. salivarius, S. mutans.* These oral streptococci are also known as alpha-hemolytic streptococci, which account for about 80% of aerobic bacteria found in odontogenic infection.

Some anaerobic cocci appear similar, morphologically, to staphylococci. They were named previously as peptococci. DNA probe investigation has shown that peptococcus and peptostreptococcus are the same bacteria.

There are two main groups of Bacteriodes. First is oropharyngeal group, which is found in the mouth and contributes to odontogenic infections. The other group found in the gut—the enteric Bacteroides, they include *B. fragilis*, *B. vidgatis*, *B. distasonis*, *B. thetaiotaomicron*, *B. ovatis*. They are rarely seen in oral cavity and mostly do not cause odontogenic infections.

Oropharyngeal *Bacteroides* are divided into:
(a) *Porphyromonas*, and (b) *Prevotella*.

a. *Porphyromonas:* It includes *P. asacchrolyticus, P. gingivalis,* and *P. endodontalis.*
b. *Prevotella:* It includes *P. melaninogenicus, P. buccae, P. intermedius, P. oralis, P. loescheii, P. ruminicola,* and *P. denticola*. *Prevotella intermedius, Porphyromonas gingivalis,* and *Porphyromonas endodontalis* appear to be the most pathogenic among them.

These gram-negative anaerobic rods are usually susceptible to most antibiotic, but they are 25% resistant to penicillin V and nearly 50% resistant to cephalexin, and other first generation cephalosporin.

The other group of anaerobic gram-negative rod is the genus *Fusobacterium*. *Fusobacterium* like *Bacteroides* are pathogenic and have the ability to destroy tissues through production of proteolytic enzymes and endotoxins. *Fusobacterium* is usually sensitive to penicillin and penicillin like drugs, but are frequently resistant to erythromycin.

Fusobacterium species appear to be the most virulent and when in combination with *S. milleri*, commonly seen in aggressive odontogenic infections that have descended into the lateral pharyngeal and retropharyngeal spaces and also into the mediastinum.

Medical Therapy

Consists of supportive care—hydration, soft or liquid diet, rich with high protein, analgesics and use of antiseptic mouthwashes to maintain the oral hygiene.

Antibiotic Therapy

The antibiotic therapy should be decided after knowing the patient's systemic condition status.

- *In noncompromised patient with well localized abscess*—surgical drainage and dental therapy will resolve the infection without antibiotic cover. In cases of poorly localized, extensive abscess and diffuse cellulitis, antibiotic therapy is a must.
- In compromised patients, as well as in patients with systemic signs and symptoms like trismus, airway compromise, fever, etc. antibiotic cover is mandatory.

Patients with diminished host defense, like uncontrolled or insulin-dependent diabetics, immunosuppressed patients, chronic alcoholics, intravenous drug abusers, and patients on renal dialysis also require antibiotic cover. In these patients, there is always a danger of sudden serious sepsis spreading from even a small septic focus.

Choice of Antibiotic Therapy

Initially always empirical antibiotic selection is done, based on the knowledge of microbiological study of the flora of oral infection. Later on after knowing the laboratory results of culture and sensitivity testing, specific antibiotic is instituted.

Penicillin is an empirical drug of choice since last many decades. But, now studies have shown that beta-lactamase

producing organisms such as *Bacteroides* are insensitive to penicillin. 30% of the microorganisms are reported as resistant. As these orofacial infections are a mixed flora of aerobes and anaerobes, the bacterial synergism that enhances growth of these different types of organisms may be disrupted by the use of penicillin; and metronidazole can supplement the penicillin.

Oral clindamycin, amoxicillin-clavulanic acid (Augmentin), 1st and 2nd generation cephalosporins are also useful in orofacial infections.

In compromised patients: Clindamycin alone or in combination with Gentamycin or 1st or 2nd generation cephalosporins can be used parenterally.

Surgical Therapy

Surgical Technique for Incision and Drainage of an Abscess

Incision and drainage helps:

- To get rid of toxic purulent material
- To decompress the edematous tissues
- To allow better perfusion of blood, containing antibiotic and defensive elements
- To increase oxygenation of the infected area.

The abscess is drained surgically and simultaneously dental treatment also should be instituted to achieve quick resolution. It involves the blunt exploration of the entire anatomic space or the abscess cavity; with the opening up of all the tissue planes within the abscess cavity. The abscess cavity is then irrigated with betadine and saline solution. A drain is inserted into the depth of the space. It may simply pass through a single incision and remain in the depth of the space, or it may be a through and through drain. The drain is secured to one of the margins of the incisions with a suture; or to itself, in case of a through and through, intra- to extraoral drains; and left *in situ*, which can again be in the same fascial space or through another fascial space.

Hilton's Method of Incision and Drainage (Figs 42.4A and 42.4B)

The method of opening an abscess ensures that no blood vessel or nerve in the vicinity is damaged and is called Hilton's method.

Steps

- **Topical anesthesia:** Topical anesthesia is achieved with the help of ethyl chloride spray.



Fig. 42.4A: Aseptic preparation of the site before draining an abscess by Hilton's method

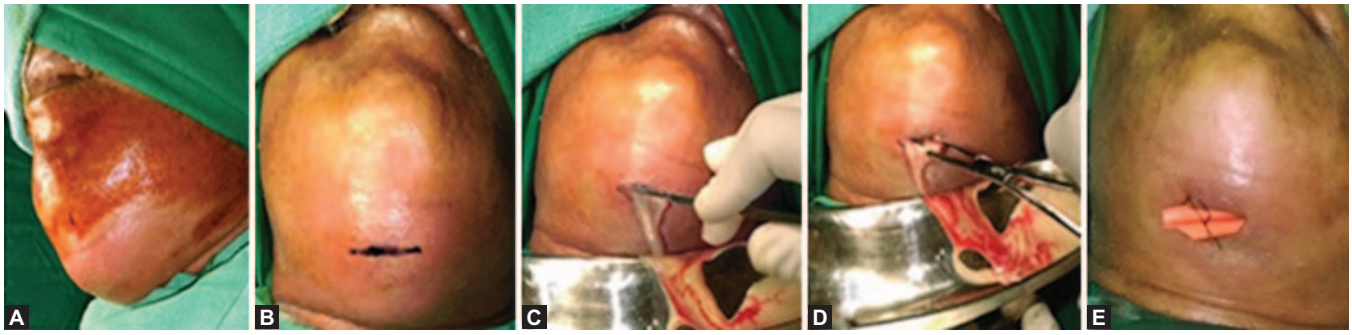


Fig. 42.4B: (A to E) Steps in Hilton's method of drainage of an abscess

- **Stab incision:** Made over a point of maximum fluctuation in the most dependent area along the skin creases, through skin and subcutaneous tissue.
- If pus is not encountered, further deepening of surgical site is achieved with sinus forceps (to avoid damage to vital structures).
- Closed forceps are pushed through the tough deep fascia and advanced towards the pus collection.
- Abscess cavity is entered and forceps opened in a direction parallel to vital structures.
- Pus flows along sides of the beaks.
- Explore the entire cavity for additional loculi.
- **Placement of drain:** A soft yeat's or corrugated rubber drain is inserted into the depth of the abscess cavity; and external part is secured to the wound margin with the help of sutures.
- Drain left for at least 24 hours.
- **Dressing:** Dressing is applied over the site of incision taken extraorally without pressure.

Purpose of keeping the drain: The purpose of drain is to allow the discharge of tissue fluids and pus from the wound by keeping it patent. The drain allows for debridement of the abscess cavity by irrigation. Tissue fluids flow along the external surface of a latex drain. Hence, it is not always necessary to make perforations in the drain, which could weaken and perhaps cause fragmentation within the tissues.

Removal of drains: Drains should be removed when the drainage has nearly completely ceased. Drains have shown to allow ingress of skin flora along their surfaces. Some form of drains, such as latex drains in particular, are irritating to the surrounding tissues and may stimulate some exudates formation on their own. Thus, drains are usually left in infected wounds for 2–7 days (Flynn 2000).

SPREAD OF OROFACIAL INFECTION

Routes of Spread

The routes by which the infections can spread are as follows:

- By direct continuity through the tissues.
- By lymphatics to the regional lymph nodes and eventually into the bloodstream. When the infection gets established in the lymph nodes, secondary abscesses may develop. The spread of infection from the lymph nodes into the tissues results in secondary areas of cellulitis or tissue space abscess.
- **By the bloodstream:** Rarely, local thrombophlebitis may propagate along the veins, entering the cranial cavity via emissary veins to produce cavernous sinus thrombophlebitis. The microorganisms or infected emboli may get swept away into the bloodstream, leading to bacteremia, septicemia, or pyemia with the development of embolic abscesses **(Table 42.3).**

Table 42.3: The lymph nodes in the face and neck region and the areas of drainage

S.No.	*Lymph nodes*	*Areas drained*
1.	Submental	Tip of the tongue, part of the floor of the mouth in the midline, mandibular incisors, related gingivae, middle alveolar process and basal bone of the mandible, mid-portion of lower lip and chin
2.	Submandibular	All maxillary teeth, mandibular teeth except incisors, inferior nasal cavity, palate, body of tongue, upper lip, lateral portion of lower lip, angle of mouth, medial angle of eye, and submental lymph nodes
3.	Accessory facial • Infraorbital	Skin of the medial angle of eye, skin of anterior face, superficial part of nose
	• Buccal	Skin of anterior face, mucous membrane of lips and cheeks
	• Mandibular	Skin over mandible, mucous membrane of lips and cheeks
4.	Preauricular	Skin inferior to temple, external auditory meatus, lateral part of forehead, lateral part of eyelids, posterior part of cheeks, portion of outer ear, parotid gland
5.	Postauricular	External ear, scalp above and behind the ear
	• Infra-auricular, occipital	Pre- and postauricular nodes Scalp posterior to ear, occipital region
	• Superficial cervical	Pinna and adjoining skin, pre- and postauricular nodes
	• Deep cervical	Submandibular, submental, inferior auricular, tonsillar and tongue nodes

FACTORS INFLUENCING SPREAD

Some infections progress more rapidly into deep fascial spaces than others. This may be because of: (A) General factors, and (B) Local factors.

General Factors

It includes—(a) host's resistance; or immunocompetence of the host, and (b) virulence of microorganisms; and (c) combination of both.

a. **Host resistance:** It depends upon: (i) Humoral factors, and (ii) cellular factors.
   i. *Humoral factors* involve immunoglobulins derived from B lymphocytes or plasma cells and complement.
   ii. *Cellular factors* include polymorphonuclear leukocytes, monocytes, lymphocytes, and tissue macrophages.

b. **Virulence of microorganisms:** It is determined by invasiveness of the causative microorganisms. These include production of lytic enzymes, potent endotoxins and exotoxins, and interference with or resistance to host humoral and cellular defenses.

   Rapid progression of infection occurs in necrotizing fasciitis, especially in immunocompromised host, particularly when virulent strains of beta-hemolytic streptococci are involved.

c. **Compromised host defenses:**
   - Uncontrolled metabolic diseases, such as, uremia, alcoholism, malnutrition, severe diabetes.
   - *Suppressing diseases*: Leukemia, lymphoma, malignant tumors.
   - *Suppressing drugs*: Cancer chemotherapeutic drugs, immunosuppressive drugs.

Local Factors

Once the balance between host resistance and bacterial pathogenicity is lost in favor of invading organisms, then the spread of infection progresses. The following are the barriers:

Intact Anatomical Barriers

- **Alveolar bone:** It is the first locally limiting barrier to further spread of a periapical infection. As the infection progresses within the bone, it spreads in the radial manner; and extends to the cortical plates. The site of perforation of the cortex is dependent upon proximity of the root apices to alveolar process.
- **Periosteum:** It is the next local barrier. This structure is better developed in the mandible; and hence can delay further spread leading to development of a subperiosteal abscess. It does not provide much resistance and the infection spreads into adjacent surrounding soft tissues.
- **Adjacent muscles and fascia:** It is the next site of localization.

The final outcome of spread depends on host's defense mechanisms.

Pathways of Dental Infections

From a tooth, once the infection crosses the apex, spread of infection depends upon the following factors: (a) Virulence of microorganisms, (b) Resistance of the host, and (c) Anatomy of the involved area **(Fig. 42.5)**.

- **Infection in the periapical area:** Focal osteomyelitis. If the infection remains confined to the periapical area, chronic periapical infection develops. This may sometimes lead to sufficient destruction of bone with well demarcated corticated radiolucency seen on a radiograph. This is known as focal osteomyelitis.
- Widespread osteomyelitis
- The infection process may proceed into deeper medullary spaces and lead to widespread osteomyelitis.

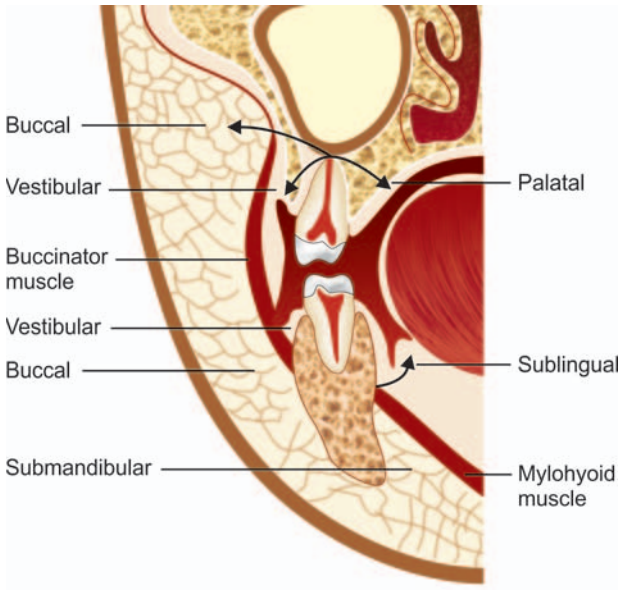


Fig. 42.5: Potential routes of spread of periapical infection. Muscle and fascial attachments determine the direction of spread. Extension beyond these attachments leads to deep space involvement

- Formation of fistulous tracts through the alveolar bone which exit into the surrounding soft tissue.

Anatomical Factors Influencing the Direction of Spread

- The site of the source of infection such as upper or lower jaw, and the particular segment of the jaw involved.
- The point at which the pus escapes from the bone and discharges into the soft tissues either labiolingually or buccopalatally.
- The natural barriers to the spread to the pus in the tissues such as layers of fascia or muscle or the jaw bones.

Anatomical Considerations in Dentoalveolar Infections

The fate of a dentoalveolar abscess is dependent upon anatomic position of the apices of the roots from which it originates, especially, the muscle attachments, particularly buccinator and mylohyoid muscles.

It is unusual for an acute dentoalveolar abscess or fistula to appear distant from its site of origin. Infection usually follows the path of least resistance.

Maxilla

A swelling or fistula in the posterior part of hard palate is usually related to the palatal roots of adjacent molars. Infections of upper teeth manifest themselves depending upon the anatomic location of their root apices. Maxillary incisor and cuspid roots lie closer to thin labial plate of bone rather than to thicker palatal bone. Hence, their infections are usually observed as bulging submucosal (vestibular) abscesses or fistulae in labial sulcus.

The muscles of upper lip arising from alveolar bone, are quite thin, and have little influence on spread of infection. Infections arising from maxillary bicuspids and molars, may extend buccally and palatally, because of the multiple roots. Infection from maxillary bicuspids may extend into connective tissue of buccal vestibule and may spread superiorly, cause cellulitis of the eyelids. The attachments of buccinator muscle are usually well above the root apices of bicuspids, however, extension into buccal space may occur.

The infection from maxillary molars may exit from alveolar bone, either buccally, palatally or posteriorly. The common site for abscess is buccal vestibule, however, buccal space may be involved. The involvement of the palate is uncommon, as the palatal roots are long.

The superior spread of infection into maxillary sinus is not common. The spread of infection posteriorly, may involve the masticator and pharyngeal spaces and spread superiorly into infratemporal space.

Mandible

Infection of mandibular incisors and cuspids, usually presents as a bulging erythematous mass, deep in labial sulcus. If the infection spreads from bone deeper to the origin of mentalis muscle, the submental space gets involved. Infection of mandibular third molars, is frequently pericoronal (pericoronitis); but can be related to root apices, if caries has involved the pulp of the unerupted or erupted tooth. The pathway of infection from the mandibular third molars may be seen to involve buccal vestibule, buccal space, masticator space, and parapharyngeal spaces.

EVALUATION OF THE PATIENT WITH OROFACIAL INFECTION

Patients with an orofacial infection, may present themselves with various signs and symptoms ranging from unimportant to the extremely serious. A quick assessment of the situation is a must.

If the patient is:
- Toxic
- Exhibits central nervous system changes and
- Airway compromise.

Then
- Immediate hospitalization
- Aggressive medical treatment
- Aggressive surgical intervention (including intubation and tracheostomy) should be done.

The basic principles of patient evaluation must be followed. These include: complete history, physical examination, clinical features, appropriate laboratory investigations, radiological investigations, and proper interpretation of findings. Adherence to the basic principles helps in arriving at an accurate diagnosis and instituting appropriate treatment.

History Taking

It helps in obtaining information regarding the origin, extent, location and potential seriousness of the problem. The following information may be stressed—(a) history of present illness; especially, onset; (b) history of toothache; or headache, or chills; their nature, location, and duration;

(c) previous hospitalization with infection; the treatment instituted and its response; (d) previous trauma to soft and hard tissues in the region; (e) history of recurrent infections; (f) history of recent rate of increase in extent of swelling; or (g) airway difficulty.

Physical Examination

General Examination

It includes—(i) examination of thorax, (ii) abdomen, (iii) extremities, (iv) heart and its murmurs, (v) recording the vital signs: this serves as a useful baseline for noting progression or regression of disease process. Pulse rate is increased, 10 beats/minute for each degree of rise in temperature.

Regional Examination

It comprises of a comprehensive physical examination and includes the following—(i) skin of face, head and neck, (ii) swellings, injuries and areas of tenderness over maxillary and frontal sinuses, (iii) sinus tracts and fistula formation, (iv) enlargement of underlying bone, (v) enlargement of salivary glands, (vi) enlargement of lymph nodes.

Extraoral examination: A comprehensive regional examination would include:

- **Inspection:** (a) Skin of face (redness), head and neck, (b) Swelling, (c) injuries, (d) Fixation of skin, or mucosa to underlying bone, and (e) Sinus or fistula formation.
- **Palpation:** (a) Size of swelling, (b) Tenderness, (c) Local temperature, (d) Fluctuation, (e) Enlargement of underlying bone, (f) Salivary glands, (g) Regional lymph nodes (enlargement, tenderness).

Intraoral examination: The examiner should have a good light for the examination of the oropharynx, while slightly depressing the tongue, in order to visualize swelling of tonsillar pillar and deviation of uvula away from the affected side.

- **Trismus:** The interincisal opening should be measured.
- **Teeth:** their number, presence of caries, and large restorations, and mobility.
- Localized swelling and fistulae.
- Sites of tooth extraction.
- **Percussion:** It is useful in determining hypersensitivity. It is performed with a metallic instrument or a tongue blade.
- Heat and cold testing.
- Electric pulp testing.
- Visualization of Stenson's and Wharton's ducts—the flow of saliva from the two ducts on both the sides should be examined.
- Soft palate, tonsillar fossa, uvula and oropharynx.
- Displacement of tissues, presence of swelling, and drainage of pus.

Ophthalmologic examination: It includes—assessment of extraocular muscle function, proptosis, or swelling of eyelids, and dorsum of root of the nose.

Clinical Features

- **Signs of infections:** The cardinal signs of inflammation are usually present to some extent.
  - *Rubor or redness:* This is usually present, when the infection is close to the tissue surface; especially in individuals with light complexion. It is due to vasodilation.
  - *Tumor or swelling:* It is due to the accumulation of inflammatory exudate or pus.
  - *Calor or heat:* It is due to pouring of warm blood from deeper tissues at the site of infection, increased velocity of blood flow, and increased rate of metabolism.
  - *Dolor or pain:* It is due to: (i) the pressure on sensory nerve endings, caused by distension of tissues (edema or spreading of infection), (ii) increased tissue tension: the action of liberated or activated factors; such as kinins, histamine, or bradykinin like substances, (iii) loss of tonicity of injured tissues, (iv) *functio laesa*: or loss of function of the affected part. It is caused by mechanical factors and reflex inhibition of muscle movements associated with pain. This is reflected in difficulty in chewing and swallowing and respiratory embarrassment.
- **Fever/Pyrexia:** It is one of the most consistent signs of infection (97.7–99.5°F—normal oral temperature).
  Other conditions, which may manifest pyrexia include:
  - Noninfectious inflammatory disorders; such as rheumatoid arthritis
  - Excess catabolism as in thyrotoxicosis.
  - Neoplastic disease such as lymphoma
  - *Postoperative*: Release of endogenous pyrogens, which stimulate the hypothalamic thermo-regulation centers.
- **Repeated chills:** It is common in bacteremia and pyogenic abscesses.
- **Headache:** It is usually associated with fever, and is thought to be due to stretching of sensitive structures surrounding dilated intracranial arteries.
- **Lymphadenopathy:** The condition of lymph nodes depends upon whether the condition is acute or chronic. In acute infections, the lymph nodes are

soft, tender and enlarged. The surrounding tissues are edematous and overlying skin is erythematous/reddish. In chronic infection, the lymph nodes are firm nontender and enlarged. The edema of surrounding tissues may not be present. The location of enlarged lymph nodes often indicates the site of infection.

Suppuration of lymph nodes occurs, when the causative organism has overcome the local defense mechanism in the node; resulting in excessive cellular reaction and collection of pus.

- **Others:**
  - Presence of draining sinuses or fistulae
  - Difficulty in opening mouth
  - Difficulty in swallowing
  - Increased salivation
  - Changes in phonation
  - Difficulty in breathing
  - Bad breath.

Clinical Symptoms of Possible Life-threatening Infections

- Respiratory impairment
- Difficulty in swallowing
- Impaired vision or eye movement or both
- Change in voice quality
- Lethargy
- Decreased level of consciousness
- Agitation, restlessness due to hypoxia.

Toxicity—Signs and Symptoms

- Pallor
- Rapid respiration, throbbing pulse
- Fever, shivering
- Appearance of illness
- Lethargy
- Diaphoresis.

Central Nervous System Changes Associated with Infection

- Decreased level of consciousness
- Evidence of meningeal irritation—severe headache, stiff neck, vomiting.
- Edema of eyelids and abnormal eye signs.

Radiological Examination

Conventional Radiography

The radiological examination: The radiological examination is helpful in locating the offending teeth or other underlying causes. The various radiographs useful are: (i) intraoral periapical radiographs, (ii) orthopantomographs (OPG), (iii) lateral oblique view of the mandible, (iv) anteroposterior (AP) and lateral view of the neck for soft tissues can be helpful in detecting retropharyngeal space infections.

Other Diagnostic Aids

The other diagnostic imaging aids play a vital role in the management of infection of fascial spaces of face and neck. It helps the surgeon, to know the anatomic extent of the fascial space infections, which aids in surgical drainage of the abscess and inflammatory exudate.

Computed tomography (CT) guided needle aspiration of fluid collections can be used to obtain material for microbial analysis. The imaging techniques can be broadly classified into following:

- CT scan,
- Magnetic resonance imaging (MRI),
- Nuclear medicine,
- Xeroradiography.

These help in diagnosing extension of infection beyond maxillofacial region.

CT scan: It is the "gold-standard", in head and neck imaging. CT and other X-ray images are based on a single factor, i.e. the X-ray beam is attenuated by the tissue present, according to its electron density. CT scan is the most widely used advanced imaging modality in the evaluation of the fascial infections. CT shows the extent of soft tissue involvement, i.e. (a) Showing complete extent of inflammatory process, (b) Epicenter of inflammatory process, (c) Differentiating between myositis-fasciitis, and abscess formation, and (d) accurately demonstrating the status of airway and involvement of various groups of lymph nodes.

CT shows extent of osseous involvement adjacently, and demonstrates early periosteal reaction associated with osteomyelitis.

CT findings, associated with fascial space involvement include edema and ill-definition of various muscles (myositis) and fascial planes (fasciitis), airway displacement or deformity of the soft tissues, air from gas forming pathogens, enhancing the inflammatory masses, fluid collection within involved space, abscess formation evidenced by a hypodense area representing an accumulation of exudates or necrotic tissue surrounded by an enhancing wall and osteomyelitis of involved bone.

Interventional procedures like:

- Fine needle aspiration cytology (FNAC) of fluid collection: To obtain material for microbial analysis,

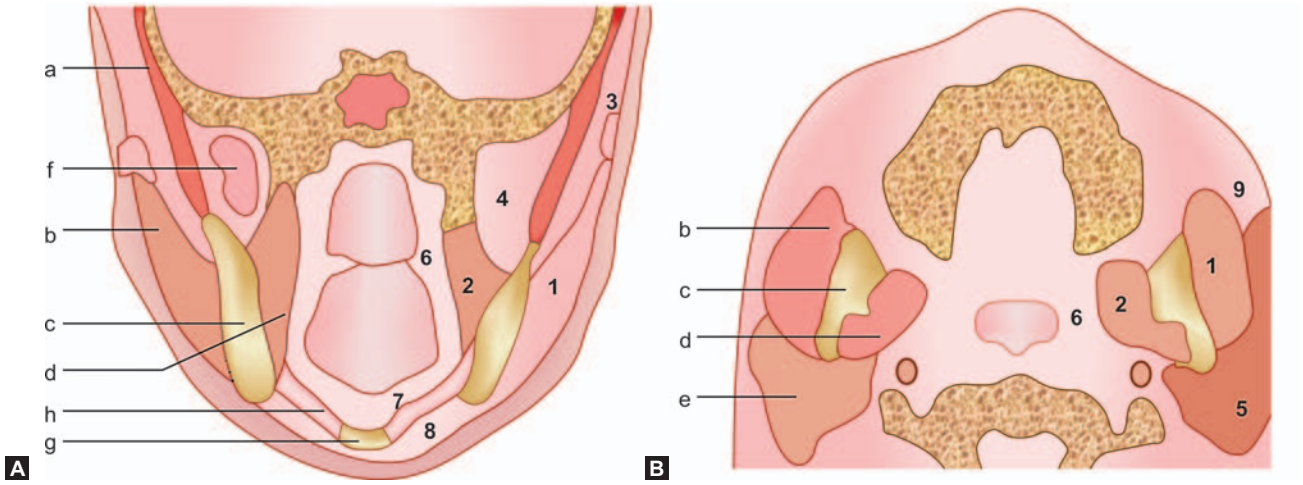
- Abscess drainage and drain placement can be done with CT guidance.

CT View of Various Spaces (Figs 42.6 and 42.7)

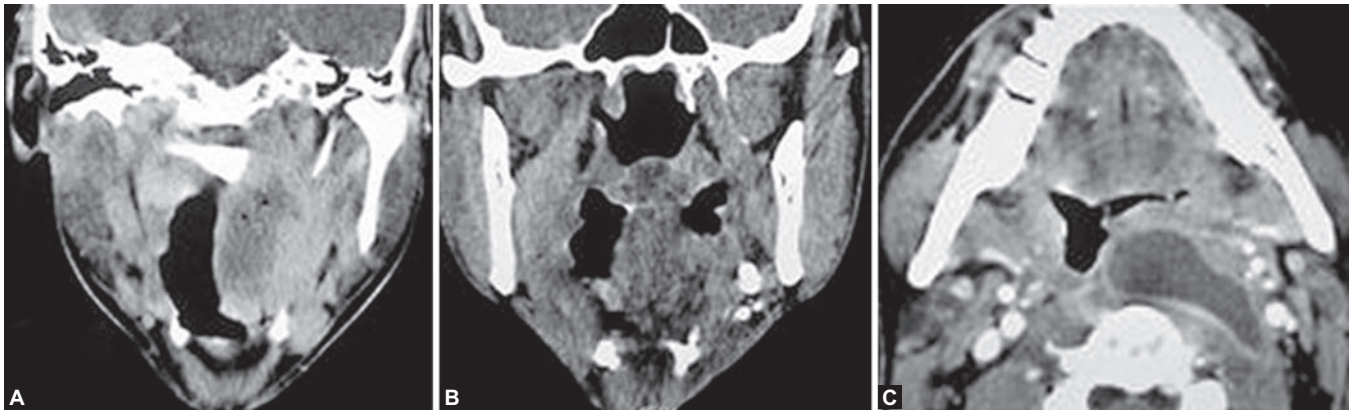
Submandibular Space

Normal View (Axial View)

- **Submandibular space proper:** The superficial lobe of submandibular gland appears as a well-defined soft tissue density, usually surrounded by a flat plane
- Submandibular group of lymph nodes, are homogenous nonenhancing appearance and never exceed 1.5 cm in diameter.
- Deep lobe of submandibular salivary gland is not well defined in axial view, since its CT density is close to that of adjacent soft tissues of the floor of the mouth; but it can be identified by coronal section.
- Mylohyoid muscle appears as a band of soft tissue density, through its origin, adjacent to the medial aspect of mandible. (On coronal section, it appears as a coronal sling extending between the medial aspect of hemimandible).
- Genioglossus muscle appears as a paramedian muscular band separated by a low density vertical cleft or midline lingual septum. In the inflammatory processes, there is loss of soft tissue plane of submandibular space.



Figs 42.6A and B: CT scan anatomy of fascial spaces—masticatory space: (A) Coronal image; (B) Axial image [(1) Masseteric region, (2) Medial pterygoid region, (3) Superficial temporal region, (4) Deep temporal region, (5) Parotid space, (6) Parapharyngeal space, (7) Sublingual space, (8) Submandibular space, (9) Adipose tissue lateral to the masseter muscle: (a) Temporalis muscle, (b) Masseter muscle, (c) Mandible, (d) Medial pterygoid muscle, (e) Parotid gland, (f) Lateral pterygoid muscle, (g) Hyoid bone, (h) Mylohyoid muscle]



Figs 42.7A to C: (A and B) Coronal computed tomography (CT) scan showing involvement of lateral parapharyngeal space; (C) Axial image also showing the involvement of lateral parapharyngeal space

Lower axial CT scan, a low density area between the mandible and mylohyoid muscle represents submandibular space. In coronal view, submandibular space is seen between medial aspect of mandible and mylohyoid muscle.

Sublingual Space

Low density area between the paramidline, genioglossus muscle medially and mylohyoid muscle and medial surface of mandible laterally. Lingual blood vessel, a very important landmark, clearly seen with IV contrast. Hyoglossus, styloglossus muscle complex, appears as a thin curvilinear muscle complex medially.

On axial CT, through inferior mandible, the anterior belly of digastric is seen in digastric fossa in the undersurface of anterior mandible.

Axial CT below the level of mandible, shows paired anterior bellies of digastric below the subcutaneous tissue of neck extending between anterior mandible and greater cornu of hyoid bone.

Masticatory Spaces

It is a distinct deep facial region, bounded by layers of deep cervical fascia. This fascia provides early barrier to spread of infections. Once the fascial boundaries are breached, masticator space infection leads to complex drainage problem.

Patients with masticator space infection are difficult to examine clinically because of accompanying trismus.

CT can be recommended in case of clinically suspected masticator space infection.

CT can demonstrate:

- The presence of only inflammatory change with no focal pus (cellulitis) precluding surgical drainage
- The presence of osteomyelitis, necessitating subperiosteal drainage
- Involvement of multiple spaces, besides masticator space, requires more extensive drainage procedure
- Presence of pus confined to masticator space, permitting intraoral drainage.

General Principles of Therapy for the Management of Acute Extensive Orofacial Infection

The management of acute odontogenic/orofacial infection comprises of:

- Immediate hospitalization
- Aggressive medical treatment (supportive treatment along with antibiotic therapy)
- Aggressive surgical intervention (including intubation and tracheostomy) should be done.

Surgical management: It consists of (i) extraction of the offending tooth or teeth, (ii) incision and drainage or a (iii) combination of both.

Antibiotic Therapy

Recent reports have shown, that on the basis of the recent changes in the antibiotic sensitivity patterns of the most frequent pathogens of orofacial infections, penicillin may no longer be the empiric antibiotic of choice for serious cases requiring hospitalization. Many recent studies, in outpatients, however, have confirmed that there is no difference in ultimate therapeutic success between penicillin and clindamycin, amoxicillin, with or without clavulanic acid and cephradine.

Indications for use of Antibiotics

- Acute onset of infection,
- Diffuse infections,
- Compromised host defenses,
- Involvement of fascial spaces,
- Severe pericoronitis, and
- Osteomyelitis.

Selection of antibiotics: For treating odontogenic infections the selection of antibiotics is done on the basis of the following:

- In case, there are no exudates available for culture and antibiotic sensitivity of organism(s) involved before initial therapy, then the initial selection is made on empiric basis.
- When pus is present, a smear can be Gram stained to provide the basis for a presumptive diagnosis and selection of antibiotic.

In general, bactericidal antibiotics should be preferred to bacteriostatic antibiotics; as these can independently destroy the invading organisms. On the other hand, bacteriostatic antibiotics, only prevent multiplication of bacteria; and depend on host's defense mechanisms for eradication of organisms.

Spectrum: It is preferable to use antibiotic with the narrowest spectrum, which are effective against the organisms involved in the infection. The use of a broad spectrum antibiotic should be avoided; as (i) it increases risk of development of resistant microbial strains; and (ii) also increases risk of superinfections, by disrupting the normal bacterial flora in various body cavities; and permits nonpathogenic bacteria to proliferate and cause disease.

Supportive therapy: It involves those modalities which aid in the patient's own body defenses. It consists of the following: (i) administration of antibiotics, (ii) hydration of patient through IV route, (iii) maintain adequate nutritional status—high protein intake through Ryle's tube feeding, (iv) analgesic, (v) bed rest, (vi) application of heat in the form of moist pack and/or mouth rinses, (vii) opening the tooth for drainage.

Principles of Surgical Management

Determination of severity of infection: It is necessary to do a thorough examination of a patient with severe infection, such as evaluation of the airway in the form of difficulty in breathing, swallowing, speaking, or handling secretions, etc. A change in quality of voice indicates a swelling in or near glottis, such as in parapharyngeal spaces (both lateral and retropharyngeal), or epiglottis. Other findings that may be obscured are as follows, which are usually indicative of parapharyngeal infection:

- Occasionally, the patient may exhibit an abnormal head posture, or a lateral deviation of head, in an attempt to position upper airway over the deviated trachea, as in a lateral pharyngeal space infection.
- In case of increased upper airway resistance, the patient may use the accessory muscles of respiration such as platysma and intercostals.

Ability to protrude the tongue past the vermilion border of the upper lip is a fairly reliable sign that the sublingual space is not severely involved.

Determination of the anatomical location of infection: It is necessary to determine the precise location and involvement of different oral, fascial and cervical swelling associated with each of the superficial and deep fascial spaces involved.

Evaluation of the host defenses: The most common diseases that compromise immune system are as follows (Flynn 2000):

- Diabetes Mellitus
- Steroid therapy within the past 2 years:
  - Asthma
  - Autoimmune or inflammatory disease
  - Organ transplant therapy
- Cancer chemotherapy within the past year
- Renal dialysis
- Human immunodeficiency virus (HIV) seropositivity
- Primary immunodeficiencies
  - Wiskott-Aldrich syndrome
  - Fanconi's syndrome
  - Agammaglobulinemia
  - Agranulocytosis

It is important for the surgeon to recognize the situation of immune compromise in patient with orofacial infection and modify the treatment accordingly. Some of the modifications include—use of bactericidal antibiotics, such as β-lactams, high doses of clindamycin, metronidazole, vancomycin, and aminoglycosides. The antibiotics to be avoided in immunocompromised patients include—macrolides and tetracyclines.

Decision on the setting of care: The following criteria justify hospital admission of patient with orofacial infection (Flynn 2000)—(1) fever over 101°F, (2) dehydration, (3) Impending airway compromise, (4) threat to vital structures, (5) infection of deep cervical space or masticator space, (6) need for general anesthesia, and (7) need for inpatient control of systemic disease.

Anesthetic implications: The cases of trismus, where the interincisal opening is less than 30 mm, are reported to be associated with a significant increase in likelihood of difficult intubation (Frerk 1991). The surgeon can use this guideline in communicating with anesthesiologist and discuss the hindrance to access to instrumentation of airway. Other studies reported that trismus, because of infection may relax under general anesthesia (Loughman and Allen 1985). The ratchet type mouth prop is very useful to open the mouth during intubation procedures.

Another commonly available method for determining adequacy of respiratory function in infected patient is pulse oximeter. A patient with no pulmonary disease, where the O_2 saturation is below 96% in room air, which declines over a period of time and rises again with administration of O_2; is indicative of compromised airway, which requires immediate attention.

Secure the airway: The first step in the management of such a patient is to secure the airway. The commonly used airway management techniques appropriate for the infected patient are as follows (Flynn 2000):

- Tracheotomy under local anesthesia
- Cricothyroidotomy under local anesthesia
- Fiberoptic intubation
- Blind awake intubation
- Bullard laryngoscopic intubation
- Transtracheal jet ventilation
- Inhalation induction with asleep intubation.

The techniques have their advantages and disadvantages; and should be appropriate for individual infected patient.

Needle decompression (Figs 42.8A to D): A simple useful technique, which is helpful to prevent aspiration of infected material, is "needle decompression" of abscess before intubation. This technique is especially appropriate in cases of pterygomandibular, peritonsillar, or lateral pharyngeal abscess that has thinned the distended overlying mucosa that is likely to rupture during passage of endotracheal tube.

Advantages

- It reduces the likelihood of sudden discharge of large amounts of pus into the airway.
- It redirects the flow of pus intraorally or extraorally, where it can readily be suctioned.
- It also allows immediate submission of an appropriate culture specimen, especially, if the puncture site has previously been prepared with antiseptic solution.

Disadvantages

- Discomfort to the patient.
- Bleeding from the site of puncture.

Surgical drainage: Some authors advocate that drainage of all spaces involved by cellulitis or abscess caused by odontogenic infection, should be done, as soon as possible after diagnosis.

The rationale for the more aggressive approach includes the following, however, final resolution requires further investigations:

- It is impossible to diagnose deep space infections either by clinical or radiological examination with 100% accuracy.
- Drainage of cellulitis seems to abort the spread of infection into neighboring deep fascial spaces.
- Adequate culture specimen can be obtained from cellulitis fluid.
- Physical debridement and irrigation of infected space may hasten healing by decreasing the size of bacterial inoculum and the amount of necrotic tissue present.
- Early drainage may prevent later colonization of the site by more highly antibiotic resistant microorganisms.
- Length of stay in the hospital may be decreased.

Guidelines for placement of incisions in infected cases:

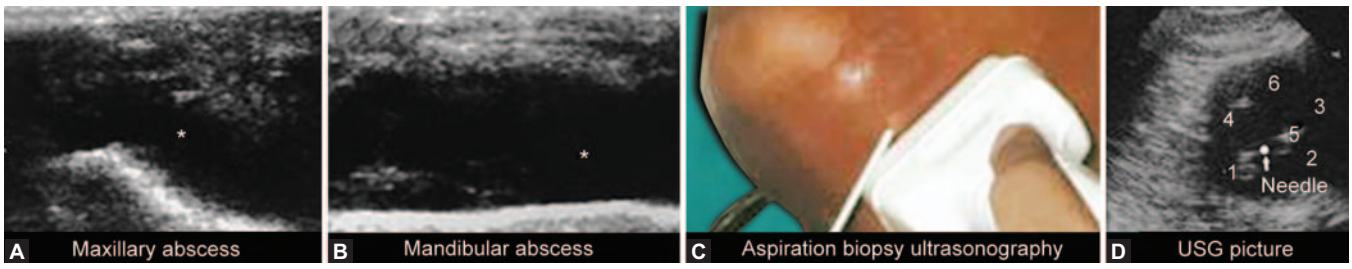
- Incisions should be placed in the most dependent areas.
- Incisions should be parallel to the skin creases.
- Incisions should lie in an esthetically acceptable site as far as possible.
- Incisions should be supported by healthy underlying dermis and subcutaneous tissue.
  Placing the incision through the thin, often shiny skin directly overlying the abscess, which normally gets undermined by an abscess burrowing its way to the surface; results in a puckered contracted scar which gets collapsed into abscess cavity.
- Incisions placed intraorally, should not crossfrenal attachments, and should be placed parallel to nerve fibers in the region of mental nerve.
- The removal of the cause; such as an infected tooth, a segment of necrotic bone, a foreign body, if not already done, then should be done at the time of incision and drainage procedure.

CT-guided percutaneous drainage: This technique employs a CT-guided catheter to drain well localized abscess. It is indicated for deep neck abscesses.

It is introduced percutaneously and guided into the abscess cavity. Its advantage is that it helps in precise locating the abscess cavity without extensive dissection and minimizes scarring. It is performed in a radiology department.

After performing incision and drainage, a specimen is obtained for Gram staining and culture; and the catheter may be left *in situ*, to serve as a drain.

Extraction of tooth in the presence of acute abscess: This is a controversial subject. One school of thought believes



Figs 42.8A to D: Needle decompression of an abscess using ultrasonography (USG) guided needle aspiration method: (A and B) Confirmation of maxillary and mandibular abscess formation through ultrasonography. Well-defined hypoechoic zones are noted; (C and D) USG guided needle aspiration helps in proper localization of pus, its volume and depth from the skin, 14–18 gauge cannula is used to collect the pus and decompress the abscess. Pus is sent for culture and antibiotic sensitivity test

that there is potential spread of infection by manipulation of tooth during extraction. The other school of thought challenges this view and believes that early extraction leads to early resolution of infection by eliminating the source of infection and by providing a portal of drainage.

There are numerous studies reported in this regard; which suggest that immediate extraction of offending teeth does not cause dissemination of infection; and may result in lesser postoperative complications than later extractions. However, these studies are not conclusive. It is worthwhile considering administration of antibiotics prior to carrying out extraction of offending tooth during acute stage of infection.

Medical supportive therapy: The ultimate success of the surgical and antibiotic therapy for serious orofacial infections depends upon adequate control of systemic diseases that may affect the host's resistance mechanism. The most common serious immunocompromising disease is diabetes mellitus, especially the insulin-dependent type. A good control of blood sugar level has been shown to affect host's resistance favorably.

Presence of fever in a serious infection increases patient's metabolic requirements and fluid needs significantly. The minimal daily fluid requirements are increased by 300 mL per degree of fever per day. Similarly, caloric requirements are increased by 5–8% per degree of fever per day. In order to meet these fluid requirements, an intravenous infusion of 100 mL per hour should be maintained; to meet the basic fluid needs, and in addition, replacement for the increased fluid losses, because of fever and diarrhea or any other unusual fluid losses. Hypotonic IV solutions, such as one fourth or one half normal saline (NS) with or without dextrose are suggested in order to provide excess free water to replace insensible losses. In case, oral intake has been impaired, by pain, swelling, drains, endotracheal intubation, parenteral nutrition may be required to be given. During prolonged hospital stays, it may be necessary to monitor patient's electrolyte balance, and provide additional supplements if necessary. This is more important in cases of necrotizing fasciitis, where hypocalcemia may be caused by sequestration of calcium ions in necrotic fat molecules.

Review and re-evaluation in the postoperative period: The review of the patient in the postoperative period can be divided into two stages:

- *Early postoperative phase:* The patient is reviewed for—(i) maintenance of airway, patency and extubation, and (ii) monitoring local and systemic signs of recovery
- *Late postoperative phase:* It includes: (i) Effectiveness of antibiotic therapy. (ii) Care of the surgical wound. In infected patients, it includes frequent wound irrigation and change of dressings, and removal of drain.

The swelling normally decreases by 48–72 hours postoperatively, allowing for a temporary rise in swelling because of surgical trauma. Trismus and WBC count, usually tend to reduce by 24–48 hours after surgery. The degree of malaise is supposed to be the earliest and the sensitive systemic indicator. Hence, when the patient feels simply better, it is a good sign.

A review of the case does not show any improvement by 48–72 hours postoperatively, then a re-evaluation should be done for the following:

- Effectiveness of the wound drainage,
- Antibiotic therapy, and
- A search for a previously undetected source of infection.

Postoperative CT examination has been very useful in identifying the adequacy of surgical drainage.

The criteria for changing antibiotics in the postoperative period are as follows:

- Development of allergy or toxicity.
- Clinical deterioration after 48 hours of antibiotic therapy, if: (a) repeat surgery has been done, or (b) postoperative CT demonstrates adequate surgical drainage.
- Culture and sensitivity or Gram stain indicating resistant microorganisms.
- Necrotizing fasciitis (use broad spectrum antibiotics).

Rehabilitation: The patient can be discharged from the hospital after having an afebrile period of 24 hours or more, and be able to consume at least adequate amount of liquid diet. Usually all the drains have to be removed prior to the discharge of the patient from the hospital. The outpatient follow up interval should be frequent at first. A deep seated infection, sometimes may resume draining after having stopped before discharge. This may be an indication of resistant organisms. In the absence of worsening signs of infection, this may be treated successfully with a change of antibiotic, especially a broader-spectrum antibiotic. Physiotherapy for trismus should be gentle, to avoid tearing of inflamed masticatory muscles. Encourage the patient to seek immediate and regular preventive and restorative dental care.

POTENTIAL SPACES

Odontogenic infections are frequently encountered in the practice of oral and maxillofacial surgery. Many of these infections can be managed by tooth extraction, endodontic therapy, surgical treatment, including drainage with

adequate antibiotic coverage. These infections often respond to surgical and antimicrobial management, however, they have the potential to spread through the fascial planes in the head and neck region to compromise vital structures in the region or involve distant structures. The perusal of literature shows numerous reports of odontogenic infections involving intracranial structures, the orbit, and the mediastinum.

The more commonly involved region is the airway. Airway compromise can occur either at presentation or secondary to postsurgical edema. If prompt treatment is not instituted with immediate recognition of the situation, it can lead to life-threatening episode and even death. Fortunately, new antibiotics and diagnostic techniques have reduced the morbidity and mortality of infection in the head and neck dramatically. Whenever, confronted with an acute, life-threatening condition due to maxillofacial infection, one must adhere to sound surgical principles and protocols for its management.

Shapiro defined fascial spaces as potential spaces between the layers of fascia. These spaces are normally filled with loose connective tissues and various anatomical structures like veins, arteries, glands, lymph nodes, etc. (The word "space" is a misnomer. There are no voids in the tissues in actual reality).

Organization of Cervical Fascia (Fig. 42.9)

- Superficial fascia
- Deep fascia:
  - Superficial layer (anterior)
  - Pretracheal fascia (middle layer)
  - Prevertebral fascia (posterior deep layer).

Pus tends to accumulate in these specific regions which are referred to as tissue spaces; none of which are actual spaces until pus is formed. Some of these *potential spaces* are compartments which contain structures such as submandibular salivary glands, the buccal pad of fat or groups of lymph nodes. Normally, these structures are surrounded by loose connective tissue, which can easily be stripped by finger pressure to produce a cavity. The pus destroys the loose connective tissue and separates the anatomical boundaries of the compartment as it increases in volume, thus leads to creation of an abscess cavity bounded by muscle, tissues and bone.

The anatomical spaces around the jaws where pus tends to accumulate: The infection in orofacial region, does not spread haphazardly through the loose connective tissue, but tends to accumulate in these potential spaces around

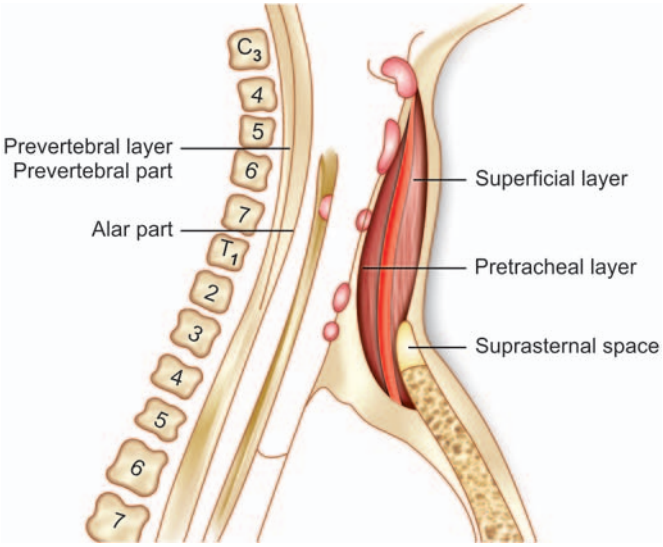


Fig. 42.9: Cervical organization of fascial layers of the deep fascia

the jaws. The detailed knowledge of their surgical anatomy, mainly the boundaries, and the related anatomical structures is important, as it facilitates planning of proper surgical drainage. Many of these spaces communicate with each other.

Pus, once collected, penetrates the fascial and muscle barriers, and eventually reaches the overlying skin.

A muscle is attached to bone by Sharpey's fibers, the attachment is mostly strong and tendinous, but the muscle, may be, in part attached mainly to the periosteum so that it and the periosteum together are readily stripped from the surface of the bone. Here again, a potential space exists deep to the muscle, if infection gains access to this plane of cleavage. As pus gets accumulated, it elevates the periosteum from the bone to form an abscess cavity until its spread is limited by the more tendinous part of the muscle.

The narrow interval between muscles also contains a layer of loose connective tissue which permits independent movement of the layers. Here again pus can accumulate to produce an anatomically defined cavity.

Grodinsky and Holyoke in 1938, described these potential spaces as follows **(Figs 42.10 and 42.11)**:

- **Space 1:** The potential space superficial and deep to the platysma muscle.
- **Space 2:** The space behind the anterior layer of deep cervical fascia.
- **Space 3:** Pretracheal space lies anterior to trachea. Pretracheal space infection leads to mediastinitis. Here,

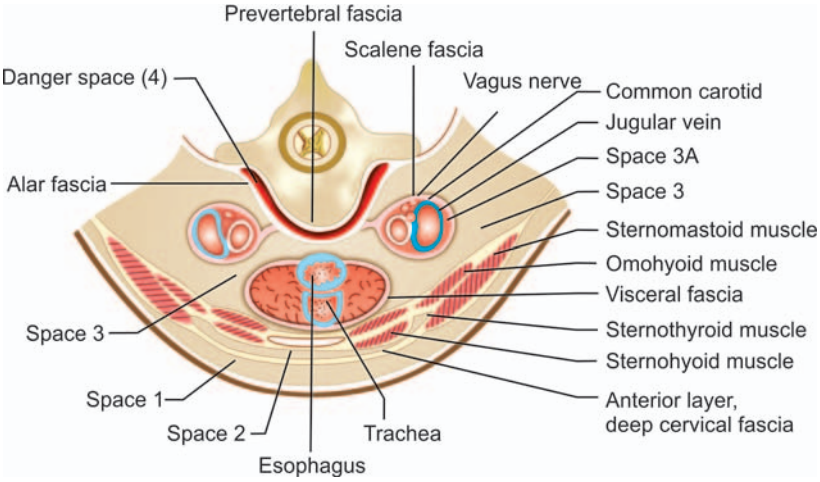


Fig. 42.10: Grodinsky and Holyoke's potential spaces

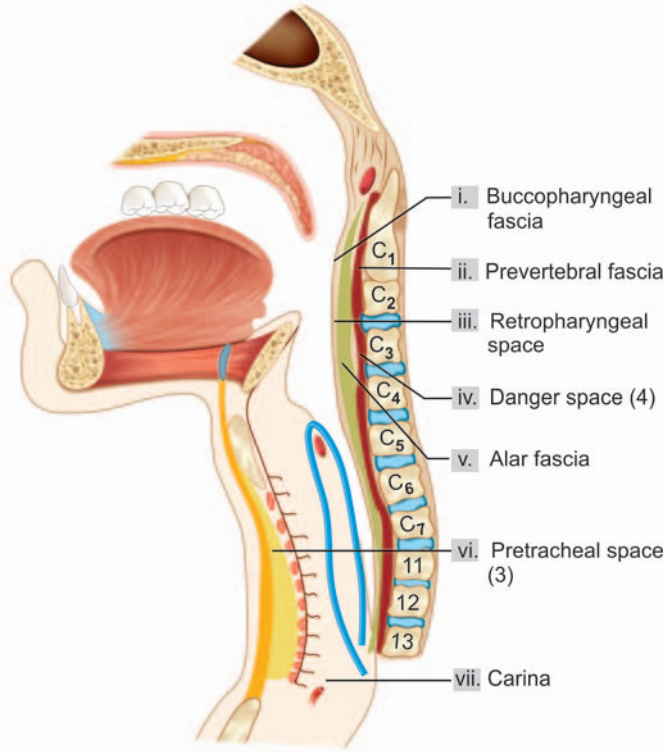


Fig. 42.11: Sagittal section of the neck showing spaces 3 and 4 and also the close proximity of retropharyngeal space to the danger space through the alar fascia [(i) Buccopharyngeal fascia, (ii) Prevertebral fascia, (iii) Retropharyngeal space, (iv) Danger space-4 (v) Alar fascia, (vi) Pretracheal space-3, (vii) Carina

the fascia fuses with the pericardium and the parietal pleura, which explains the occurrence of empyema and pericardial effusion in mediastinitis.

- **Space 3A:** Viscera-vascular space (*Lincoln's Highway* as coined by Mosher)—is the carotid sheath from the jugular foramen and carotid canal at the base of the skull to the pericardium or middle mediastinum. Infections in this space are usually associated with internal jugular vein thrombophlebitis or carotid artery erosion.
- **Space 4:** *Danger space* is a potential space between the alar and prevertebral fascia. It extends from the base of the skull to the posterior mediastinum, as far as the diaphragm. Oropharyngeal infections can enter the posterior mediastinum via the retropharyngeal space to the danger space, which is continuous with the posterior mediastinum. The spread of infection from the retropharyngeal space occurs mostly at the fusion of the alar and visceral fascia between C6 and T4 by rupturing through the alar fascia.

Space of Burns: Suprasternal Space (see Fig. 42.9)

The superficial fascia splits below the level of the hyoid bone to form two spaces:

1. It forms the lower part of the roof of the posterior triangle, the fascia splits into two layers, both of which are attached to the clavicle.
2. It forms the lower part of the roof of the anterior triangle and the fascia splits to form the suprasternal space or the space of "burns". The layers pass down to be attached one to the anterior, the other to the posterior border of the manubrium sterni.

Between these layers following structures are present:

- Sternal head of the sternocleidomastoid muscle

- The communication between the anterior jugular veins
- Lymph glands
- Interclavicular ligament.

CLASSIFICATION OF FASCIAL SPACES

Based on the Mode of Involvement

- **Direct involvement:** *Primary spaces*—(a) maxillary spaces (b) mandibular spaces.
- **Indirect involvement:** *Secondary spaces.*

Spaces involved in Odontogenic Infections

- **Primary maxillary spaces:** Canine, buccal, and infratemporal spaces.
- **Primary mandibular spaces:** Submental, buccal, submandibular, and sublingual spaces.
- **Secondary fascial spaces:** Masseteric, pterygomandibular, superficial and deep temporal, lateral pharyngeal, retropharyngeal, and prevertebral spaces, parotid space.

Based on Clinical Significance

- Face—buccal, canine, masticatory, parotid
- Suprahyoid—sublingual, submandibular (submaxillary, submental), pharyngomaxillary (lateral pharyngeal), peritonsillar
- Infrahyoid—anterovisceral (pretracheal)
- Spaces of total neck—retropharyngeal, space of carotid sheath.

Potential Primary Spaces Related to Upper Jaw

Upper Lip

An abscess occurring in upper incisors or canine region leads to infection of the base of upper lip.

The abscess is formed on the oral side of orbicularis oris muscle; and therefore, is a vestibular abscess, and tends to point in the vestibule. The direction is guided by the origin of orbicularis oris muscle, which is beneath anterior nasal spine. This results in pointing of the abscess towards the apex of lateral incisor. The abscess, rarely points in the floor of nose, where it can be mistaken for a boil of the nose. Involvement of upper lip on outer surface of orbicularis oris muscle occurs due to skin infections, such as, furuncle.

Infections, in the area of upper lip, incisors and canine, may give rise to orbital cellulitis, or cavernous sinus thrombophlebitis. The path taken by infection is from superior labial venous plexus to anterior facial vein; then in a retrograde direction, via, ophthalmic veins to cavernous sinus. This pathway is facilitated because of absence of valves in these veins.

Treatment: The abscesses in the region of upper lip are treated in the following ways:

- Antibiotic therapy
- Incision and drainage
- Extraction of offending tooth/root canal treatment.

Differential Diagnosis of Swellings of Upper Lip

- **Trauma to upper lip:** Any trauma to upper lip can produce a considerable size of swelling.
- **Trauma to upper incisor:** Any trauma to upper incisors can produce swelling of upper lip. It starts to subside after 48 hours.
- **Hypersensitivity reactions**
  - Allergic swellings of upper lip may arise with local application of various substances from toothpaste to lipstick. The enlarged lip appears to be soft and nontender; and reduces in size with antihistaminics.
  - Other edematous swellings: (i) Merkerson-Rosenthal syndrome. This syndrome presents with swollen lip, fissured tongue and facial palsy.
    Biopsy of lip will reveal, noncaseating Langhan's giant cell granulomas, which if associated with neuropathy, is likely to be sarcoidosis; and if associated with granulomatous bowel disease, then it is Crohn's disease.
- **Cysts:** Cysts of jaws produce swelling in vestibule which extend and cause enlargement of upper lip; such as nasopalatine cyst or any odontogenic cyst in upper incisor region.
  Nasolabial cyst: It produces a prominent swelling in the region of nasolabial fold; as it lies against bone between ala of the nose and upper lip.
- **Neoplasms:** Occasionally, such tumors as pleomorphic adenoma or mucoepidermoid carcinoma may arise in labial tissues. These are usually firm in consistency.

Canine Fossa Involvement (Infraorbital Space)

- Odontogenic infections
- Nasal infections; less frequent.

Periapical abscess of cuspids, usually presents as labial sulcus swelling; and less commonly as palatal swelling. Periapical abscess, which discharges buccally from an upper canine or first premolar; may lead to accumulation of pus in the canine fossa, deep to muscles of facial expression moving upper lip.

Involvement: The teeth which frequently give rise to abscess in the area are the maxillary canines and premolars and sometimes the mesiobuccal root of first molars. The periapical abscess discharges buccally superior to the origin of the caninus muscle and pus accumulates in the canine fossa.

Surgical Anatomy

Boundaries (Fig. 42.12)

- **Superiorly:** Levator labii superioris alaque nasi, levator labii superioris, and zygomaticus minor muscles
- Inferiorly, caninus muscle
- Anteriorly, orbicularis oris
- Posteriorly, buccinator muscle
- Medially, anterolateral surface of maxilla.
- **Canine with short root:** Levator anguli oris takes origin from bone below the origin of levator anguli oris, (levator labii superioris), i.e. infraorbital foramen, and levator labii superiors, above foramen and overlaps the anguli oris. The pus from a periapical abscess will emerge and tends to point in upper buccal sulcus, as buccinator muscle has no attachment to bone anterior to first molar.
- **Canine with a long root:** The root apex in these cases is above the origin of canine muscle, but below the origin of the quadratus muscle. The pus from periapical abscess may emerge above the origin of levator anguli oris. In such situations, pus escapes to the space between levator labii superioris and levator labii superioris alaque nasi, containing the branches of the infraorbital nerve and blood vessels. The infection may finally spread anteriorly through the gap between the angular and infraorbital heads of the quadratus muscle and emerges under the skin just below the inner corner of the eye, or escape posteriorly between the infraorbital head and zygomatic head of the quadratus muscle, emerging under the skin, just below the outer corner of the eye.

Clinical Features (Figs 42.13 and 42.14)

- Swelling of cheek and upper lip (vestibular abscess).
- Obliteration of nasolabial fold (pus accumulates in canine fossa).
- Drooping of angle of the mouth.
- Edema of lower eyelid; it indicates pointing of abscess below medial corner
  - *Extraoral clinical features* —
    - *Early phase:* Usually on the first or second day, there is an inflammatory enlargement of the upper lip, and the angle of the mouth is seen to droop. There is obliteration of nasolabial fold and periorbital edema.
    - *Late phase:* This usually occurs on the second or the third day.
- Marked periorbital edema, forcing the eyelid to close.
- Redness and marked tenderness of the facial tissues.
- When the infection progresses to chronic stage, it may result in production of chronic fistula in the cleft area between the levator labii superioris alaque nasi, and zygomaticus minor muscles near the medial canthus of the eye.
  - *Intraoral features:* The offending tooth is mobile and is tender to percussion.

Incision and drainage: The approach to this area is through the mucosa of buccal vestibule in the region of lateral incisor and canine. A curved mosquito forceps is inserted superior to the attachment of caninus muscle, and the infraorbital space is entered. Pus is evacuated and a drain is inserted and is secured to one of the margins with a suture.

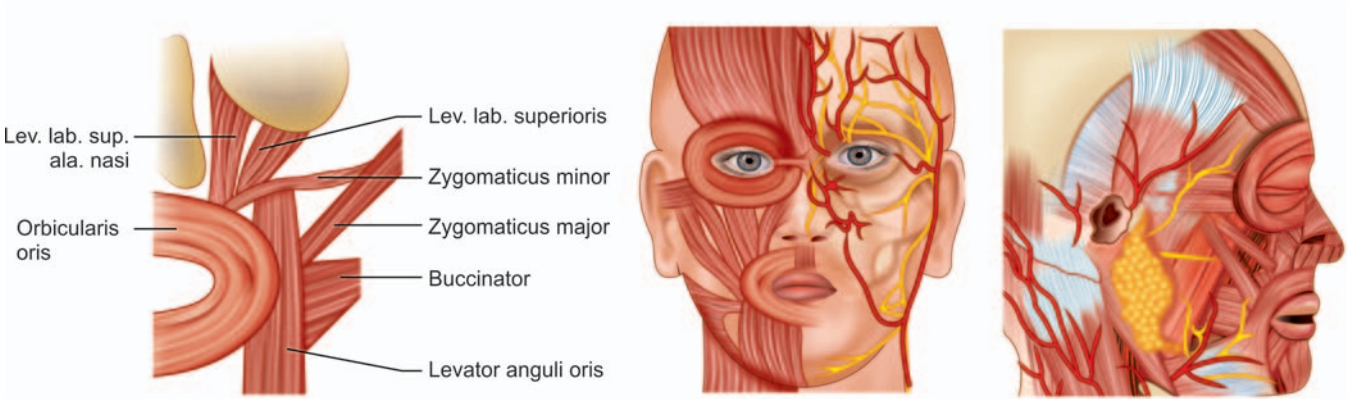
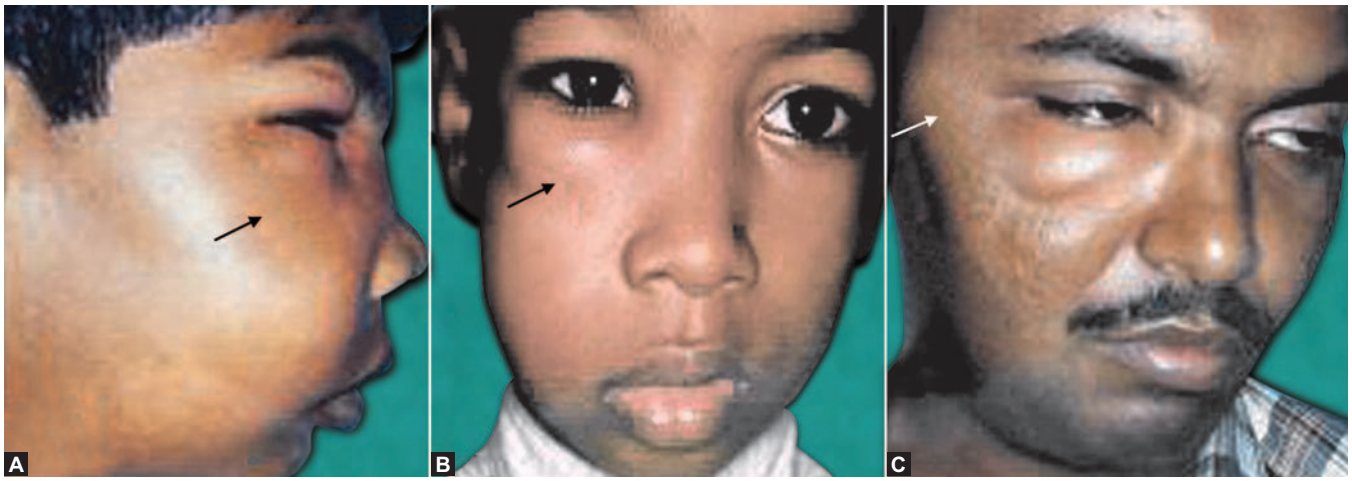


Fig. 42.12: Canine fossa space (infraorbital space) and its boundaries, anatomical pictures showing its vital relations



Figs 42.13A to D: Extraoral clinical pictures of canine fossa infection



Figs 42.14A to C: Infraorbital or canine fossa infection. Clinical extraoral pictures of three different patients—(A) Note the obliteration of nasolabial fold and infection tracking towards medial canthus of the eye; (B) Infection tracking towards lateral canthus of the eye; (C) Along with canine fossa infection, there is spread of infection in the infratemporal region (arrow)

Palatal Abscess (Figs 42.15A to D)

Involvement: Periodontal abscesses from palatal pockets and apical abscesses from the palatal roots of the posterior teeth are the source of palatal infection. Occasionally the lateral incisor is the frequent cause, as the infection can migrate posteriorly, as far as the soft palate owing to the more palatal orientation of its roots.

Surgical Anatomy

Boundaries: The palatal space is bounded by the cortical plate of hard palate inferiorly, and the overlying periosteum and mucosa superiorly; and laterally by the alveolar process of maxilla and the teeth.

Clinical Features

Intraorally, a well-defined circumscribed fluctuant swelling is seen, which is confined to one side of the palate, adjacent to the offending tooth. Discoloration may not be present. The offending tooth is tender to percussion.

Incision and Drainage

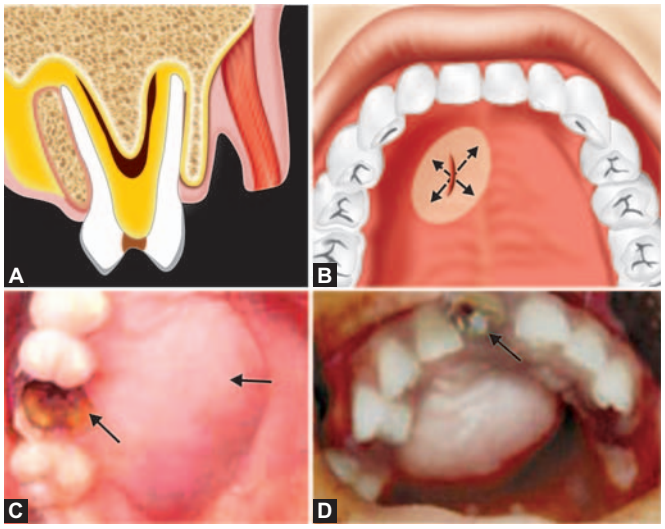
An AP incision is made through the mucosa, down to the bone, keeping in mind the course of greater palatine nerve and vessels. A curved mosquito forceps is inserted and the pus is evacuated. A small piece of rubber drain is inserted into the abscess cavity and secured with a suture.

Buccal Space Involvement (Figs 42.16 and 42.17)

Buccal space is the potential space between buccinator and masseter muscle.

Surgical Anatomy: Boundaries

- **Anteromedially:** Buccinator muscle
- **Posteromedially:** Masseter muscle overlying the anterior border of ramus of mandible



Figs 42.15A to D: Palatal subperiosteal abscess—(A) Periapical pathosis pathway to the palate, where the pressure of the accumulated pus elevates the thick mucoperiosteum; (B) Incision for a palatal subperiosteal abscess. The incision should be planned along the medial border of the swelling to avoid damage to the palatine arteries. Hemostat should be inserted along with the dotted arrows to drain the pus completely; (C) Clinical picture of palatal abscess. Note the offending tooth, which should be extracted or treated endodontically; (D) Clinical picture of another palatal abscess due to periapical lesion of right upper central incisor, which is being treated endodontically

- **Laterally:** Forward extension of deep fascia from the capsule of parotid gland and platysma muscle
- **Inferiorly:** Limited by the attachment of the deep fascia to the mandible and by depressor anguli oris
- **Superiorly:** The zygomatic process of the maxilla and the zygomaticus major and minor muscles.

Contents: Buccal pad of fat, Stenson's (parotid) duct, facial artery and vein.

Teeth commonly involved: Maxillary and mandibular premolars and molars. The location of the root tip to the level of origin of buccinator muscle determines the spread of infection either intraorally into the vestibule or deep into the buccal space. Pericoronitis in lower third molar—pus can travel forward along the channel formed by the muscle attached to the sloping external oblique ridge and the body of the mandible. In this case, pus pools intraorally opposite 1st or 2nd molars. If pus penetrates the muscle in the retromolar area, then it is directed laterally into the buccal space.

Clinical Features (Figs 42.18A to C)

When pus accumulates on oral side of the muscle—"Gum boil" is seen in the vestibule. If pus accumulates lateral to the muscle, prominent extraoral swelling is seen extending from lower border of mandible to the infraorbital margin and from the anterior margin of masseter muscle to the corner of mouth. Sometimes edema of the lower eyelid is seen.

Spread: Continuation with pterygomandibular space to infratemporal space along the fascia, accompanying the Stenson's duct. To submasseteric space—if infection tracks backwards and penetrates the paratidomasseteric fascia.

Incision and drainage: Horizontal incision through the oral mucosa of the cheek in the premolar, molar region. If the pus is lateral to the muscle, then the muscle is penetrated with curved mosquito forceps to enter the buccal space. Drain is placed and secured with suture.

Differential Diagnosis

- **Cellulitis:** It is caused by *Haemophilus influenzae*. It is usually seen in infants and children less than 3 years of age. Usually, there is high fever, for at least 24 hours prior to appearance of clinical manifestations.
- **Erysipelas:** There is rapid onset, dark red swelling, and associated otitis media frequently present.
- **Crohn's disease:** (Recurrent buccal space abscess) It is a segmental transmural intestinal disease. There is intermittent abdominal pain, fever, weight loss, and diarrhea. It is characterized by inflammatory granulomas present over entire length of gastrointestinal (GI) tract from mouth to anus. These granulomatous lesions and ulcerations can progress to the buccal space abscess.

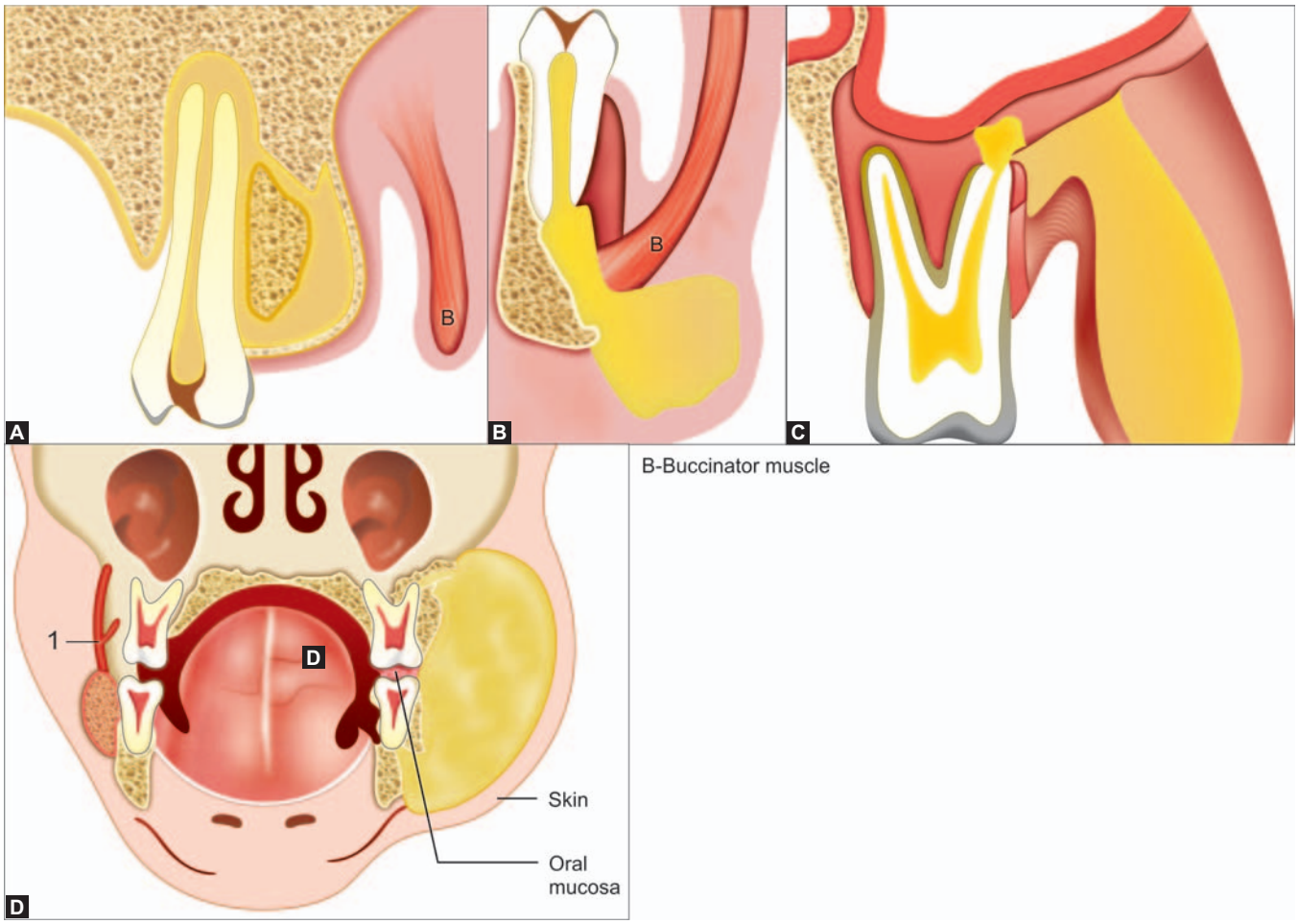
Infratemporal Fossa Space (Fig. 42.19)

It is also called "retrozygomatic space" by Sicher, as it is partly situated behind the zygomatic bone.

The space is continuous with upper part of pterygomandibular space anteriorly. However, it is separated from it by lateral pterygoid muscle posteriorly. Thus, the infratemporal fossa forms the upper extremity of pterygomandibular space.

Involvement

- Infections of the infratemporal space arise from the infection of the buccal roots of the maxillary second and third molars, particularly, from unerupted third molars, and



Figs 42.16A to D: Buccal space infection: (A) Infection below the buccinator muscle from upper teeth involves "buccal vestibule". Infection perforating the cortex above the muscle, involves "buccal space"; (B) Infection perforating the cortical plate below the buccinator muscle from lower teeth, involves "buccal space"; (C) Buccal abscess originating from periapical infection can break through the thin cortical bone over the apices, above the insertion of buccinator muscle. From here, the pus can move laterally and inferiorly between the buccinator muscle and the skin to the lower border of the mandible and beyond; (D) Involvement of buccal space due to periapical pathosis of upper and lower teeth

- Local anesthesia injections with contaminated needles in the area of tuberosity,
- Spread from the other spaces infection.

Surgical Anatomy

- **Boundaries**
  - Laterally, bounded by ramus of mandible, temporalis muscle and its tendon.
  - Medially, bounded by medial pterygoid plate, lateral pterygoid muscle, medial pterygoid muscle, lower part of temporal fossa of the skull and lateral wall of pharynx.
  - Superiorly, bounded by infratemporal surface of greater wing of sphenoid and by zygomatic arch.
  - Inferiorly, bounded by lateral pterygoid muscle, which forms the floor of the fossa, and its lower head is said to mark the border between pterygomandibular and infratemporal spaces.
  - Anteriorly, bounded by infratemporal surface of maxilla.
  - Posteriorly, bounded by parotid gland.
- **Contents:** The fossa contains origins of medial pterygoid and lateral pterygoid muscles. The lower head of lateral pterygoid muscle borders the pterygomandibular and



Figs 42.17A to E: Clinical picture of buccal space involvement



Figs 42.18A to C: (A) Periapical infection moving below the insertion of buccinator muscle, clinically exhibits as vestibular abscess or gum boil; (B) Periapical infection moving above the insertion of buccinator muscle, clinically seen on extraoral picture. Buccal space involvement is seen; (C) Intraoral clinical picture of the buccal space involvement by pus between the buccinator muscle and the skin and the oral mucosa

infratemporal spaces. It contains pterygoid venous plexus of veins. It is traversed by internal maxillary artery, mandibular nerve, and middle meningeal artery.

Clinical Features (Figs 42.20A to F)

- **Extraoral:** The following features are usually seen: (i) trismus—marked limitation of oral opening, (ii) bulging of temporalis muscle, (iii) marked swelling of the face on the affected side in front of the ear, overlying the area of the temporomandibular joint, behind the zygomatic process, (iv) the eye is often closed and is proptosed.
- **Intraoral:** Swelling in the tuberosity area. Elevation of body temperature up to 104°F.

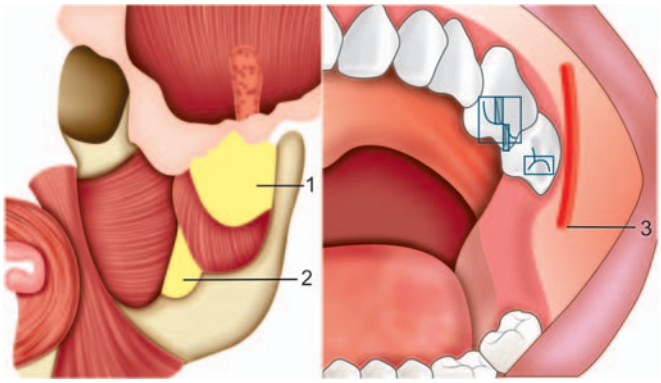


Fig. 42.19: Infratemporal fossa space [(1) Infratemporal space, (2) Buccal space, (3) Intraoral incision for the drainage of infratemporal space along the anterior border of ramus]

Incision and Drainage

- **Intraoral approach:** If the trismus is not marked, and fluctuation is detected early, an intraoral incision is given in the buccal vestibule opposite the second and third molars.
  The exploration is carried out medial to coronoid process and temporalis muscle upwards and backwards with a sinus forceps, or a curved hemostat. The space is entered, and drained; and a small piece of corrugated rubber drain is kept and secured to the mucosa with a suture.
- **Extraoral approach:** In severe intractable infection, extraoral incision is the only method of drainage. Incision is made at the upper and posterior edge of



Figs 42.20A to F: Clinical pictures of involvement of infratemporal space due to odontogenic infection

the temporalis muscle, within the hairline. A sinus forceps is then directed upwards and medially. Pus is evacuated; rubber drain is inserted and secured to the skin with a suture, and dressing is given.

Despite appropriate and prompt treatment, the condition takes long time to resolve. The restriction of mouth opening persists for long time over a few weeks, and improves in due course of time with active physiotherapy with jaw exercises. In case of failure to improve mouth opening, the following procedures are resorted to—(i) temporalis myotomy and (ii) excision of coronoid process.

Spread: Pus can extend upwards to involve the temporal space, or inferiorly it may perforate the lateral pterygoid muscle, to involve the pterygomandibular space.

Further, infection of infratemporal space should always be regarded as a serious event, because of the proximity of pterygoid plexus of veins, from which infection can track upwards to the cavernous sinus via: (i) deep facial veins, or (ii) emissary veins; and via other foramina directly from the infratemporal fossa to the middle cranial fossa. Emissary veins connect these with cavernous sinus through sphenoidal emissary foramen (E of Vesalius), foramen lacerum, foramen spinosum, and foramen ovale.

Thus, rarely, it may involve central nervous system; which is presented as headache, irritability, photophobia, vomiting, and drowsiness.

Potential Primary Spaces Related to Lower Jaw

Submental Space

Involvement

It is involved most frequently by the infections originating from the six anterior mandibular teeth; then perforate the cortical plate below the origin of mentalis muscle labially; and mylohyoid lingually.

The space can be secondarily involved due to infection of submental lymph nodes, following lymphatic spread from lower incisors, lower lip, skin overlying the chin, anterior part of the floor of the mouth, tip of the tongue and sublingual tissues.

Surgical Anatomy

- **Boundaries (Fig. 42.21)**
  - *Lateral:* Lower border of mandible, and anterior bellies of digastric muscle.
  - *Superior:* Mylohyoid muscle.
  - *Inferior:* Suprahyoid portion of the investing layer of deep cervical fascia, which is in turn covered by the platysma, superficial fascia and skin.
- **Contents:** Submental lymph nodes, and anterior jugular veins. The lymph nodes lie embedded in adipose tissue, and hence, submental abscesses tend to remain well circumscribed.

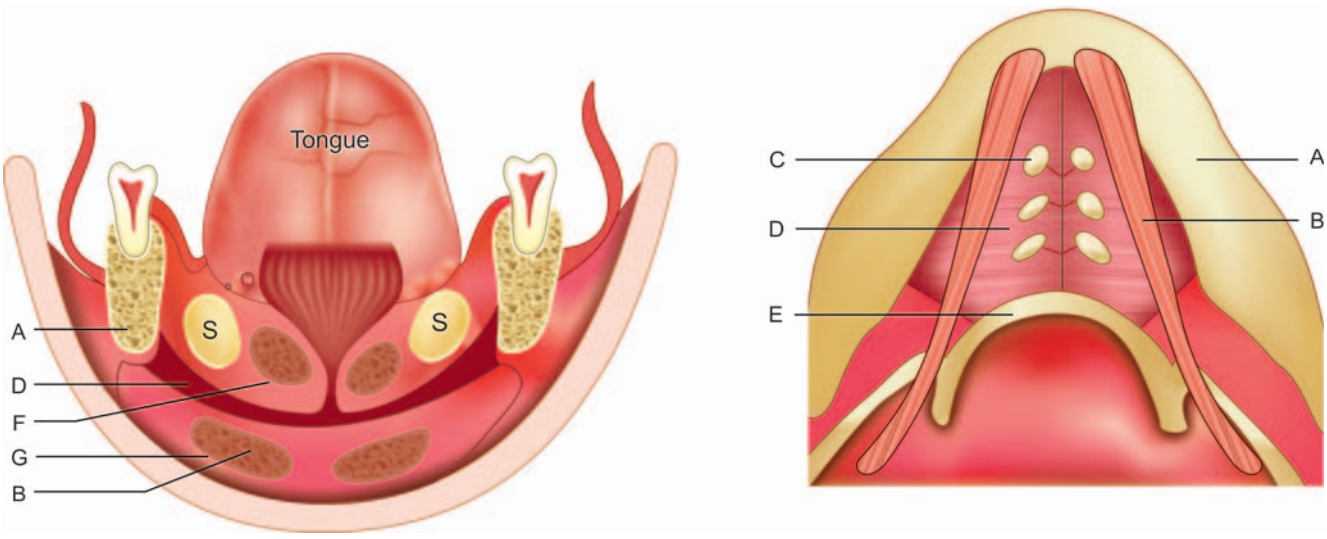


Fig. 42.21: Surgical anatomy diagram of submental space: (A) Mandible; (B) Anterior belly of digastric muscle; (C) Submental lymph nodes; (D) Mylohyoid muscle; (E) Hyoid bone; (F) Geniohyoid muscles; (G) Cervical fascia

Clinical Features (Figs 42.22 and 42.23)

- **Extraoral findings:** Distinct, firm swelling in midline, beneath the chin. Skin overlying the swelling is board-like and taut. Fluctuation may be present.
- **Intraoral findings:** The anterior teeth are either nonvital, fractured or carious. The offending tooth may exhibit tenderness to percussion and may show mobility. The patient may experience considerable discomfort on swallowing.

Incision and Drainage (Figs 42.23A and B)

It is performed by making a transverse incision in the skin below the symphysis of the mandible. Blunt dissection is carried out by inserting a Kelly's forceps or sinus forceps through this incision, upward and backward. A small piece of corrugated rubber drain is inserted in the abscess cavity, and is secured to one of the margins of the wound with a suture.



Fig. 42.22: Clinical extraoral picture of submental space involvement due to odontogenic infection

Spread

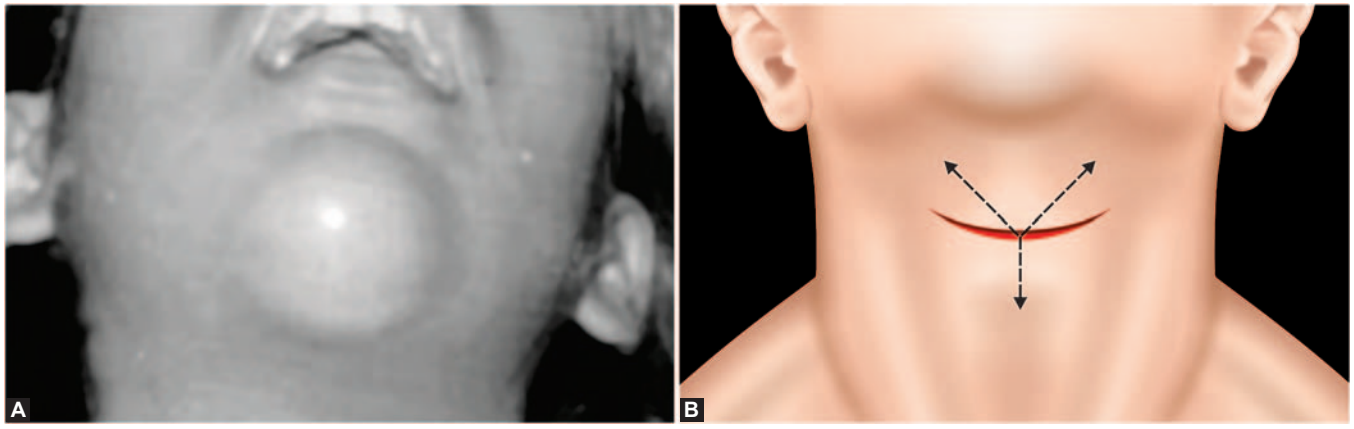
The infection can spread: (i) posteriorly, to involve submandibular space or (ii) it may discharge on the face, in the submental region.

Submandibular Space

The space lies between the anterior and posterior bellies of digastric muscles. The upper part lies beneath the inferior border of mandible and the lower part lies deep to the investing layer of deep cervical fascia. The submandibular spaces are considered to be the anterior extensions of parapharyngeal space.

Involvement

- It is involved most frequently by infections originating from the mandibular molars. The pus perforates the lingual cortical plate of mandible, inferior to the attachment of mylohyoid muscle, and passes directly into the submandibular space.
- The infection from the submandibular salivary gland may pass via lymphatics to the submandibular lymph nodes.
- It is also involved, as an extension of infection from submental space; or from the submental lymph nodes via the lymphatics; when the nodes fail to contain the infection within them.
- It is also involved by an infection originating from the posterior part of sublingual space.
- It is also involved from infection originating from middle third of the tongue, posterior part of the floor of the mouth,



Figs 42.23A and B: (A) Extraoral clinical picture of typical submental space infection due to lower anterior teeth periapical lesion; (B) Incision and drainage for submental space abscess

- Maxillary teeth,
- Cheek,
- Maxillary sinus and
- Palate.

Surgical Anatomy

Boundaries (Fig. 42.24)

- Anteromedially, the floor is formed by mylohyoid muscle, which is covered by loose areolar tissue and fat.
- Posteromedially, the floor is formed by hyoglossus muscle.
- Superolaterally, medial surface of mandible below the mylohyoid ridge.

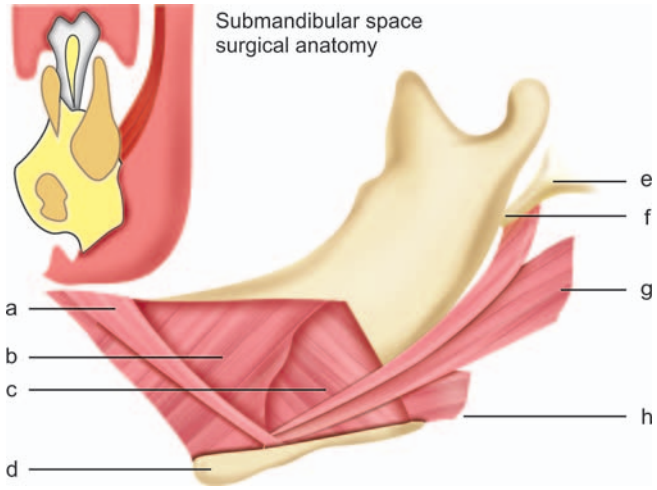


Fig. 42.24: Submandibular space: Surgical anatomy [(a) Anterior belly of digastric muscle, (b) Mylohyoid muscle, (c) Hyoglossus muscle, (d) Hyoid bone, (e) Styloid process and stylohyoid ligament, (f) Stylohyoid muscle, (g) Posterior belly of digastric muscle, (h) Middle constrictor of pharynx muscle]

- Anterosuperiorly, anterior belly of digastric.
- Posterosuperiorly, posterior belly of digastric, stylohyoid and the stylopharyngeus muscles.
- Laterally, platysma, superficial fascia and skin.

Contents

Superficial lobe of submandibular salivary gland and submandibular lymph nodes, facial artery and vein.

Clinical Features (Figs 42.25A and B)

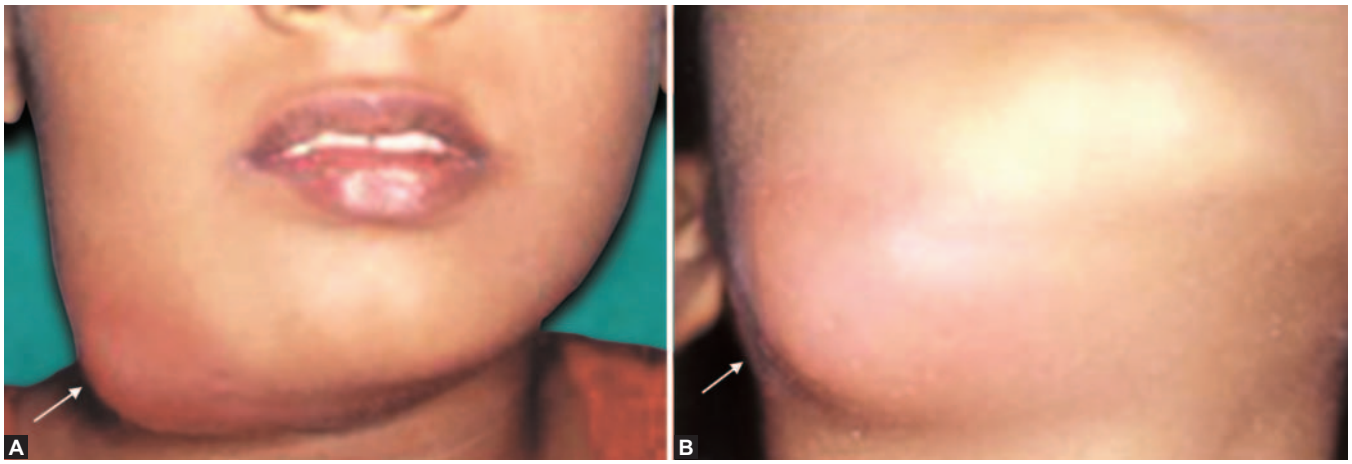
- **Extraoral:** (i) Firm swelling in submandibular region, below the inferior border of mandible, (ii) generalized constitutional symptoms, (iii) some degree of tenderness, (iv) redness of overlying skin.
- **Intraoral:** (i) Teeth are sensitive to percussion, (ii) teeth are mobile, (iii) dysphagia, and (iv) moderate trismus.

Incision and Drainage (Figs 42.26A and B)

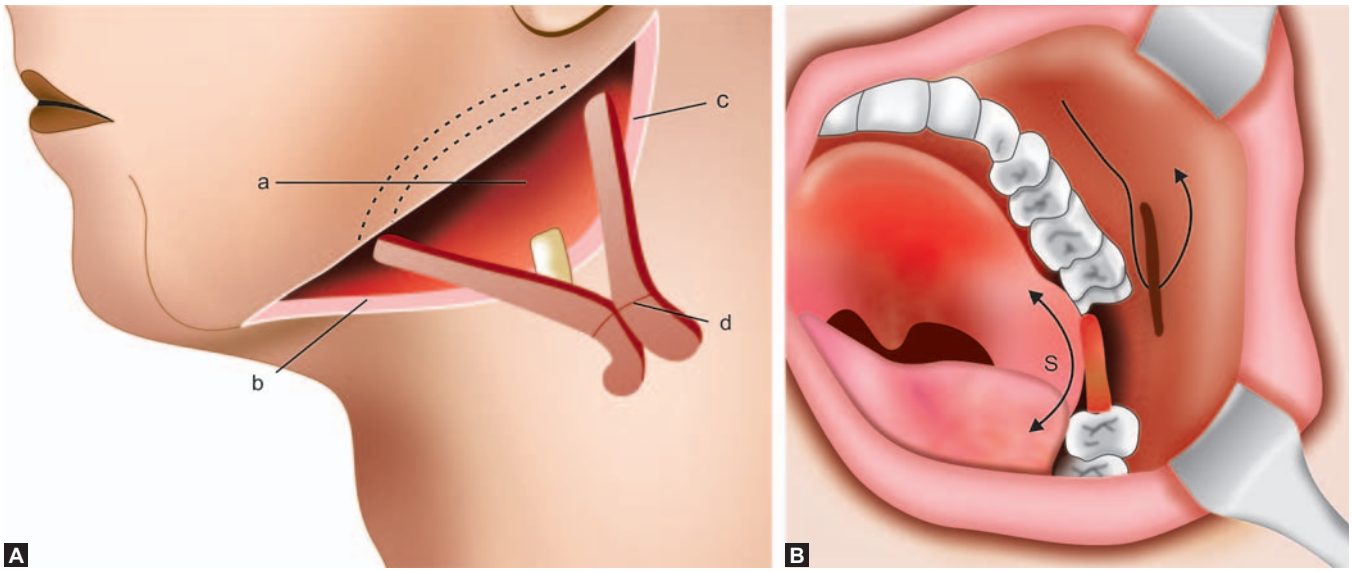
An incision of about 1.5–2 cm length is made 2 cm below the lower border of mandible, in the skin creases. Skin and subcutaneous tissues are incised. A sinus forceps is inserted through the incision superiorly and posteriorly on the lingual side of the mandible below the mylohyoid to release pus from submandibular space. A corrugated rubber drain is inserted in the abscess cavity and is secured with a suture and dressing is applied.

Spread

- There are no major anatomic barriers between the two submandibular and submental spaces. Hence, infection can extend into the submental space.
- There are no anatomical barriers, hence infection can spread and extend easily across the midline, and



Figs 42.25A and B: Extraoral clinical pictures of right side submandibular space involvement



Figs 42.26A and B: (A) Submandibular space extraoral drainage. The drains are inserted superiorly and medially to the inferior border of the mandible (a) Submandibular space swelling, (b) Anterior belly of digastric, (c) Posterior belly of digastric, (d) Rubber drains secured with suture; (B) Intraoral incision for drainage of submandibular space infection (Red). Black incision line is for infratemporal space

involve the submandibular space on the contralateral side.

- The submandibular space communicates with sublingual space around the posterior border of mylohyoid muscle **(Fig. 42.27)**.
- Infection can spread backwards to involve parapharyngeal spaces.
- The spread of infection can also be by direct continuity; and is influenced by the attachment of mylohyoid muscle, in relation to the level of root apices of mandibular teeth.

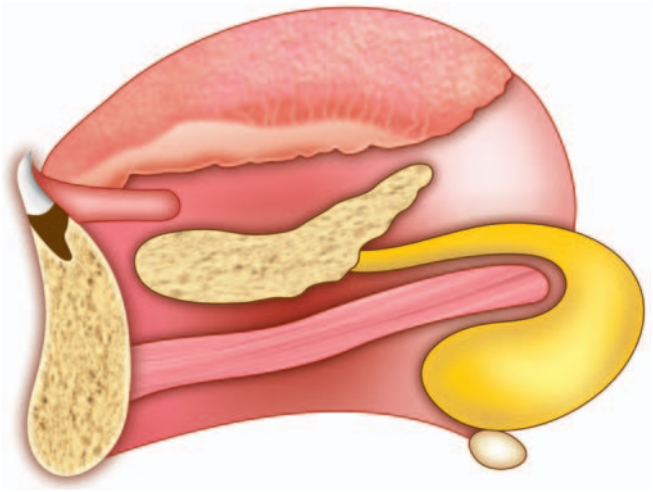


Fig. 42.27: Communication of submandibular space with sublingual space around the posterior border of mylohyoid muscle

Differential Diagnosis

- Secondary deposits of a malignant neoplasm.
- Lymphoma arising in the lymph nodes of upper neck. These may undergo necrosis and present as a fluctuant swelling.
- TB lymphadenitis.

Infiltration of surrounding tissues by neoplasms will produce swelling and induration resembling cellulitis. However, the redness of the overlying skin will be less marked as well as the degree of tenderness. Incision of the swelling, if carried out, will reveal fragments of the necrotic tissue with the liquefied neoplasm. In such cases biopsy will establish the diagnosis.

Sublingual Space

This space is a V-shaped trough lying lateral to muscles of tongue, including hyoglossus, genioglossus and geniohyoid.

Involvement

The teeth which frequently give rise to involvement of sublingual space are the mandibular incisors, canines, premolars and sometimes first molars. The apices of these teeth are superior to the mylohyoid muscle. The infection perforates lingual cortical plate below the level

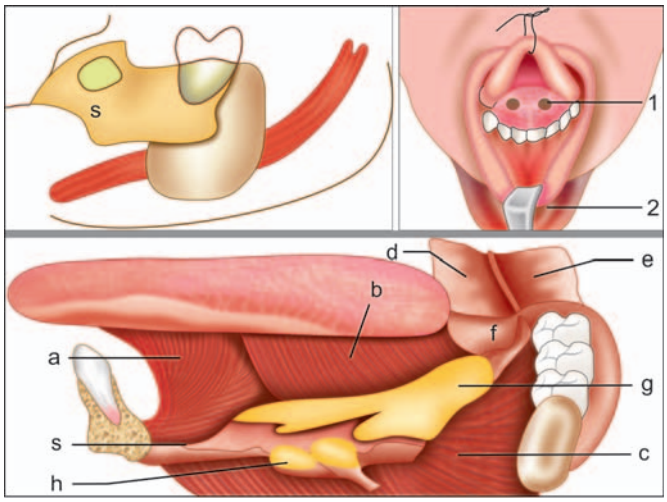


Fig. 42.28: Sublingual space anatomy [(a) genioglossus, (b) hyoglossus, (c) mylohyoid, (d) superior constrictor of pharynx, (e) buccinator, (f) styloglossus, (g) deep part of submandibular gland, (h) sublingual gland, (S) sublingual space, (1) Sublingual space infection intraoral swelling. (2) Submental swelling]

of the mucosa of the floor of the mouth and passes into the sublingual space.

It is a paired space; but the two sides communicate anteriorly. This space communicates with submandibular space around the posterior border of mylohyoid muscle.

Surgical Anatomy (Fig. 42.28)

Boundaries

It is covered

- *Superiorly:* Only by the mucosa of floor of the mouth
- *Inferiorly*: Mylohyoid muscle
- *Laterally*: Medial side of the mandible, above the mylohyoid muscle
- *Medially*: Hyoglossus, genioglossus and geniohyoid muscles
- *Posteriorly*: Hyoid bone
- *Laterally and inferiorly* by mylohyoid muscle and lingual side of mandible.

Contents

Major contents include: Geniohyoid and genioglossus muscles, and the hyoglossus muscle complex. It also contains (i) deep part of the submandibular salivary gland and its duct anteriorly, (ii) sublingual salivary gland, (iii) lingual nerve, and (iv) hypoglossal nerve.

Clinical Features (Figs 42.29A to G)

- **Extraoral:** There is little or no swelling. The lymph nodes may be enlarged and tender. Pain and discomfort on deglutition. Speech may be affected.
- **Intraoral:** Firm, painful swelling seen in the floor of the mouth on the affected side. The floor of the mouth is raised. The tongue may be pushed superiorly. This will bring about airway obstruction. The ability to protrude the tongue beyond the vermillion border of upper lip is affected.

Incision and Drainage (Fig. 42.30)

- **Intraorally:** An incision is made close to the lingual cortical plate, lateral to the sublingual plica, as the important structure at this site is the sublingual nerve which is deeply placed and less likely to be damaged by this approach. The other important structures lie medial to the plica and include the Wharton's duct, sublingual artery and veins and the lingual nerve. The sinus forceps is then inserted and opened to evacuate the pus.
- **Extraorally:** When both the submental and sublingual spaces contain pus, they can be drained via a skin incision placed in the submental region, pushing a closed sinus forceps through the mylohyoid muscle. Similarly, when the submandibular space is involved, a sublingual space abscess can be approached and drained through an incision in the skin overlying the submandibular space, via the submandibular space.

Spread

- Infection always crosses the midline, and can affect the space on the opposite side.
- Infection from the posteroinferior part of the space, can spread around the submandibular salivary gland into submandibular space, and again can spread posteriorly, via the tunnel under the superior constrictor for the styloglossus into the pterygomandibular and parapharyngeal spaces.
- Infection can also spread via the lymphatics to the submental or submandibular lymph nodes.
- The sublingual space is separated from the submental space by the mylohyoid muscle, which forms a complete diaphragm in the floor of the mouth. The spread to the submental region occurs most often as a



Figs 42.29A to G: (A to F) Extraoral clinical picture of right side submandibular, submental and sublingual space involvement; (G) Intraoral clinical picture of raised floor of the mouth, indicating involvement of sublingual space

result of lymphatic spread to submental lymph nodes. However, there are also, perforating arteries which pass through the mylohyoid to form anastomosis between sublingual and submandibular arteries which accompany the nerves to the mylohyoid. In some patients, infection can spread to the submental space through the apertures in the muscle formed by these perforating arteries.

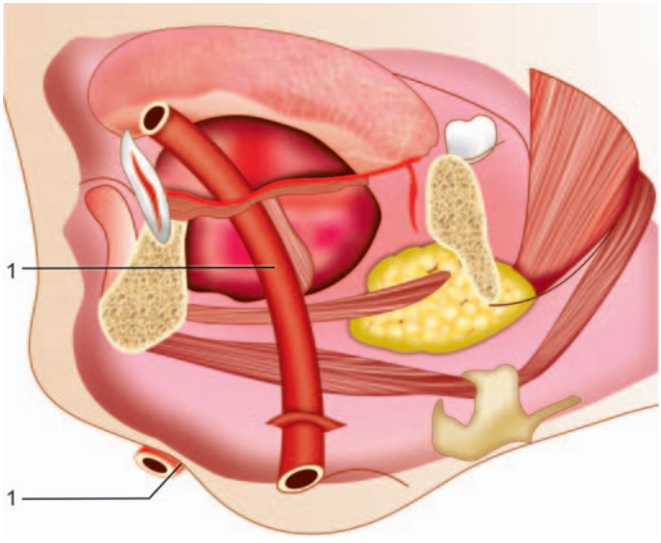


Fig. 42.30: Through and through intra- to extraoral drainage of a submental and sublingual space infection (1, bilateral through and through drains)

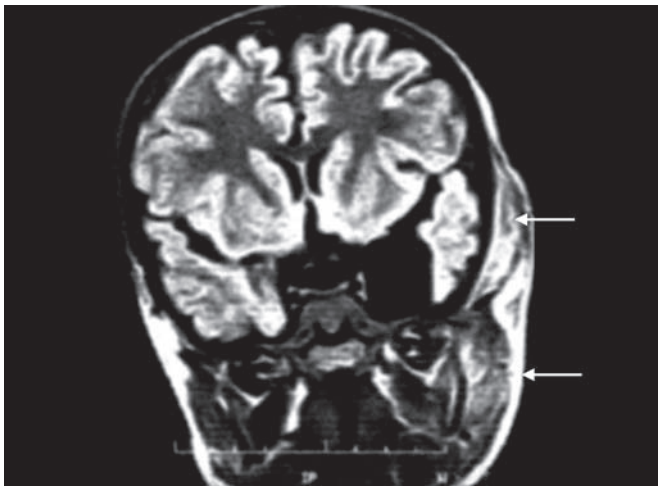


Fig. 42.31: An MRI (magnetic resonance imaging) scan of a 6-year-old child suffering from left side temporal abscess due to periapical pathology of lower left 2nd deciduous molar. Ascending infection is seen after involving the masticatory space (arrows)

Secondary Potential Fascial Spaces

Temporal Space (Fig. 42.31)

Involvement is secondary to the initial involvement of pterygopalatine and infratemporal spaces.

Surgical Anatomy

Temporal pouches are fascial spaces in relation to the temporalis muscle. They are two in number: (1) superficial temporal space and (2) deep temporal space. The superficial temporal pouch lies between the temporal fascia and temporalis muscle. The deep temporal pouch lies deep to the temporalis muscle and the skull. Below the level of zygomatic arch, superficial and deep temporal pouches communicate directly with the infratemporal and pterygopalatine fossae.

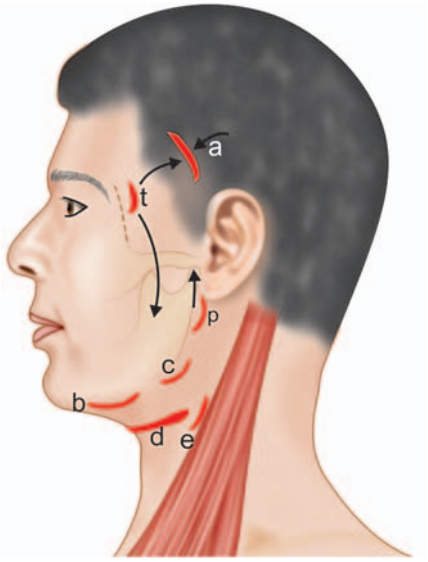


Fig. 42.32: Incisions for extraoral drainage of various deep fascial spaces infection: (a) Superficial or deep temporal, (b) Submental or submandibular, (c) Submandibular, submasseteric, or pterygomandibular, (d) Lateral pharyngeal and upper part of the retropharyngeal space, (e) Retropharyngeal space and carotid sheath, (t) Temporal space can be drained through this incision also, (p) Parotid abscess

Clinical Features

Pain and trismus are usually present. Swelling over temporal region may or may not be present.

Incision and Drainage (Fig. 42.32)

Extraoral incision in temporal region, well above the hairline, 45° to zygomatic arch. The hemostat is inserted above and below the temporalis muscle.

Parotid Space (Figs 42.33 and 42.34)

Involvement

- The infections are either blood-borne, or occur as retrograde infections through Stenson's duct.
- The gland is strongly attached to its fascial covering, i.e. parotid fascia, and there is very little intervening loose connective tissue. This makes extension of odontogenic infections into the parotid space usually very difficult.



Fig. 42.33: Parotid space abscess

- **Contiguity:** However, the gland is contiguous to submasseteric, pterygomandibular and lateral pharyngeal spaces; and on rare occasions the parotid space can be involved by an odontogenic infection from one of these spaces.

Surgical Anatomy

Boundaries

The space is formed by splitting of the superficial layer of deep cervical fascia surrounding the parotid gland, and lies posterior to the masticatory space.

Inferiorly: Stylomandibular ligament, which separates parotid space from the mandibular space.

Contents: Parotid gland and parotid lymph nodes, facial nerve, retromandibular vein, and external carotid artery.



Figs 42.34A to E: Parotid space involvement: (A) Lateral view of the face; (B) Front view showing involvement of right parotid space; (C) Intraoral view showing right cheek swelling and pus discharge from parotid duct; (D and E) Extraoral and intraoral views of left parotid space involvement in another patient

Clinical Features

- Severe pain, which may be referred to the ear; and is accentuated by eating. Because of the pain associated with eating, these patients do not consume adequate fluids, and hence, these patients may get severely dehydrated.
- Presence of swelling over the masseter muscle, extending from the level of zygomatic arch to the lower border of mandible. Anteriorly, it ends at the anterior border of ramus of the mandible, and posteriorly, it extends into the retromandibular region.
- Ear lobe seems to be everted or lifted up.
- There is escape of pus from the Stenson's duct, when the gland is milked.

Incision and drainage

The drainage requires an external approach. A retromandibular incision is used, because the pus is usually not in a single pool, but is located in numerous loculations within glandular parenchyma and exploration of a wider area is often necessary to evaluate all the sites involved. An incision is placed in the skin behind the posterior border of mandible extending from the level of the inferior aspect of the lobule of the ear to just above the mandible. A sinus forceps is inserted, and with blunt dissection the parotid fascia is reached. The exploration of various parts of the gland is accomplished with the forceps. A rubber drain is inserted and secured to the skin with a suture.

Spread

Communications between parotid space and submandibular space exist via anterior branches of posterior facial vein. Infection can spread to submasseteric, pterygomandibular and lateral pharyngeal spaces.

Masticatory Spaces (Figs 42.35 and 42.36)

Masticatory spaces comprise of the following spaces: (i) Pterygomandibular, (ii) Submasseteric, (iii) temporal-superficial temporal, and (iv) deep temporal or subtemporal spaces. All these spaces are well differentiated, and communicate with other fascial spaces; such as buccal, submandibular, and parapharyngeal spaces. Infection from one compartment, may spread to any of the other compartments. Amongst the muscles of mastication, only the outer surface of masseter and inner surface of medial pterygoid muscles are covered by true fascia.

Masticatory spaces are divided into two by the ramus of mandible:

- Lateral compartment
- Medial compartment.

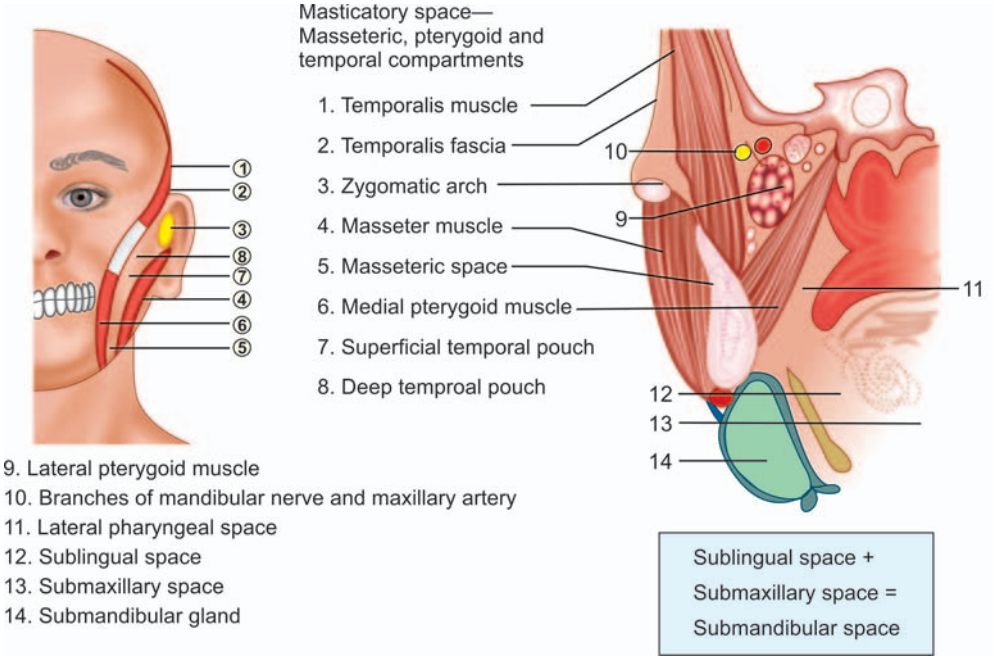


Fig. 42.35: Masticatory space surgical anatomy

Masticatory space is formed by splitting of investing fascia into superficial and deep layers; which define the lateral and medial extent of space. The superficial layer lies along lateral surface of masseter and lower half of temporalis muscles. Superiorly, the superficial layer fuses with periosteum of zygoma and temporalis fascia. The deep layer passes along the medial surface of pterygoid muscles, before attaching to base of skull superiorly.

The masticatory space borders the number of other spaces, which include: the parotid space posteriorly, parapharyngeal space medially, and the submandibular and sublingual spaces inferiorly.

Submasseteric Space

Masseter consists of three layers, which are fused anteriorly, but can be easily separated posteriorly. There is potential space in the substance of the muscle between the middle and the deep heads, while the bony insertion is firm above and below, the intermediate fibers have only a loose attachment. It is possible for these fibers to be separated from bone relatively easily by the accumulation of pus at this site.

When the pus accumulates between the ramus of the mandible and the masseter muscle, it produces a submasseteric space abscess.

Involvement

Infection usually originates from the lower third molars; either resulting from (i) pericoronitis related to vertical and distoangular 3rd molars or (ii) a periapical abscess spreads subperiosteally in a distal direction.

The presence of buccinator attachment probably discourages backward extension of pericoronal infection, where 3rd molar crown is anterior to this muscle barrier.

The extension of abscess inferiorly is limited by the firm attachment of masseter to lower border of ramus of mandible. The forward spread beyond the anterior border of ramus is restricted by the anterior tail of the tendon of temporalis, which is inserted into the anterior border of the ramus.

Surgical Anatomy

Boundaries

- **Anterior:** Anterior border of masseter muscle and buccinator
- **Posterior:** Parotid gland, and posterior part of masseter
- **Inferior:** Attachment of the masseter to the lower border of mandible
- **Medial:** Lateral surface of the ramus of mandible
- **Lateral:** Medial surface of the masseter muscle

Contents

Masseteric nerve, superficial temporal artery, and transverse facial artery.

It contains muscles of mastication; masseter, lateral and medial pterygoids, and insertion of temporalis muscle. It also contains ramus and posterior part of mandible; and branches of mandibular division of trigeminal nerve. These branches include—buccal, lingual, and inferior alveolar nerves.

Clinical Features

External facial swelling is moderate in size; and is confined to the outline of the masseter muscle, i.e. the swelling is seen extending from the lower border of the mandible to the zygomatic arch; and anteriorly to the anterior border of masseter; and posteriorly to the posterior border of the mandible.

There is tenderness over the angle of the mandible. There is almost complete limitation of mouth opening. Fluctuation may be absent; and if present, cannot be elicited, because the muscle lies between the pus and the surface. There is pyrexia and malaise.



Fig. 42.36: Clinical extraoral picture of masticatory space odontogenic infection in two different patients

The ramus of the mandible is more dependent upon blood supply from the overlying muscle than the body of the mandible, which is supplied by inferior alveolar artery. As a result, ischemic changes may take place in that part of bone denuded by periosteum by a submasseteric abscess so that a low-grade osteomyelitis of lateral cortical plate may occur with sequestrum formation. Often submasseteric infection leads to subperiosteal new bone deposition beneath the periosteum. Necrosis of the muscle can also occur.

Incision and Drainage

There are two approaches:

1. **Intraoral approach:** An incision is made vertically over the lower part of anterior border of the ramus of the mandible, deep to the bone. A sinus forceps are passed along the lateral surface of the ramus downwards and backwards and the pus is drained. The drain is inserted and secured with a suture.
   The abscess is usually situated below the level of incision, and not at a point of dependent drainage, and hence the drainage may be inefficient.
2. **Extraoral approach:** When the mouth cannot be opened, an incision is placed in the skin behind the angle of the mandible to open the abscess by Hilton's method. A rubber drain is inserted and secured in position with a suture. Dressing is applied.

Pterygomandibular Space (Table 42.4)

Involvement

- The situation most frequently responsible for involvement of this space, is the pericoronitis related to the mandibular 3rd molar.
- Infection can also be produced by a contaminated needle used for an inferior alveolar nerve block.
- Infection, at times, can originate from a maxillary 3rd molar, following a posterior superior alveolar nerve block injection.

Surgical Anatomy (Fig. 42.37)

Boundaries

- **Lateral:** Medial surface of ramus of mandible
- **Medial:** Lateral surface of medial pterygoid muscle
- **Posterior:** Parotid gland (deep portion)
- **Anterior:** Pterygomandibular raphae
- **Superior:** Lateral pterygoid muscle forms roof to the pterygomandibular space. The space, just below the lateral pterygoid muscle communicates with the pharyngeal spaces.

Contents

Lingual nerve, mandibular nerve, inferior alveolar or mandibular artery. Mylohyoid nerve and vessels. Loose areolar connective tissue.

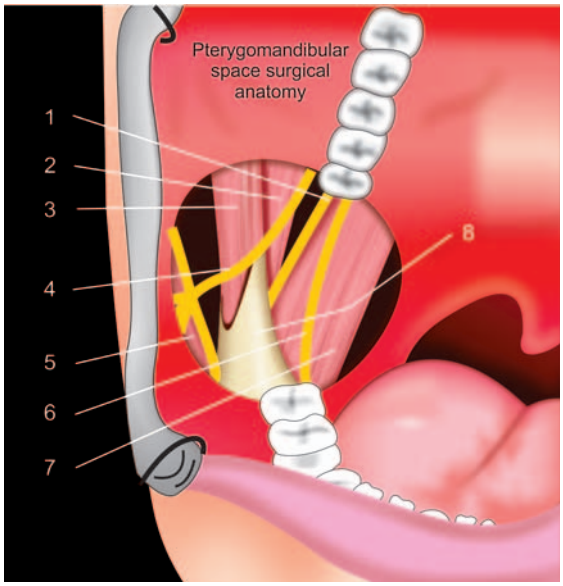


Fig. 42.37: Pterygomandibular space: Surgical anatomy [(1) Inferior alveolar nerve, (2) Deep tendon temporalis, (3) Superficial tendon temporalis, (4) Buccal nerve, (5) Buccinator muscle (cut), (6) Lingual nerve, (7) Medial pterygoid muscle, (8) Ramus of the mandible]

Table 42.4: Main features of pterygomandibular, lateral pharyngeal and peritonsillar space

	Pterygomandibular space	*Lateral pharyngeal space*	*Peritonsillar space*
Anatomy	Between mandible and medial pterygoid	Between medial pterygoid and superior constrictor	Between superior constrictor and mucous membrane
Limitation of opening	Extreme	Moderate	Some
External swelling	Little	None	None
Swelling in mouth and throat	Swelling over medial aspect of anterior border of ramus	Swelling over pillars of fauces, little swelling on superior constrictor	Swelling over pillars of fauces and most of superior constrictor

Clinical Features

Even the established cases of pterygomandibular space infections, do not cause much swelling of face over the submandibular region. However, there is severe degree of limitation of mouth opening. Tenderness can be elicited over the area of swollen soft tissues medial to anterior border of ramus of the mandible. Dysphagia is present. Medial displacement of the lateral wall of the pharynx, redness and edema of the area around the 3rd molar. Midline of the palate is displaced to the unaffected side and the uvula is swollen. Difficulty in breathing.

Incision and Drainage (Fig. 42.38)

The abscess usually tends to point at the anterior border of the ramus of the mandible and drainage can be easily done by intraoral route.

- **Intraoral:** A vertical incision, approximately 1.5 cm in length, is made on the anterior and medial aspect of the ramus of mandible. A sinus forceps in inserted in the abscess cavity, opened and closed and withdrawn. The pus is evacuated, a rubber drain is introduced and is secured in position with a suture.
- **Extraoral:** An incision is taken in the skin below the angle of the mandible. A sinus forceps is inserted towards the medial side of the ramus in an upward and backward direction. Pus is evacuated and the drain is inserted from an intraoral approach and sutured in position.

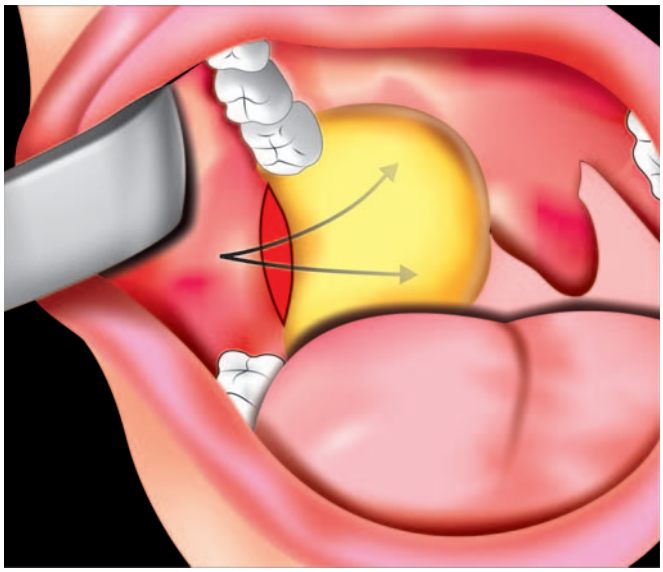


Fig. 42.38: Intraoral incision for draining the pterygomandibular or lateral pharyngeal space abscess. Dissection is done posteriorly for pterygomandibular space. For lateral pharyngeal space, dissection is done first medially and then posteriorly

Spread

- Occasionally, infection may spread superiorly along the medial surface of ramus to involve the infratemporal fossa and beneath the temporal fascia.
- The infection can spread posteriorly to lateral pharyngeal space and then to retropharyngeal space.
- It can also spread around the front of the ramus of the mandible to involve the buccal space.
- It can also spread around the front of the ramus of the mandible extending anteroinferiorly below the lower border and under the superior constrictor to involve the submandibular space.

Parapharyngeal Spaces

They include lateral pharyngeal and retropharyngeal spaces. These are the major pathways for spread of head and neck infections. These spaces form a "ring" around pharynx; and together form a pathway for spread of orofacial infections in neck and mediastinum. The parapharyngeal spaces communicate directly with both submandibular space anteroinferiorly; and retromandibular space posteriorly.

Lateral Pharyngeal Space (Figs 42.39 and 42.40)

It is a potential cone-shaped space or cleft with its base uppermost at the base of skull and its apex at the greater horn of the hyoid bone. The space is divided into two by the styloid process, as anterior and posterior compartments. Infection of this space is extremely serious owing to the intimate relationship with the carotid sheath.

Involvement

- It is involved from an abscess extending backwards from mandibular 3rd molar area.
- By backward spread from sublingual, submandibular and pterygomandibular space infections.
- Lateral spread from tonsillar abscess.
- Surgical displacement of mandibular third molar distally under the lingual flap and backwards into the lateral pharyngeal space. Similarly, a 3rd molar root may get dislodged into the space through a hole in the lingual plate.

The boundary walls of the space do not permit easy communication with the adjacent spaces. Infection passes most easily between lateral pharyngeal space and submandibular space by tracking along the styloglossus muscle.



Fig. 42.39: Lateral pharyngeal space involvement along with peritonsillar abscess



Figs 42.40A to D: (A and B) Clinical picture of a patient with lateral pharyngeal and pterygomandibular space infection; (C) Extraoral drains are in place in the anterior and posterior compartments of lateral pharyngeal space, additional intraoral drain was put in the pterygomandibular space; (D) Patient after complete recovery

There is a weak zone in the posterior part of the fascia around the submandibular salivary gland, medial to stylomandibular ligament, and rupture of a submandibular abscess into the parapharyngeal space at this point may result in rapid onset of respiratory embarrassment.

Surgical Anatomy

- **Boundaries:**
  - Superiorly, base of the skull. Petrous portion of the temporal bone with foramen lacerum and jugular foramen.
  - Inferiorly, hyoid bone (submandibular gland and posterior belly of digastric).
  - Anteriorly, bounded by pterygomandibular raphe.
  - Laterally, bounded by the ascending ramus of mandible, insertion of medial pterygoid muscle, and medial surface of deep lobe of parotid gland along with their covering fascia.
  - Medially, bounded by pharyngeal wall, (palatal muscles at the level of nasopharynx; and pharyngeal constrictors (superior and middle) and stylopharyngeus; covered by buccopharyngeal fascia; at the level of oropharynx.
  - Posteriorly, bounded by styloid muscle, and upper part of carotid sheath, prevertebral fascia, with foramen lacerum and jugular foramen.

These spaces separate the muscles of mastication from muscles of deglutition.

Some surgeons include a downward continuation of this compartment around carotid sheath; as far as the thoracic inlet. Thus, they include inferior constrictor and esophagus in the medial wall, the lateral lobe of thyroid gland as an anterior relation, and sternocleidomastoid and superior belly of omohyoid in the lateral wall.

- **Contents:**
  - *Anterior compartment:* Lymph nodes, ascending pharyngeal, facial artery, loose areolar connective tissue.
  - *Posterior compartment:* Carotid sheath (internal jugular vein, internal carotid artery, and vagus nerve), glossopharyngeal nerve, spinal accessory

nerve, hypoglossal nerve, and cervical sympathetic trunk.

Clinical Features

Clinical picture is grave, because of generalized septicemia and respiratory embarrassment due to edema of the larynx. General constitutional symptoms in the form of malaise and pyrexia are present.

- **Anterior compartment:**
  - *Extraoral:* Brawny induration of the face, above the angle of the mandible. This induration may extend downward to the submandibular region, as well as, upwards to the parotid region on the ipsilateral side. External swelling is less extensive. There is subtle swelling in lateral neck, just above the hyoid bone, between posterior belly of digastric and sternocleidomastoid muscle externally. This is the area where lateral pharyngeal space is closest to the skin.
  - *Intraoral:* The anterior part of the lateral pharyngeal wall may be swollen; that pushes the soft palate and the palatine tonsil towards the midline. Marked trismus may be present. Severe pain arising from the collection of pus between the medial pterygoid and superior constrictor muscles. Dysphagia is present.
- **Posterior compartment:** The clinical picture is dominated by septicemia. Usually little or no trismus is present. Slight pain is present.
  Internal swelling involves the lateral wall of pharynx behind the palatopharyngeal arch.

Incision and Drainage

Extraoral approach—an incision is made along the anterior border of sternocleidomastoid muscle, extending from below the angle of the mandible, to the middle 3rd of submandibular gland. The fascia behind the gland is incised and a curved hemostat is inserted and carefully directed medially behind the mandible, as well as superiorly and slightly posteriorly until the abscess cavity is reached. A rubber drain is inserted and is secured to the skin with a suture.

A 3–5 cm long incision is placed low over the submandibular space just superior and parallel to the hyoid bone. The posterior end should lie just over the anterior border of sternocleidomastoid muscle. The dissection is carried through skin, subcutaneous tissue, superficial fascia, and platysma muscle to expose the superficial or anterior layer of deep cervical fascia. The fascia is exposed sufficiently to identify submandibular gland and the posterior belly of digastric muscle. The surgeon will be able to identify by finger dissection and palpation, the angle of the mandible, hyoid bone, sternocleidomastoid muscle. The dissection is then carried further just posterior to the posterior belly of digastric muscle in a superior, medial, and posterior direction. The dissection of lateral pharyngeal space is completed when the surgeon is able to palpate the endotracheal tube medially, the ipsilateral transverse processes of the vertebrae posteromedially, and the carotid sheath posterolaterally. The surgeon should avoid rupturing the pharyngeal mucosa by using only gentle force during finger dissection, as the infected tissues are quite friable.

Intraoral approach: A vertical incision is placed over the pterygomandibular raphe. A sinus forceps or curved hemostat is passed through the pterygomandibular raphae along the medial surface of the mandible, medial to the medial pterygoid and just lateral to the superior constrictor is then divided posteriorly to the pus pocket.

Spread

Infection can spread in the following manner:

- It can either spread upwards through various foramina such as, foramen ovale, foramen lacerum, and jugular foramen, present at the base of the skull, producing brain abscess, meningitis or sinus thrombosis.
- It can also spread downwards into the carotid sheath towards the mediastinum; a pathway which Mosher called the "Lincoln's highway" of the neck.

Retropharyngeal Space: Prevertebral Space

It is a potential midline space between the pharyngobasilar fascia, which attaches the pharyngeal constrictors to the base of skull, and prevertebral fascia.

Involvement

The space is involved by an extension of infection from the lateral pharyngeal space.

Surgical Anatomy

Boundaries

- Laterally, carotid sheath.
- The retropharyngeal space is continuous with retro-esophageal space into the posterior mediastinum to the level of 6th thoracic vertebra.
- There are no midline attachments in the retro-pharyngeal space; thereby, permitting unimpeded

inferior extension of inflammatory and neoplastic processes into mediastinum.

Clinical Features

There is usually a preceding or concurrent acute infection of the throat. Patient will complain of painful deglutition, and if the swelling is marked or in the lower portion of the pharynx, obstructive symptoms such as snoring, choking or even dyspnea and stertorous breathing may occur. A unilateral cervical adenitis on the affected side is always seen. The voice is same as in quinsy.

Incision and Drainage

The space can be safely divided into two for the convenience of description: (a) Suprahyoid portion, and (b) Infrahyoid portion.

a. **Suprahyoid portion:** The suprahyoid portion of retropharyngeal space can be approached by using the same incision described for lateral pharyngeal space. The space is approached through the lateral pharyngeal space, hence the dissection is the same, until the lateral pharyngeal space is further explored by blunt finger dissection. The dissection is continued until the surgeon is able to palpate the contralateral transverse processes of the vertebrae, the endotracheal tube from its posterior aspect, and if necessary the opposite carotid artery.
b. **Infrahyoid portion:** If the space is involved below the hyoid bone, then the posterior end of the low submandibular incision described earlier is extended inferiorly along the anterior border of sternocleidomastoid muscle. As the dissection passes deep to anterior layer of deep cervical fascia, the sternocleidomastoid muscle is retracted posterolaterally to expose the carotid sheath. The loose connective tissue lying between the carotid sheath and the esophagus is bluntly dissected medially and posteriorly to expose the visceral fascia, which surrounds the trachea, esophagus and thyroid gland. Blunt dissection with finger is used to follow the visceral fascia into the retropharyngeal space. Multiple soft drains are then placed in the superior and inferior portions of the retropharyngeal space as well as in the lateral pharyngeal space.

Peritonsillar Abscess (Quinsy) (see Fig. 42.39)

It is a localized infection in the connective tissue bed between the tonsil and the superior constrictor muscle, between the anterior and posterior pillars of fauces.

Involvement

- Infection coming from the depth of the tonsillar crypt or supratonsillar fossa.
- As a complication of acute pericoronal abscess in which case the abscess points near the lower pole of the tonsil.

Clinical Features

- Patient looks ill, anoxic and dehydrated.
- Pain on one side of the throat radiating to the ear.
- Dysphagia
- Limitation of mouth opening may not be pronounced.
- Speech is difficult, especially, in bilateral cases and a peculiar muffled "hot potato in mouth" voice is characteristic.
- Drooling of saliva.
- When the abscess is fully developed; a large tense swelling of anterior pillar of fauces, and a bulge in the soft palate on the affected side, which in extreme cases reaches the midline; and pushes the uvula downwards and forwards, until it impinges against the opposite tonsil.
- Coated tongue with marked fetor oris.

Incision and Drainage

It can be achieved by using a guarded knife and sinus forceps, which are inserted into the most prominent part of the soft palate, where the fluctuation is the maximal.

Spread

Edema may eventually affect the base of the tongue, epiglottis and aryepiglottic fold. In 3–5 days duration, the mass becomes fluctuant and ruptures by pointing usually through the anterior tonsillar pillar.

Pericoronitis/Pericoronal Abscess

The meaning of the word "peri" means, surrounding, "coronos" means pertaining to crown, and "itis" means inflammation. The meaning of the word would be inflammation of the surrounding tissues of the tooth.

Definition

The definition would be an inflammatory process involving the soft tissue covering of the crown of partially erupted or unerupted teeth.

Etiology

It is usually seen in teeth, which are prevented from eruption for prolonged time, such as malpositioned or impacted teeth, mostly mandibular 3rd molars.

- Bilateral concurrent pericoronitis predisposes infectious mononucleosis, or Vincent's infection.
- Trauma to the overlying gingivae from the cusps of an opposing tooth is the most common etiology associated with inflammation due to bacterial invasion.
- It can be classified into following stages—(a) acute, (b) subacute, and (c) chronic.
- Many pericoronal infections are suppurative and some are ulcerative.

Classical ulcerative pericoronitis is due to Vincent's infection, acute herpetic gingivostomatitis may start around the lower 3rd molar and spread forward and backwards onto the fauces and soft palate.

Clinical Features

- **Acute:** Well localized dull pain, swollen red tender gingival pad, pus discharge from underneath the gingival pad, fetor oris, indentations of cusps of upper teeth, slight discomfort on swallowing, restriction of oral opening, enlarged, tender submandibular lymph glands on the affected side.
  Facial swelling, limitation of oral opening, severe throbbing pain, interfering sleep, discomfort on swallowing.
  Constitutional symptoms: Pyrexia, malaise, and anorexia.
  Regional lymph nodes are palpable, enlarged and tender.
  If left untreated, most likely to spread to adjacent tissue spaces.
- **Subacute: Clinical features:** Well localized dull pain, swollen, red, tender gum pad, pus discharge, fetor oris, indentations of cusps of upper teeth, slight discomfort on swallowing, difficulty in oral opening, enlarged, tender submandibular lymph glands on the affected side.
- **Chronic** recurrent episodes of infection. Clinical features—(i) asymptomatic, (ii) occasional mild discomfort/bad taste due to pus discharge, and (iii) subacute or acute exacerbations.

Spread

The pericoronal infection, if left untreated can spread to the following regions:

- It can extend submucosally and form a vestibular abscess against mandibular second or 3rd molars; and may discharge as intraoral sinus.
- It can extend on the outer surface of buccinator causing buccal space abscess.
- It can extend into the submandibular, pterygomandibular and submasseteric spaces.
- Rarely, it can extend down to lower border of mandible behind the depressor anguli oris muscle; and burst through the skin (if not incised).

POSSIBLE UNTOWARD OR LIFE-THREATENING COMPLICATIONS OF OROFACIAL INFECTION

These complications may be classified as follows:

- Those related to the lower jaw
  - Ludwig's angina
  - Descending deep cellulitis of the neck, resulting in mediastinitis
  - Carotid sheath invasion.
- Those related to the upper jaw
  - Intracranial complications, with possibilities of cavernous sinus thrombosis, brain abscess, dural meningitis and osteomyelitis of the skull.
  - Retrobulbar cellulitis with possibility of blindness.

Ludwig's Angina

Historical Background and Definition

It is the name given to a massive, firm, brawny cellulitis/induration, and acute, toxic stage, involving simultaneously, the submandibular, sublingual and submental spaces bilaterally. It was first described by Wilhelm Friedreich Von Ludwig (1836). As the definition suggests, only the bilateral involvement of abovementioned spaces is considered to be classical, disease entity. All other types of presentations, though massive are not considered as Ludwig's angina.

The term "Ludwig's angina" was coined by Camerer in 1837, who presented cases which included classic description of the entity as done in the previous year by WF Ludwig. The word "angina" is derived from the Latin word *angere*, meaning suffocation or choking sensation; and the word "Ludwig" comes from the person to whom the credit goes for its description. Interestingly, Ludwig died of throat inflammation in 1865.

Von Ludwig described the classical features of the disease and presented a case of Franklin NN whom he treated successfully.

The condition had established its unique identity in general medical personnel with three "F"s as—it was to be *feared*, it rarely becomes *fluctuant*, and it was often *fatal*.

Many terminologies were used for this condition which includes:

- **Marbus strangulatorius:** It is so called, because of the choking effect, which the victim experiences.
- **Angina maligna.**
- **Garrotillo:** It is the Spanish version for Hangman's noose.

Etiology

The following causes can be attributed to Ludwig's angina:

- **Odontogenic:** This is the cause in majority of cases (90% in some studies). It can cause infections in various other forms:
  - Acute dentoalveolar abscess
  - Acute periodontal abscess
  - Acute pericoronal abscess.

Acute dentoalveolar abscess: *The most common teeth involved are mandibular 2nd and 3rd molars.*

Acute periodontal abscess: Deep abscess may involve sublingual spaces.

Acute pericoronal abscess: In relation to erupting mandible 3rd molars, which can extend to the following spaces:

  - Submandibular space
  - Buccal space
  - Sublingual space
  - Pterygomandibular space.
  - Infected mandibular cyst also can spread to form Ludwig's angina.
- **Iatrogenic:** Use of a contaminated needle for giving local anesthesia.
- **Traumatic injuries to orofacial region:** These can be in the form of: (a) mandibular fractures, the chances of developing Ludwig's angina are more, if the fracture is compounded and comminuted, (b) deep lacerations or penetrating injuries such as punctured wounds.
- *Osteomyelitis* secondary to compound mandibular fractures; or acute exacerbation of chronic osteomyelitis of mandible may develop into Ludwig's angina.
- **Submandibular and sublingual sialadenitis:** Acute or chronic infection from these glands.
- **Secondary infections of oral malignancies:** The associated malignancies of the region may give rise to secondary infection, leading to the condition.
- **Miscellaneous causes:** It includes rare causes such as:
  - Infection in the tonsils or pharynx such as purulent tonsillitis, etc.
  - Foreign bodies such as fish bone, etc.
  - Oral soft tissue lacerations.
- Cervical lymphoid tissues.

Pathology

The condition is a cellulitis—a diffuse inflammation of soft tissues which is not circumscribed or confined to one area, but in contrast to the abscess, tends to spread through tissue spaces and along fascial planes.

Such type of spreading infection occurs in the presence of organisms that produce significant amounts of hyaluronidase and fibrinolysins, which act to break down or dissolve, respectively hyaluronic acid and fibrin. Streptococci, being the potent producers of hyaluronidase are always associated with classical or true Ludwig's angina.

Microbiology

A plethora of microorganisms has been implicated as the causative agents of this condition. Previously, it was thought that, the streptococci and mixed oral flora, were the commonly reported microorganisms. Contemporarily, the reports have demonstrated presence of staphylococci, streptococci, gram-negative enteric microorganisms, such as *E. coli* and *Pseudomonas*, and anaerobes including *Bacteroides* (*B. melaninogenicus, B. oralis,* and *B. corrodens*), anaerobic streptococci, Peptostreptococcus and fusospirochetes.

The isolation of these organisms does not indicate that there is changing oral flora; but are due to employment of sophisticated and modern culture techniques.

In early stages, with almost no putrefaction, the disease shows mixed aerobic and anaerobic infection. In later stages, where frank putrefaction exists, when the infection gets localized, the infection becomes more anaerobic and the bacteria found are almost anaerobic.

Involvement

Most cases originate in association with mandibular second and third molars. A possible explanation to this can be given by evaluating the anatomical relationship of these teeth and the involved spaces.

The bone around these teeth is usually thicker on the buccal aspect than lingual side. The apices of these teeth are placed below the mylohyoid line of mylohyoid muscle, so that infection tends to spread primarily to submandibular space. Hence, the submandibular space plays a vital role in development and progress of the disease. The subsequent spread of the disease is determined by the muscles in the area.

The condition usually follows a submandibular space infection caused by a periapical infection, or pericoronitis around mandibular third molar. The infection then spreads to the sublingual space on the same side, around the deep part of the submandibular gland. The submental space is involved by lymphatic spread. The condition can also occur in converse manner, i.e. by spread from the sublingual spaces to the submandibular spaces **(Fig. 42.41)**.

Clinical Features

The following signs and symptoms are present with varying degree of severity **(Fig. 42.42)**:

- **General examination:** It includes: (i) general constitutional symptoms: patient looks toxic, very ill and dehydrated. There is pyrexia, anorexia, chills, and malaise; (ii) marked pyrexia; (iii) difficulty in swallowing (dysphagia); (iv) impaired speech, and hoarseness of voice.
- **Regional examination:** Extraoral examination **(Figs 42.43 and 42.44)**.
  - Firm/Hard brawny (board-like, woody hard) swelling in the bilateral submandibular and submental regions, which soon extends down the anterior part of the neck to the clavicles. Swelling is nonpitting, minimally or nonfluctuant associated with severe tenderness. Classically, the swelling shows ill-defined borders with induration.
  - Severe muscle spasm may lead to trismus with restricted mouth opening and also jaw movements. Typically mouth remains open due to edema of sublingual tissues leading to raised tongue almost touching the palatal vault. In extreme circumstances, tongue may actually protrude from the mouth; the tongue movements are reduced.
  - Airway obstruction.
  - Respiratory rate may be seen to be raised; breathing being shallow with accessory muscles of respiration being used.
  - There may be dilation of alae nasi, raising of thoracic inlet by the scalenes and sternocleidomastoid muscles and in-drawing of the tissues above the clavicle.
  - Cyanosis may occur due the progressive hypoxia.
  - Fatal death may occur in untreated case of Ludwig's angina within 10–24 hours due to asphyxia.
- Intraorally, the swelling develops rapidly, which involves (i) the sublingual tissues, and distends or raises the floor of mouth, woody edema of the floor of the mouth and tongue (ii) tongue may be raised against palate; (iii) increased salivation, stiffness of tongue movements, difficulty in swallowing; (iv) backward spread of infection leads to edema of glottis, resulting in respiratory obstruction/embarrassment. Stridor being the alarming sign of this fatal extension needing emergency intervention to keep airway patent.

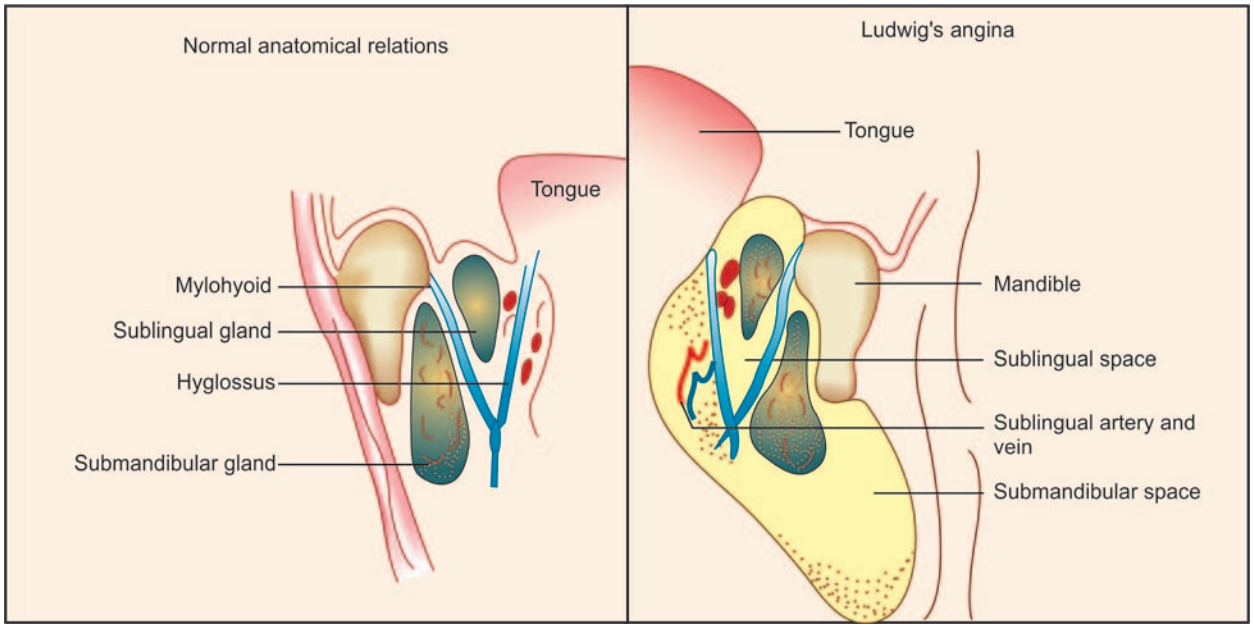


Fig. 42.41: Comparison of normal anatomical relations to involvement of spaces in Ludwig's angina



Fig. 42.42: The typical clinical pictures of the patients suffering from Ludwig's angina. Note the toxic patients, with firm, brawny induration with raised floor of the mouth, tongue protruding out and elevated

There is reduced control of muscles and jaw posture—salivation is excessive and saliva may be even seen drooling.

Part of the tongue may get pushed backward making swallowing even liquid very difficult or even impossible. Oral opening and jaw movements may be reduced.

Progressive dyspnea is caused by backward spread of infection, until in the untreated case, edema of the glottis causes a complete respiratory obstruction.

Spread

- From the sublingual spaces, the infection may spread backwards in the substance of the tongue in the cleft between the hyoglossus and genioglossus muscles along the course of sublingual artery. By this route the infection reaches the region of epiglottis and produces swelling around the laryngeal inlet.
- Due to anatomical continuity of various spaces with submandibular space, the infection may track to submasseteric, and pterygomandibular spaces; and more posteriorly, parapharyngeal, paratonsillar spaces; and worsening airway compromise.
- Infection from the submandibular region, can spread downwards along and beneath the investing layer of deep cervical fascia, towards clavicle and subsequently to mediastinum **(Fig. 42.45)**.
- Uncommonly, infection can spread below and reach close to carotid sheath, pterygopalatine fossa, leading to cavernous sinus thrombosis with subsequent meningitis.

Fate of Ludwig's Angina

Ludwig's angina, if untreated, can be fatal within 12–24 hours; death arising from asphyxia. Established cases may become more complicated with involvement of other spaces. The other causes of death include: septicemia/septic shock, mediastinitis, and aspiration pneumonia, which are also caused by the complications of the disease.



Figs 42.43A to F: (A and B) Clinical picture of Ludwig's angina; (C to E) Drainage, decompression of Ludwig's angina patient with multiple corrugated rubber drains in place; (F) Patient after complete recovery

With the introduction of newer antibiotics, the mortality rate has been significantly dropped, from almost 75% to 4%. However, the possible fatal outcome of new cases cannot be ignored.

Principles of Treatment

It should be taken as a life-threatening emergency situation. It is best treated by aggressive intervention.
The treatment is based on the combination of the following factors: (1) early diagnosis, (2) maintenance of patent airway, (3) intense and prolonged antibiotic therapy, (4) extraction of the offending teeth, and (5) surgical drainage or decompression of fascial spaces.

The general anesthesia should be given to such patients by a skilled and experienced anesthesiologist. The endotracheal tube should be passed with the help of fiberoptic laryngoscope, while the patient is conscious and wide awake.

With the use of IV anesthetic agents used for induction, the patient maintain airway by the vigorous use of voluntary muscles, together with the accessory muscles of respiration. When a general anesthetic is used, this voluntary control is lost. Further, when the patient becomes unconscious, there is a massive increase in the edema; the airway becomes occluded; and it becomes quite difficult to pass an endotracheal tube as the pharynx billows inwards.



Figs 42.44A to D: Severe stage of Ludwig's angina



Fig. 42.45: Descending spread of infection in Ludwig's angina patient

A nasopharyngeal airway and a tracheostomy set should be kept ready by the side of the bed of the patient of Ludwig's angina. Evaluation of blood gases gives an indication of the degree of respiratory obstruction and may indicate the need for tracheostomy even if the patient is not in distress.

Airway Maintenance

This condition is considered to be fatal. Death can occur from asphyxia rather than the infection itself, leading to septicemia and shock. Hence, it is advisable to observe the patient for respiratory obstruction and restlessness. In case of respiratory embarrassment the following points should be considered for using artificial airway.

- It can cause trauma and resultant inflammation may worsen the edema and airway obstruction.
- Chances of inadvertently rupturing any pointing or superficial abscess in the pharyngeal wall are high as it is a blind procedure and may itself lead to aspiration of pus and instant death.

Intubation of the patient: Blind intubation should be avoided. Nasoendotracheal intubation is far more reliable and almost predictable and should be preferred.

Surgical airway: It may be required in case of severe upper respiratory obstruction.

Laryngotomy, cricothyroidotomy (tracheotomy) are always preferred over tracheostomy or rather emergency tracheostomy is avoided because of:

- Identification of landmarks that may be required before it, is most of the time quite difficult due to associated massive edema and tissue distortion.
- The surgery itself may lead to spread of infection to deeper tissues due to additional incision required.
- There are high chances of getting pneumonia as sequelae of tracheostomy which itself is a life-threatening condition (Aird 1957).
- Tracheal stenosis is observed in 25–50% of cases following tracheostomy.

Use of Cuffed Endotracheal Tube

- Avoid sedatives, narcotic agents that may deteriorate respiration.
- Degree of respiratory obstruction can be better evaluated using pulse oximeter and evaluating blood gases. It is better to rely on these parameters as clinical picture may vary from patient to patient and may even mask extreme airway obstruction.
- **Anesthesia:** As a general rule, it is always better to use local anesthesia for surgical intervention. Local infiltration with 2% lidocaine with adrenaline into skin and superficial tissues of neck is sufficient to fulfill the need for surgical intervention. In patients, who are already intubated, general anesthesia can be considered after evaluating its advantages over local anesthesia.

- Intravenous analgesics can be supplemented to relieve pain.

Surgical Intervention

It has two aims: (i) remove the cause, (ii) surgical decompression: Decompression of the spaces involved.

- **Removal of the cause:** Removing the offending tooth may facilitate evacuation of pus present in close vicinity of the tooth without any special surgical intervention.
- In most cases of Ludwig's angina, small amount of pus is always associated with the offending tooth close to its lingual cortex.
- The initial stage of Ludwig's angina or those cases which progress to Ludwig's angina are seen to be managed by simple extraction coupled with antibiotics.

Surgical Decompression

As Ludwig's angina is, in fact cellulitis, its treatment by aggressive surgical intervention is a debatable issue. The advantages of early surgical decompression include the following:

- It reduces pressure of edematous tissues on the airway reducing respiratory embarrassment.
- It allows prompt drainage should suppuration develop.
- It allows obtaining specimen or samples for Gram staining, and culture and sensitivity, for identification of microorganisms; and accordingly adjustment of antibiotics later on.
- It allows placement of drains, which may be valuable to drain pus collection as time progresses, and irrigation of the tissues at regular intervals.

Bilateral submandibular incisions and if required a midline submental incision 1 cm below the inferior border of mandible are sufficient to drain the involved spaces.

Following aseptic technique and adequate local anesthesia, an incision is made, which divides skin, the superficial fascia, platysma, investing layer of deep fascia, geniohyoid and finally mylohyoid muscles.

To be effective, it is essential to divide deep fascia and the mylohyoid muscle, then only it will drain sublingual space. A through and through drain is placed to relieve the intense pressure of the edematous tissues on the airway. Sublingual space can be separately drained by intraoral approach if required and if oral opening permits it. Surgical drain should be secured by suturing to the margins of the incision.

In most of Ludwig's angina cases, little or no pus can be drained out by surgical intervention, as it is a cellulitis, but in later stages or during postsurgical period, profuse pus may be seen draining. Whatever may be the situation, bilateral and complete drainage or rather decompression is the key for success of surgical intervention.

Care: It should be taken to preserve or avoid trauma to: (i) facial vessels near angle, (ii) lingual nerve, and (iii) jugular vein, laterally below angle region.

Antibiotic Therapy

Antibiotics: Antibiotics play a vital role in managing Ludwig's angina. Usually, IV antibiotics with proper dosage and frequency are necessary.

Penicillin and its Derivatives

- Penicillins are the first line of antibiotics in treating such infection as it covers the majority of aerobic Gram positive microbial flora commonly associated with this infection. It is administered in the form of aqueous penicillin G, 2–4 million units, IV 4–6 hourly; or 500 mg 6 hourly orally.
- *Semisynthetic derivatives of penicillin:* Ampicillin/amoxycillin; 500 mg 6 and 8 hourly, IV and orally respectively.
- *Cloxacillin:* 500 mg orally, 8 hourly.
- *In case of allergy to penicillin:* Erythromycin 600 mg 6–8 hourly.
- Gentamicin has activity against some resistant staphylococci and pseudomonas. 80 mg IM, BD.
- Clindamycin IV 300–600 mg 8 hourly, orally or intravenously. Its spectrum of activity includes gram-positive cocci including penicillinase resistant staphylococci, and *Bacteroides*.
- *Metronidazole:* It is a useful antibiotic against anaerobic flora found in oral infections. It is administered in the form of 400 mg 8 hourly orally or intravenously.
- *Cephalosporins:* These are closely related to penicillin and have similar spectrum of their activity. These are usually reserved for resistant infections. Usually, a combination of antibiotic therapy is indicated for aggressive management of Ludwig's angina, penicillin or its derivative alongwith metronidazole or gentamicin.

Antibiotics should be changed subsequent to the result of bacterial culture and sensitivity testing. The therapy should also be changed, if favorable results are not observed after 48–72 hours of therapy.

Hydration: Most cases of Ludwig's angina are dehydrated, because of two reasons:

1. Diminished liquid intake due to pain, discomfort associated with swallowing (dysphagia).
2. Due to the toxic nature of the condition, there is usually excessive urination and perspiration which further diminishes body fluids.

For these reasons patients should be encouraged to have liquids frequently and if required intravenously, fluids can maintain hydration and even calories.

Hydrotherapy: It is a debatable issue till today. It was defined by Steward Mead (1939) and practiced routinely as an adjunct procedure. In contrast, cold application decreased inflammation, decreased exudates—edema formation and decreased swelling. It can be said that cold application in postsurgical cases of Ludwig's angina when given intermittently reduces edema, tissue tension and aids fast recovery. It is usually given by placing gauze pieces over the most indurated area and wetting them intermittently with cold water. Significant improvement from discomfort can be expected in initial 48 hours.

Simple Prototype Protocol

Preoperative

- **Airway assessment:** Observe signs and symptoms of obstruction. Thorough examination including: mouth opening, tongue mobility or protrusion, uvula and faucial region. Evaluate need for endotracheal intubation; or surgical airway preferably using pulse oximeter monitoring. Lateral neck radiographs, CT scan, MRI (additional) for extensions beyond maxillofacial region.
- **Etiological findings:** Further radiographs—OPG, and other radiographs.
- **Risk factor consideration:** Diabetes, immunodeficiency status.
- **Hydration:** Check with blood pressure, pulse and urine output.
- **Temperature:** Assess blood/urine cultures for septicemia. Apply cold packs. Use of antipyretics.
- *Chest radiographs*, to rule out pneumonia.
- **Evaluate laboratory data:** Blood counts and proteins.
- Consider emergency airway preparations.

Perioperative

(a) Intubation: Due care for surgical airway in emergency. (b) Removal of cause, and surgical drainage. (c) Antibiotics.

Postoperative

- Extubate after confirming adequate airway.
- Irrigation of drains periodically.
- **Culture reports:** Adjust antibiotics accordingly.
- Re-evaluate laboratory data: Blood counts.
- Monitoring course of infection: If necessary re-exploration or drainage.
- Regular follow-up.

Irrigation: Copious irrigation of the wound drains with an antibacterial solution. Typically, bacitracin in a mixture of H_2O_2 and normal saline is recommended. In an odontogenic infection, antibiotic regimen should be targeted to the microorganism most likely to cause the infection, yet should cover a spectrum broad enough to sufficiently combat infrequent pathogens.

Complications: Ludwig's angina continues to be a cause of significant morbidity and mortality. The complications can be listed as follows: (1) osteomyelitis, (2) maxillary sinusitis, (3) localized respiratory tract disturbances, (4) digestive tract disturbances.

More serious complications include: (1) life-threatening airway obstruction (2) septicemia (3) distant metastatic foci, (4) mediastinitis (5) pericarditis (6) internal jugular vein thrombosis (7) neurological complications\ intracranial involvement includes—(a) meningitis, (b) epidural abscess/brain abscess (c) cavernous sinus thrombosis (8) involvement of carotid sheath—carotid artery erosions, and (9) Death.

Signs and symptoms of these conditions should be looked for and recognized as early as possible, because some of the complications can be fatal.

Involvement of Carotid Sheath

Carotid sheath is a fascial condensation surrounding the internal jugular vein, the vagus nerve, the common and internal carotid arteries. It lies below the sternocleidomastoid muscle and the part most commonly affected lies above the posterior belly of the omohyoid muscle.

Involvement

Infection of the carotid sheath may be derived from the submaxillary/submandibular space, the infratemporal space and the parapharyngeal space.

Clinical Features

If lateral pharyngeal space is infected, the signs of involvement of carotid sheath should be looked for. Its involvement is frequently associated with thrombosis of the internal jugular vein, as the vessel may be adherent to the sheath. The patient usually takes a turn for the worse

when this complication sets in. Chills, septicemia, fever is present. The swelling extends down the neck, with localized pain along the course of the vessels.

- The most ominous of these signs is "herald bleeds", which are intermittent bleeding episodes from nose or pharynx that are caused by incipient erosions of carotid artery or internal jugular vein.
- Other signs of involvement of carotid sheath include: palsies of cranial nerves IX, X, and XII, Horner's syndrome, and an enlarging hematoma in the neck.
- Manifestations of septic shock.
- History of persistent swelling after drainage of a peritonsillar abscess; and a protracted course.

Thrombophlebitis of internal jugular vein may occur as a complication; and if pus in the lateral pharyngeal space is undrained for any length of time, the common carotid artery, may become eroded with fatal consequence. Inequality of pupils due to involvement of cervical sympathetic can be a warning signal of such a disastrous sequel.

Management

If involvement of the carotid sheath is suspected, then vascular control of carotid artery should be established before the rest of the lateral pharyngeal space is dissected. Abscess of the carotid sheath is serious and early intervention is a must. The incision is made along the anterior border of the sternocleidomastoid muscle. Generally, the region above the omohyoid gives a satisfactory exposure, where the external jugular vein can be explored. If it is thrombosed, then it is ligated below the lowest level of its involvement to prevent further spread of infection.

Brain Abscess

Etiology

It can occur from bacteremia accompanying an odontogenic infection. The microorganisms reaching the brain produce inflammation, localized edema and septic thrombosis. The abscess may be single or multiple.

Clinical Features

The signs and symptoms vary depending upon the site of involvement. Headache is the most consistent symptom. Nausea and vomiting are common. Other signs and symptoms include—hemiplagia, papilledema, aphasia, convulsions, hemisensory deficit, hemianopia and abducent nerve palsy. Abscess of the frontal lobe may cause stupor, confusion and subtle changes in personality.

Treatment

(1) Drug therapy (antibiotics, steroids and mannitol to reduce edema). IV chloramphenicol is an initial antibiotic of choice. The causative organism is identified and its antibiotic sensitivity is determined. Early diagnosis and treatment are important if the prognosis is to be favorable.
(2) Surgery to provide drainage.

Meningitis

It is the most common neurological complication resulting for infection in orofacial region.

Clinical Features

It is characterized by headache, fever, stiffness of the neck, and vomiting. Patient is often confused and eventually may become comatose. Convulsions may occur. Kernig's sign (strong passive resistance when an attempt is made to extend the knee from the flexed thigh position) and Brudzinski's sign (abrupt neck flexion in the supine resulting in involuntary flexion of the knees).

The diagnosis is based on the results of lumbar puncture and examination of increased pressure and is opalescent or cloudy. It contains numerous polymorphonuclear cells, the protein is generally high and glucose is almost always reduced. The treatment of meningitis is medical rather than surgical. A combination of chloramphenicol and penicillin G is the treatment of choice until the organism can be identified by culture and its antibiotic sensitivity determined. Antibiotics should be continued for at least a week after the fever subsides and cerebrospinal fluid (CSF) returns to normal. An addition to antibiotics, attention should be given to maintain proper hydration and electrolyte balance, control of cerebral edema and avoidance of vascular collapse and shock.

Mediastinitis

Odontogenic infection spreading to the mediastinum is rare and is an ominous life-threatening late complication and should be suspected in the patient who exhibits exacerbation of fever associated with substernal pain. Progressive septicemia, mediastinal abscesses, pleural effusion, empyema, compression of mediastinal veins with decreased venous return to the heart and pericarditis may occur, with death as the final step. A 40% mortality rate persists in the antibiotic era, often due to delayed diagnosis and inadequate surgical drainage **(Fig. 42.46)**. *This is an infection involving the mediastinal connective tissue that fills the interpleural space and surrounds the median thoracic organs.* The mediastinum is the central

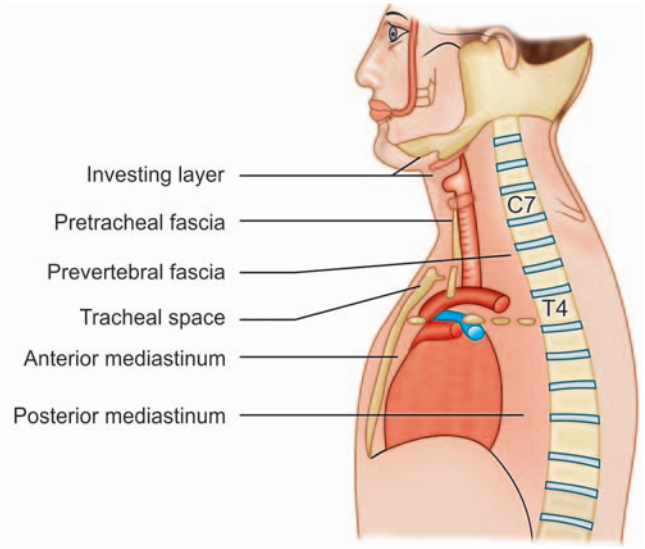


Fig. 42.46: Anterior mediastinum and posterior mediastinum



Fig. 42.47: Descending necrotizing mediastinitis (DNM)

portion of the thorax. It is bounded bilaterally by the pleura, ventrally by the sternum, dorsally by the vertebrae and inferiorly by the diaphragm. Vital structures located within or coursing through the mediastinum include the heart, aortic arch, carotid and subclavian arteries, thoracic duct, vagus, phrenic and splanchnic nerves, superior and inferior vena cavae, trachea and esophagus).

This descending cervical cellulitis can arise from submandibular space infection, and parapharyngeal space infection which may get involved from pterygomandibular space or the zygomaticotemporal space or the buccal space. Respiratory dynamics also influence the spread of infection within the mediastinum. Fluctuations in the negative intrathoracic pressures tend to draw the contents of fascial spaces into the mediastinum. Further, oral contents (air, saliva, anaerobic oral organisms) are often forced into the mediastinum, which contribute to virulent necrotizing mediastinitis **(Fig. 42.47)**. The fulminating infection can infiltrate diffusely across tissue barriers, taking the form of a descending necrotizing mediastinitis (DNM). This most lethal form of descending infection spreads along fascial planes from an oropharyngeal source through the neck to gain access to the mediastinum, necrosis occurs because the infection is often polymicrobial and gas producing.

Clinical Presentation (Fig. 42.48)

- **Age:** Most patients are in 3rd–5th decade of life.
- **Sex:** Male to female predilection of 5:1.
- **Predisposing conditions:** Diabetes, alcoholism, obesity, malnutrition and immunosuppression.



Fig. 42.48: Clinical presentation and management of a patient in intensive medical care unit, suffering from descending infection from lower right first molar, involving mediastinum and multiple organ failure

- **Signs and symptoms:** Unremitting high fever, tachycardia, tachypnea and hypotension. Pleuritic chest pain, dyspnea and retrosternal discomfort may also be present. Brawny edema, induration of the neck and chest and crepitus may be palpable. An odontogenic, peritonsillar or retropharyngeal abscess may be visible, depending on the degree of trismus. A profound leukocytosis with a left shift is common.

Radiographic study: The chest radiograph will show typical widening of the mediastinum, pneumomediastinum, pleural effusion and obliteration of the retrosternal or retrocardiac clarity.

The lateral cervical film may demonstrate widening of the retropharyngeal space, loss of normal cervical lordosis and gas along the soft tissue planes of the neck **(Fig. 42.49)**.

CT scan of the neck and chest will reveal the size and location of mediastinal fluid collection, with or without gas bubbles, pericardial effusion, empyema and airway patency **(Figs 42.50A and B)**.

Microbiology

A mixed aerobic (alpha- and beta-hemolytic *Streptococcus*, *Staphylococcus* and gram-negative bacilli) and anaerobic (*Bacteroides*, *Peptostreptococcus* and *Fusobacterium*) infection of polymicrobial nature has been implicated in the majority of cases.

Treatment

Early recognition, airway control, aggressive surgical intervention, appropriate antibiotic therapy, supportive systemic care and hyperbaric oxygen therapy, whenever indicated.



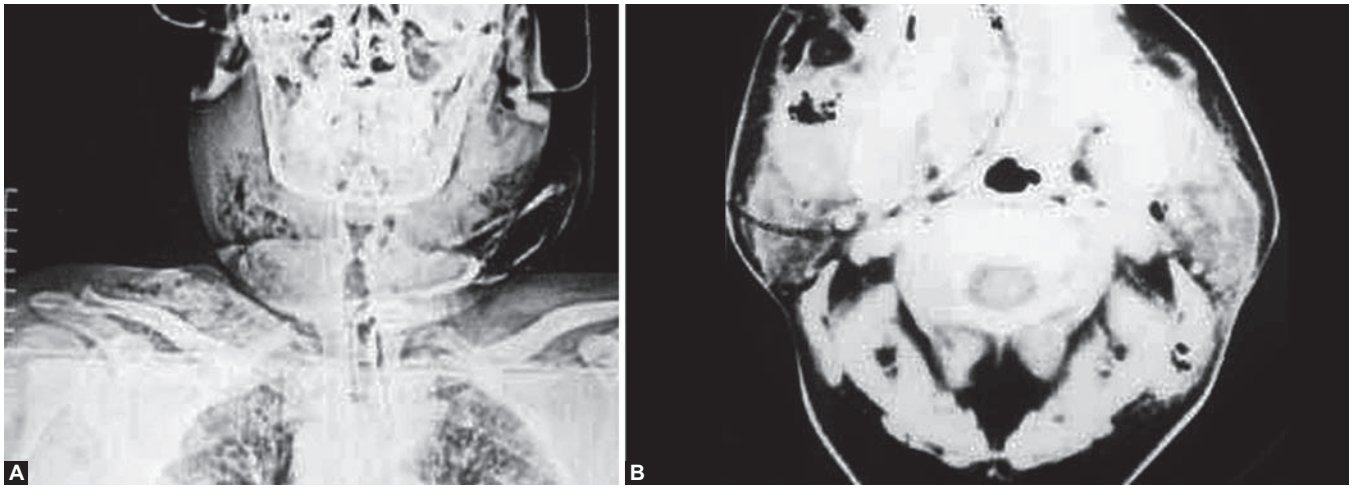
Fig. 42.49: Lateral cervical radiograph showing widening of retropharyngeal space and gas formation along the soft tissue planes

Cavernous Sinus Thrombophlebitis: Intracranial Complication (Figs 42.51A and B)

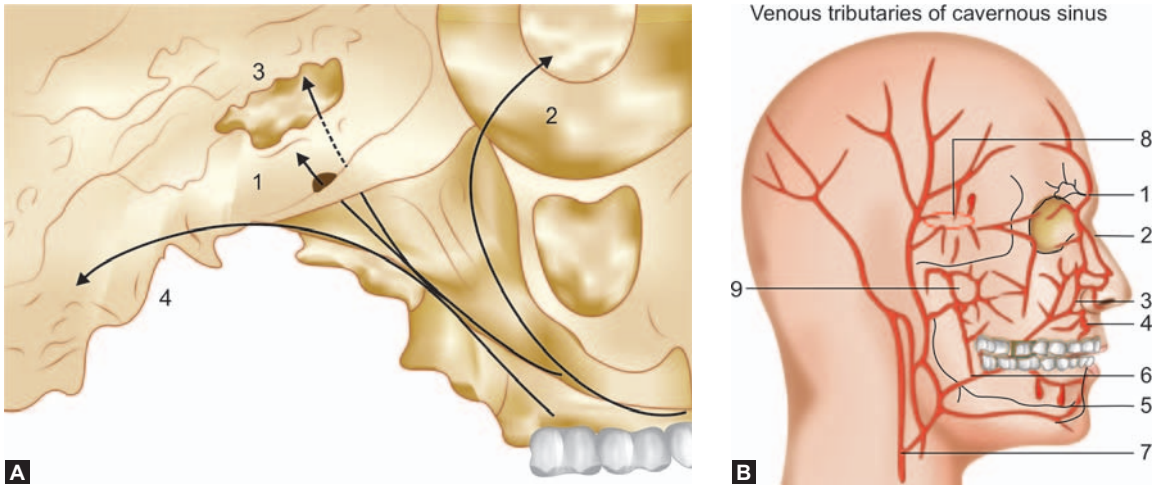
Involvement

It is a serious condition consisting of formation of thrombus in the cavernous sinus or its communicating branches. Infection of head, face and intraoral structures above the maxilla, particularly, lead to this disease. There are two routes by which infection may reach cavernous sinus.

External route: Infection from the face and lip is carried by facial and angular veins and nasofrontal veins (danger area of the face) to the superior ophthalmic vein, which enters the cavernous sinus through the superior orbital fissure, *while in internal system*, the dental infection is carried by the way of the pterygoid plexus from the posterior maxillary region, from here through the inferior orbital fissure into the terminal part of the inferior ophthalmic vein and then through the superior orbital fissure into cavernous sinus. The infection spreading by the facial or external route is very rapid with a short fulminating course because of the large, open system of the veins leading directly to cavernous sinus. In contrast, infection spreading through the pterygoid or internal route reaches the cavernous sinus only through many small, twisting passages and has a much slower course. *The other pathway from the pterygoid plexus*, is an emissary vein, which connects the cavernous sinus with the pterygoid plexus of veins. It passes through



Figs 42.50A and B: (A) Computed tomography (CT) scan of chest and neck showing mediastinum fluid collection, pericardial effusion and massive involvement of the fascial spaces with gas formation; (B) Axial CT scan showing again extensive involvement with gas bubbles



Figs 42.51A and B: Pathways of ascending infections from jaws to intracranial cavity. (A) (1) Foramen ovale, (2) Via orbital tissues, then via ophthalmic veins or superior orbital fissure, (3) Sphenoid sinus and overlying sella turcica, (4) Petrous portion of temporal bone. (B) (1) Superior ophthalmic vein, (2) Inferior ophthalmic vein, (3) Angular vein, (4) Superior labial vein, (5) Inferior labial vein, (6) Facial vein and common facial vein, (7) Carotid artery, (8) Cavernous sinus, (9) Pterygoid venous plexus

an opening of the base of the greater sphenoid wing, the foramen of Vesalius or through the fibrocartilage filling the foramen lacerum or foramen ovale.

Infection, usually involves one side initially, but can easily spread to the opposite side through the circular veins.

Rapid complications and occasionally death can result, from infections by virulent organisms from the upper part of the face, because:

- The short distance from the facial regions to the sinuses of the brain through the superiorly draining venous system.
- Frequent and complicated anastomoses of these veins leading to direct communications with the sinuses.
- The lack of protective valves that other venous systems of the body possess and which factor is significantly absent in the facial vessels involved in this complication.

Microbiology

The various bacteria implicated are streptococci and staphylococci and some gram-negative bacteria.

Clinical Features (Fig. 42.52)

Generalized constitutional symptoms, high fluctuating fever, chills, rapid pulse and sweating.

- **Initial symptoms:** It presents with: (i) swelling of the face, with edematous involvement of the eyelids. Pain in the eye and tenderness to pressure; (ii) venous obstruction leading to marked edema and congestion of eyelids; (ii) edema of conjunctiva due to impaired venous return; (iii) pulsating exophthalmos, where carotid pulse is transmitted through retrobulbar edema; (iv) cranial nerve involvement: (oculomotor, trochlear, abducens, ophthalmic division of trigeminal nerve, and carotid sympathetic plexus. It results in ophthalmoplegia, paresis or paralysis of the abducens nerve is diagnosed by the weakness or paralysis of the lateral rectus muscle of the eye. The weakness of the other muscles of the eye, culminates in paralysis, diminished or absent corneal reflex, ptosis and dilation of pupil, exophthalmos, photophobia with profuse lacrimation and pain in the distribution of the ophthalmic division of the 5th cranial nerve; (v) papilledema with multiple retinal hemorrhages, (if retina can be visualized), and chemosis, epistaxis, due to increased intracranial pressure and decreased venous return.
- **Late symptoms:** (vi) If left untreated, thrombophlebitis spreads to other side, and bilateral signs can be seen.



Fig. 42.52: Clinical presentation of cavernous sinus thrombophlebitis

- **Advanced stage:** There may be signs of advanced toxemia and meningitis, producing stiffness of the neck, with positive Kernig's sign and Brudzinski's signs and Biot's respiration. Unless it is treated early, the prognosis is poor. Septicemia with leukocytosis and severe acidosis with a positive blood culture.

Treatment

- **Antibiotic therapy:** IV chloramphenicol 1 g 6 hourly.
- Heparinization, to prevent extension of thrombosis, heparin 20,000 units in 1,500 mL of 5% dextrose or dicumarol 200 mg may be given orally, for the first day, and 100 mg daily, thereafter.
- Neurosurgical consultation.
- **Mannitol:** It reduces edema,
- Anticoagulants: It prevents venous thrombosis.
- Surgical drainage.

Points to Remember

- Etiology
- Pathways of odontogenic infections
- Microbiology
- Spread of orofacial infections
- Evaluation of the patient with orofacial infections and treatment
- Potential spaces
- Classification of fascial spaces
- Possible untoward or life-threatening complications of orofacial infections.

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CHAPTER 43

Osteomyelitis and Osteoradionecrosis of the Jaw Bones

OSTEOMYELITIS OF THE JAW BONES

Introduction and Definition

The words, "osseus" in Latin means bony, and "osteon" in Greek means "bone", and "myelos" means marrow; and "itis" in Greek means inflammation. In 1834, Nelaton first coined the word "Osteomyelitis".

By definition osteomyelitis (OML) *is an inflammation of medullary portion of bone or bone marrow or cancellous bone*. However, the process is rarely confined to medulla. It involves cortical bone and periosteum as well. Therefore, *OML may be defined as an inflammatory condition of bone that begins as an infection of medullary cavity and haversian systems of the cortex and extends to involve the periosteum of the affected area*.

The inflammation may be *acute, subacute or chronic*. It may *be localized;* or may *involve a larger portion of bone*. It may be *suppurative or nonsuppurative*.

Osteomyelitis of the jaws was once a common and dreaded disease; because of its prolonged therapy and the resultant disfigurement and dysfunction, due to loss of major portion of the jaw bone.

In the contemporary world, the incidence of OML of the jaws has become less, because of the worldwide availability of newer antimicrobials, better awareness, and better dental health care. However, we do come across a few cases of OML; the causes can be attributed to the following: (1) development of certain strains of organisms, which are resistant to certain antibiotics, and (2) presence of more cases of medically handicapped individuals in the present population. It is an opportunistic disease, as presented by the host to the pathogenic microbe.

Predisposing Factors

The factors that predispose to OML are: (1) Conditions affecting host resistance or defences, (2) Compromised vascular integrity and perfusion in the host bone, at the local, regional or systemic level and (3) Virulence of microorganisms. These factors play an important role in the onset and severity of OML **(Table 43.1)**.

- **Conditions that alter host defences** would include chronic debilitating systemic diseases—such as diabetes mellitus, agranulocytosis, leukemia, severe anemia, malnutrition, drug abuse, chronic alcoholism, sickle cell disease, and febrile illnesses such as typhoid.
- **Conditions that alter vascularity of bone**, include—therapeutic irradiation, osteoporosis, Paget's disease, fibrous dysplasia, bone malignancy, metallic bone necrosis (caused by mercury, bismuth, and arsenic). An intrinsic and extrinsic vascular component has a more profound influence, both in onset of occurrence as well as in resolution outcome.
- **Virulence of organisms**: Certain organisms precipitate thrombi formation by virtue of their destructive lysosomal enzymes (Hudson 1993). Lysosomal and enzymatic degradation of host tissue, along with microvascular thrombosis brought about by pathogen-borne bioactive peptides and chemoattracted leukocytic purulence, forms a protective barrier for the infectious foci, allowing organisms to proliferate in an enriched host medium, while protected from the host immunity.

Table 43.1: Another group of risk factors predisposing to OML of jaws (Hudson-1993)

1. Noncompliant patients refractory to health care delivery
2. Systemic, metabolically compromised individuals who can be further categorized into the following subsets (a) Age of patients, (b) Malnutrition, (c) Immunosuppression, (d) Congenital or acquired pathophysiology disrupting microvascular perfusion of the calcified tissue structure and investing soft tissue envelope.
3. Inaccessibility to health care delivery.

Brodie's (sterile) abscess of long bone OML is the classic example of this isolational phenomenon, which can also occur in OML of tooth-bearing bone, but to a lesser extent.

The process of OML is initiated by invasion of bacteria into the cancellous bone, followed by acute inflammation hyperemia, increased capillary permeability; and infiltration of granulocytes. The failure of microcirculation in the cancellous bone is a critical factor in the establishment of the OML. The infection spreads along the path of least resistance. Since the involved area becomes ischemic and bone becomes necrotic, bacteria can then proliferate, because normal blood borne defenses do not reach the tissue and OML spreads, until it is stopped by medical and surgical therapy.

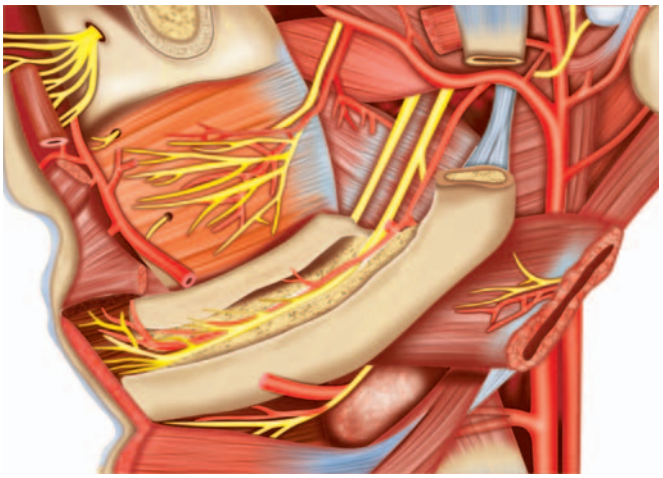


Fig. 43.1: Blood supply to mandible and its musculature

Etiology

Osteomyelitis of the jaws is caused by:

- **Odontogenic infections**: Primarily odontogenic infections originating from pulpal or periodontal tissues, pericoronitis, infected socket, infected cyst, tumor, etc.
- **Trauma**: It is the second leading cause: (a) Especially, compound fracture, and (b) Surgery-iatrogenic cause
- **Infections of orofacial regions derived from**:
  - Periostitis following gingival ulceration,
  - Lymph nodes infected from furuncles, and
  - Lacerations
  - Peritonsillar abscess.
- **Infections derived by hematogenous route**: Furuncle on face, wound on the skin, upper respiratory tract infection, middle ear infection, mastoiditis, systemic tuberculosis
- The infections from the last two groups account for a small percentage of cases.

Pathogenesis

Osteomyelitis is initiated from a contiguous focus of infection or by hematogenous spread.

Osteomyelitis is an infectious process of the medullary myeloid cavity of bone. In the craniofacial skeleton only the mandible and the calvarium have myeloid compartments.

The important factor in the establishment of OML is the compromise in the blood supply. It is worth considering the blood supply and venous drainage of mandible **(Figs 43.1 and 43.2)**.

- Blood supply (1) *Primary supply*: The mandible is supplied by inferior alveolar artery, except coronoid process, which is supplied by temporalis muscle

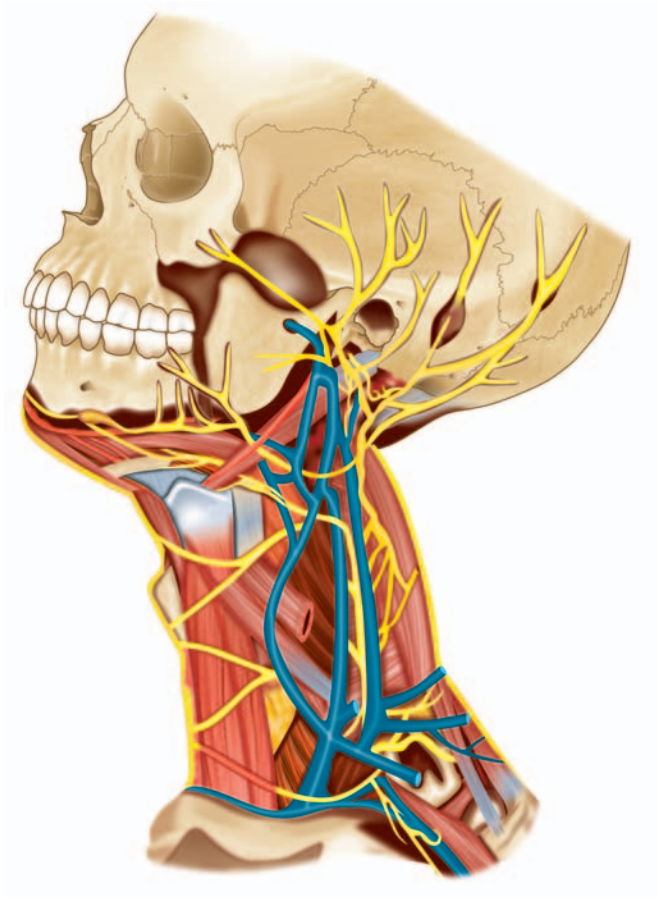


Fig. 43.2: Venous and lymphatic drainage of the head and neck region

vessels. (2) *Secondary supply*: It is the periosteal supply, which generally runs parallel to cortical surface of bone, giving off nutrient vessels those penetrate cortical bone and anastomose with the branches of inferior alveolar artery.

- **Venous drainage of mandible**: There are two routes: (1) Via inferior alveolar vein; it runs upwards, and joins pharyngeal plexus, and (2) It runs downwards, and joins external jugular veins.

  Waldron (1943), gave an exhaustive morphologic description of vascular morphology of mandible and associated structures to account for spread of OML. He described mandibular vascular support as being provided through multiple arterial loops from a single major vessel, which renders large portion of bone susceptible to necrosis with the occurrence of major vessel infectious thrombosis.

  Waldervogel (1970), described, its relationship to vascular support of long bones of developing and adult human skeleton. He made several conclusions:

1. There tends to be segregation of vascular channels, which act like "end organs", due to lack of terminal collateral anastomosis, ultimately, leading to vascular plugging by bacteria, microthrombi or both.
2. When afferent vessels anastomose with medullary channels, there is a possibility of a decrease in venous flow with associated areas of greater turbulence.
3. There may be a reduction in host immune defence mechanism associated with these vascular channels in calcified tissue.

   A true osteomyelitic infectious process does not occur in the maxilla despite the presence of tooth follicle or anatomic respiratory sinus cavities, including the nose.

Osteomyelitis in Maxilla

It is rare; due to: (1) Extensive blood supply and significant collateral blood flow in midface, (2) Porous nature of membranous bone, (3) Thin cortical plates, and (4) Abundant medullary spaces. These preclude confinement of infections within bone; and permit dissipation of edema and pus into soft tissues and paranasal air sinuses.

The mechanism of formation and accumulation of pus is worth understanding.

The process leading to OML is initiated by acute inflammation, hyperemia, increased capillary permeability and infiltration of granulocytes. Tissue necrosis occurs, as proteolytic enzymes are liberated and as destruction of bacteria and vascular thombosis continues, there is a pus formation. The pus is a combination of necrotic tissue and dead bacteria and white blood cells (WBCs) accumulate. When pus accumulates, the intramedullary pressure increases resulting in vascular collapse, venous stasis, and ischemia. Subsequently, pus travels through haversian and nutrient canals and accumulates beneath the periosteum, elevating it from the cortex; and thereby further reducing vascular supply. Compression of neurovascular bundle accelerates thrombosis, ischemia, and infarction, later resulting in paresthesia and sequestrum formation.

Extensive periosteal elevation is seen more frequently in children, since periosteum is presumed to be less firmly bound to bone. If pus continues to accumulate, the periosteum is penetrated; mucosal and cutaneous abscesses and fistulae develop. As natural host defenses and therapy begin to be effective, the process may become chronic, inflammation regresses, granulation tissue is formed; new blood vessels cause lysis of bone, thus separating fragments of necrotic bone (sequestrum) from viable bone.

Small sections of bone may be completely lyzed, whereas larger ones may be isolated by a bed of granulation tissue encased in a sheath of new bone (***Involucrum***). **Sequestra**, may be revascularized, remain quiescent, or continue to be chronically infected and require surgical removal. Occasionally, involucrum gets penetrated by channels, known as ***cloacae***, through which pus escapes from sequestrum to an epithelial surface.

Radiographically, the bone surrounding sequestrum appears less densely mineralized than sequestrum itself, since vascularity of vital bone creates relative demineralization. Ischemia causes increase in CO_2 level, which attracts calcium due to change in pH. The calcium deposition leads to increase in mineralization of the sequestrum.

Microbiology

In the past, the etiology of OML was associated with skin surface bacteria; *S. aureus*; and to a lesser extent *S. epidermidis*, or hemolytic streptococci. However, the picture of *S. aureus* as primary offending pathogen does not hold true with regard to OML of tooth-bearing bone. Sinus tract culture results, especially in the jaws, are often misleading, as they are usually contaminated with *Staphylococcus* organisms.

Most of the cases are caused by aerobic streptococci (α-hemolytic streptococci, *Streptococcus viridans*), anaerobic streptococci; and other anaerobes, such as Peptostreptococci, Fusobacteria, and *Bacteroides* (Peterson 1999). Sometimes, anaerobic or microaerophilic cocci, Gram-negative organisms such as *Klebsiella*, *Pseudomonas*

and *Proteus* are also found. Other organisms such as *M. tuberculosis*, *T. pallidum*, and *Actinomyces* species produce their respective specific forms of OML. Hence, established acute OML is usually a polymicrobial disease and includes: Streptococci, *Bacteroides*, Peptostreptococci and Fusobacteria, as well as other opportunistic bacteria. Marx et al. (1992), identified Actinomycoses, *Eikenella* and *Arachnia* as pathogens in some of the more refractory forms of OML of jaws. Other unusual organisms such as *Coccidioides*, Tuberculous bacilli, *Treponema* and *Klebsiella* have also been implicated as causative agents. The change in bacterial pattern is not because of ecology. It is attributable to the employment of more sophisticated culture methods.

Classification and Staging

Due to the long-standing existence of OML as a clinical entity, a variety of classifications of this disease process have evolved.

A variety of classifications of various forms of the disease are given, which are as follows:

- **Historically accepted classification:** It is based on clinical course.
  (A) Acute, and (B) Chronic. The arbitrary time limit, to identify acute from chronic forms, is of 1 month. (Koorbusch et al. 1992, Marx; 1992, and Mercuri; 1992) **(Table 43.2)**.
- *Classification based on pathogenesis of altered vascular perfusion as a major contributing factor to the presence and persistence of OML as a clinical disease.* (Vibhagool et al. 1993): There are three types:
  - Hematogenous OML
  - OML secondary to a contiguous focus of infection
  - OML associated with or without peripheral vascular disease.
- *Classification based on presence or absence of suppuration* ***(Table 43.3)***.
- Cierny et al. (1985) and Vibhagool (1993) developed a classification and staging system; based on
  - Anatomic location of infectious process, and
  - Physiological status of the host, (iii) Systemic or local factors affecting immune system, metabolism, and local vascularity **(Table 43.4)**.

Acute Pyogenic OML (Acute Suppurative OML)

It may have the appearance of a typical odontogenic infection.

It can be localized and widespread, with extensive sequestration and possible pathological fracture.

Table 43.2: Hudson's classification of OML of the jaws

A.	*Acute Forms of OML* (suppurative or nonsuppurative) include:
	a. *Contiguous focus:* (i) Trauma, (ii) Surgery, and (iii) Odontogenic infections b. *Progressive:* (i) Burns, (ii) Sinusitis, and (iii) Vascular insufficiency c. *Hematogenous (metastatic):* Developing skeleton (children)
B.	*Chronic Forms of OML*
	a. *Recurrent multifocal:* (i) Developing skeleton (children), (ii) Escalated osteogenic activity (< age 25 years) b. Garre's: (i) Unique proliferative subperiosteal reaction, (ii) Developing skeleton (children to young adults) c. *Suppurative or nonsuppurative:* (i) Inadequately treated forms, (ii) Systemically compromised forms, and (iii) Refractory forms (CROML: Chronic refractory OML) d. *Diffuse sclerosing:* (i) Fastidious organisms, and (ii) Compromised host/ pathogen interface

Table 43.3: Suppurative and nonsuppurative OML

Suppurative OML	*Nonsuppurative OML*
i. Acute suppurative (pyogenic) OML	i. Chronic sclerosing OML
ii. Chronic suppurative (pyogenic) OML	a. Focal sclerosing OML b. Diffuse sclerosing OML
a. Primary b. Secondary	ii. Garre's sclerosing OML
iii. Infantile OML	iii. Actinomycotic OML
	iv. Radiation OML (ORN)
	v. Specific infective OML
	a. Tuberculosis b. Syphilis

Microbiology

It is caused by pyogenic organisms. OML in the tooth-bearing area is polymicrobial in nature. The most commonly found organisms in odontogenic OML is *Staphylococcus aureus*; and also *Streptococcus pyogenes*. Vincent's spirochetes may also be present. Gram-negative bacilli may also be present (*E. coli*).

Etiology

(1) Odontogenic infections, (2) Local traumatic injuries, (3) Peritonsillar abscess, (4) Furunculosis, (5) Hematogenous infections, (6) Infected compounded odontoma (Romer, 1955), (7) Compound fractures of jaws are complicated by OML.

Table 43.4: Classification and staging system of OML developed by Cierny et al. and Vibhagool

I. Anatomic Types		
Stage I	Medullary OML:	It involved medullary bone without cortical involvement; usually hematogenous
Stage II	Superficial OML:	Less than 2 cm of bony defect without cancellous bone
Stage III	Localized OML:	Less than 2 cm bony defect seen on radiograph, defect does not appear to involve both cortices
Stage IV	Diffuse OML:	The defect is less than 2 cm, pathological fracture, infection, and nonunion
II. Physiological Types		
A Host:	Normal host	
B Host:	Systemic compromise (Bs); local compromise (Bl)	
C Host:	Treatment is worse than the disease.	
III. Systemic or Local Factors that Affect Immune Surveillance, Metabolism, and Local Vascularity		
a. *Systemic (Bs):*	(i) Malnutrition, (ii) Renal or hepatic failure, (iii) Diabetes mellitus, (iv) Chronic hypoxia, (v) Immune deficiency or suppression, (vi) Malignancy, (vii) Extremes of age, (viii) Autoimmune disease, and (ix) Tobacco and Alcohol abuse	
a. *Local (Bl):*	(i) Chronic lymphedema, (ii) Venous stasis, (iii) Major vessel disease, (iv) Arteritis, (v) Extensive scarring, (vi) Radiation fibrosis, (vii) Small vessel disease, and (viii) Loss of local sensation	

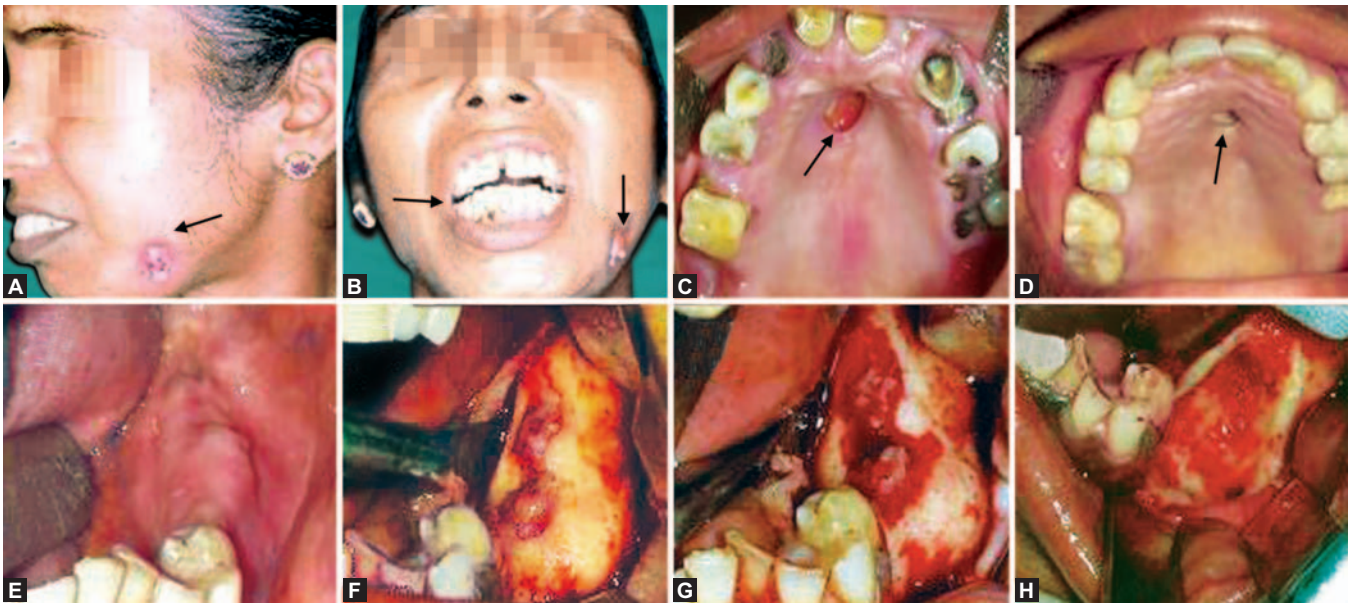
- **Odontogenic infections (Figs 43.3A to H)**: These are the common local cause of OML. These infections may result from:
  - Periapical disease secondary to pulp pathosis,
  - Periodontal disease, **(Figs 43.4A to C)**
  - Pericoronitis of long duration,
  - Infected odontogenic cyst, and
  - Infection of an extraction wound or fracture site.
- **Local traumatic injuries**: (a) Injuries of gingiva, are usually insignificant; however, may become serious in patients with low resistance (Ivy and Cook, 1942), and (b) Instruments used for extraction of teeth.
- **Peritonsillar abscess**: It has been reported as a cause of OML of ascending ramus.
- **Furunculosis**: Of skin is a rare cause of OML. Hoenig et al. (1931) have reported such a case.
- **Hematogenous infection**: It may cause multiple sites of OML. The organisms enter the blood stream through a minor wound in the skin, or infection of upper respiratory tract, or infection of middle ear. The predisposing factors include: (1) Undernourished children, (2) Lowered general resistance of body, (3) Generalized body diseases: such as; diabetes, leukemia and agranulocytosis, and (4) Acute illnesses, such as influenza, measles, scarlet fever, pertussis and pneumonia, etc. Blair et al. (1931), reported one case following tonsillitis, one following measles, and one following diphtheria. Galli, (1926) reported a case of OML of maxilla associated with renal complication. Recently, with the use of newer antibiotics and early institution of antibiotics hematogenous spread is not commonly seen.

Clinical features: *Occurrence*: In adults, it is more common in mandible and involves alveolar process, angle of mandible, posterior part of ramus and coronoid process. OML of condyle is reportedly rare (Linsey, 1953).

A. Early cases are characterized by:

- **Generalized constitutional symptoms**: High intermittent fever, malaise, nausea, vomiting, anorexia
- Deep seated boring, continuous intense pain in the affected area
- Intermittent paresthesia or anesthesia of the lower lip, which helps the clinician to differentiate this condition from alveolar abscess.
- Facial cellulitis, or indurated swelling of moderate size, which is more confined to the periosteal envelop and its contents. (i) Thrombosis of inferior alveolar vasa nervorum, (ii) Rise in pressure from edema in inferior alveolar canal, (iii) Teeth are tender to percussion and loose, and
- Trismus.

  In children: (i) Fulminating. (ii) Severe and serious. (iii) Involvement of maxilla or mandible. (iv) Complicated by the presence of unerupted developing teeth buds, which become necrotic and act as foreign bodies and prolong the disease process.



Figs 43.3A to H: (A) Clinical picture of acute suppurative osteomyelitis due to odontogenic infection. Note the draining sinus; (B) The decreased oral opening of the patient due to oral submucous fibrosis; (C) Intraoral palatal perforation and pus discharge; (D) In another patient chronic suppurative osteomyelitis due to odontogenic cause, palatal chronic fistula seen; (E) Intraoral picture showing swelling and pus discharge from lower left first, second and third molar region; (F) Surgical exposure showing presence of granulation tissue; (G) Curettage done, sequestras exposed; (H) Sequestrectomy and saucerization carried out

Long-term involvement of temporomandibular joint (TMJ) can cause ankylosis of TMJ and subsequently affect the growth and development of facial structures.

Laboratory studies: Show mild leukocytosis [polymorphonuclear leukocytes (PMNL)] and albuminuria.

B. Established cases are characterized by:

- Deep pain, malaise, fever, dehydration, anorexia
- Teeth in involved area begin to loosen and become sensitive to percussion
- Purulent discharge through sinuses: (a) Intraorally; (i) around gingival sulcus: or (ii) through buccal vestibule, and (b) Extraorally on the face, through cutaneous fistulae
- Fetid odor is often present
- Trismus may be present
- Dehydration, acidosis and toxemia
- Regional lymphadenopathy is usually pesent.

Laboratory studies show: (1) Moderate leukocytosis (PMNL), and (2) Slightly elevated erythrocyte sedimentation rate (ESR) (3) Anemia, and (4) Albuminuria. Blood cultures, wound culture and sensitivity, and complete blood count along with peaks and troughs on any antimicrobial prescribed should be assessed on a regular basis. Radiological changes are absent initially.

Chronic Osteomyelitis

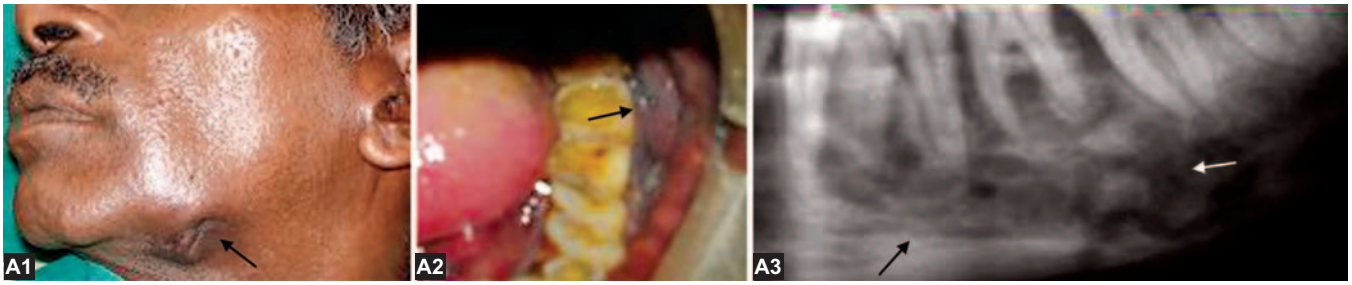
It can be (a) *primary*: resulting from organisms which are less virulent, and (b) *secondary:* occurring after acute OML, when the treatment did not succeed in eliminating the infection **(Figs 43.4A and B)**.

The clinical features are usually limited to: (1) Pain and tenderness: the pain is minimal, (2) Nonhealing bony and overlying soft tissue wounds with induration of soft tissues, (3) Intraoral or extraoral draining fistulae, (4) Thickened or "wooden" character of bone, (5) Enlargement of mandible, because of deposition of subperiosteal new bone. (6) Pathological fractures may occur, **(Figs 43.5A to C)** (7) Sterile abscess (Brodie's abscess), common to long bones is rare in jaws. (8) Teeth in the area tend to become loose and sensitive to palpation and percussion.

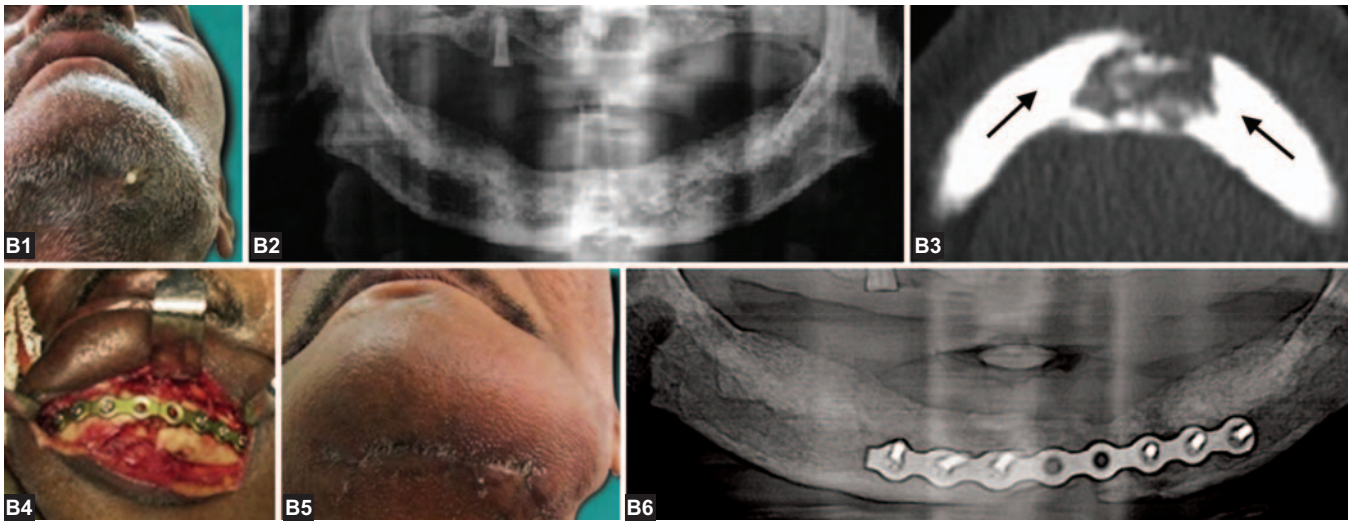
Radiographic Findings

The radiological examination can be accomplished by the use of the following methods:

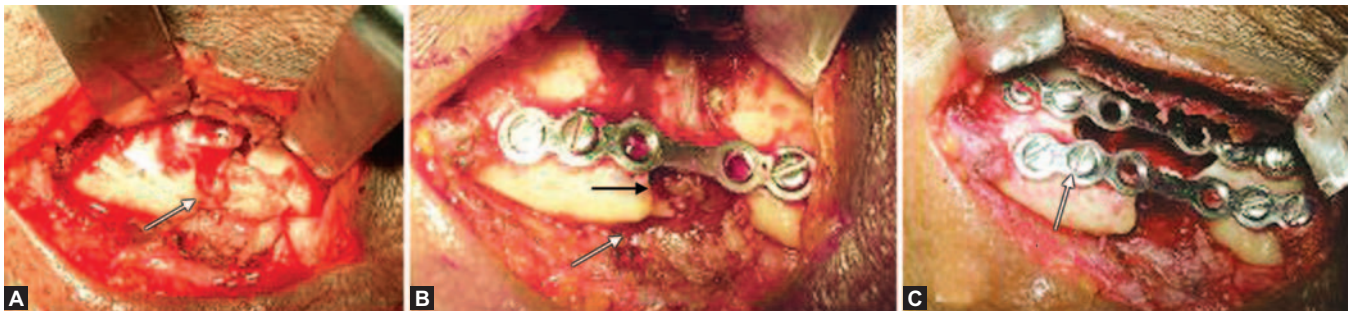
A. **Conventional radiography**: Radiographic changes occur only 3 weeks after initiation of OML process.



Figs 43.4.A1 to 3: Chronic osteomyelitis due to periodontal disease: (A1) Extraoral sinus; (A2) Chronic intraoral abscess in lower left first and second molar region; (A3) OPG showing multiple sequestra



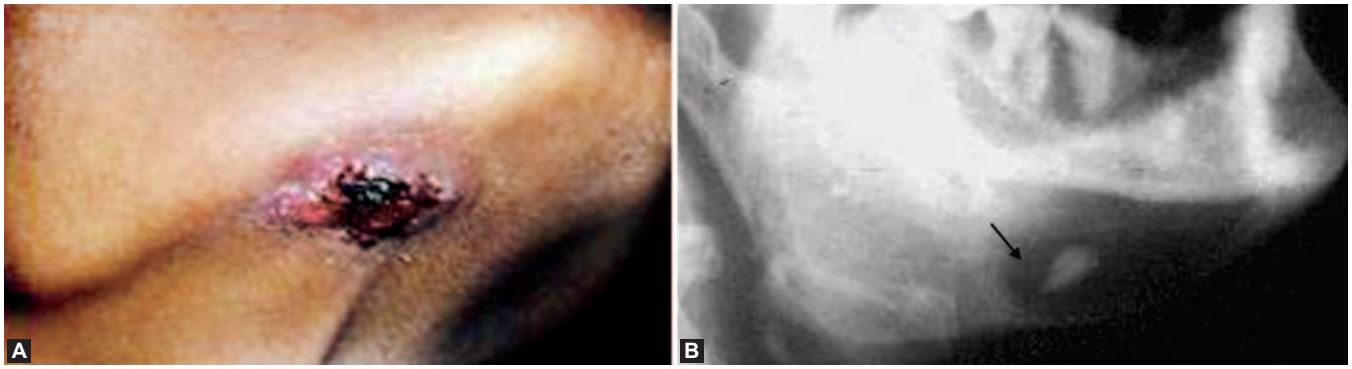
Figs 43.4B1 to 6: Chronic osteomyelitis due to external injury in a diabetic patient: (B1) Extraoral draining sinus and swelling; (B2) OPG showing notched radiolucency at the inferior border in symphysis region; (B3) CT scan revealing destruction and sequestrum in symphysis region; (B4) Extraoral surgical exposure for sequestrum removal and curettage and reconstruction plate fixation; (B5) Extraoral healing; and (B6) Postoperative OPG



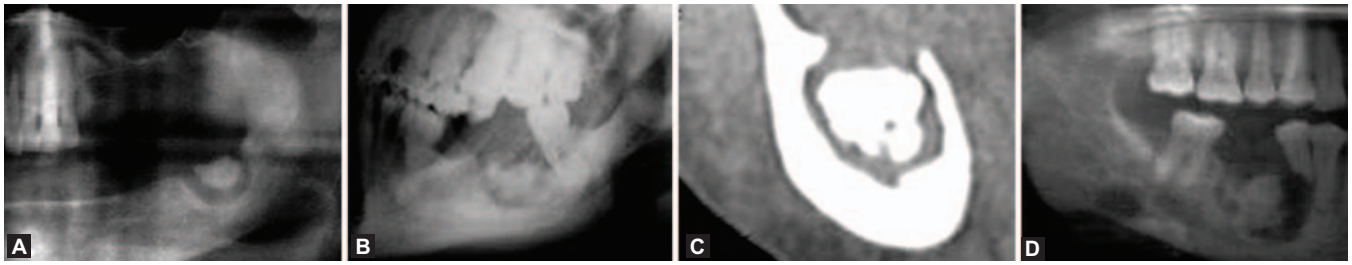
Figs 43.5A to C: Pathological fracture due to chronic osteomyelitis: (A) Pathological fracture exposed surgically; (B) Chronic unhealthy granulation tissue curettage done with freshening of bony margins; (C) Bony defect bridged and fragments stabilized using bone plate fixation

It is generally accepted that 30–60% of mineralized portions of bone must be destroyed before significant radiographic changes are noted. This degree of bone alteration requires a minimum of 4–8 days after the onset of acute OML. Therefore, in early stages, history and clinical features constitute the sole data upon which diagnosis can be made.

In early stage, there is widening of marrow spaces, and enlargement of Volkmann's canals, which imparts a "mottled appearance".



Figs 43.6A and B: (A) Extraoral draining sinus, (B) Lateral oblique view showing the radiopaque sequestrum



Figs 43.7A to D: OPG, lateral view mandible X-ray and dentascan image showing the sequestrum and involucrum

The granulation tissue between living and dead bone produces irregular lines and zones of radiolucency. This results in characteristic "moth-eaten appearance" of established OML.

In later stages, the cortex gets involved and due to ischemia, an island of cortical bone becomes devitalized and becomes favorable for the precipitation of ionized calcium, mobilized by the surrounding osteolytic process. The gradual resorption around periphery of infarcted area of bone separates it off as a sequestrum. Such a devitalized piece of bone appears sclerosed and becomes a foreign body which is called as sequestrum. These segments appear highly calcified and therefore appear prominent. Large areas of bone destruction are seen as radiolucent areas.

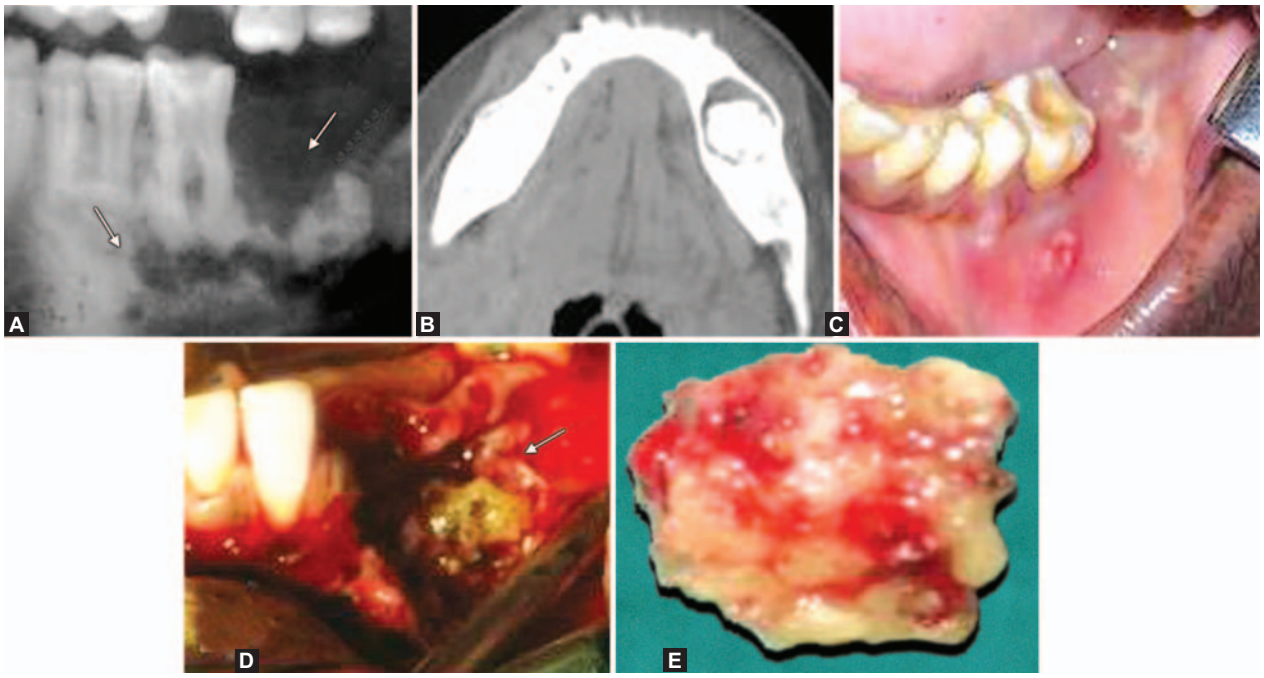
Subperiosteal new bone, *the involucrum*, can be seen as a fine linear opacity, or as a series of laminated opacities, like an onion skin, parallel to surface of cortex. This is seen at the lower border; or may be best outlined on buccal cortex by an occlusal film. This adds to loss of radiological definition of original underlying bone structure. Where new bone is superimposed upon that of jaw, a delicate "fingerprint" or "orange-peel" appearance is seen.

The deposition of subperiosteal new bone—involucrum is particularly marked in children and adolescents, and absent in adults. Later, substantial fragments of dead bone, especially, thick cortical bone may be separated from adjacent bone by well-demarcated radiolucent zones and may even become displaced from their original position.

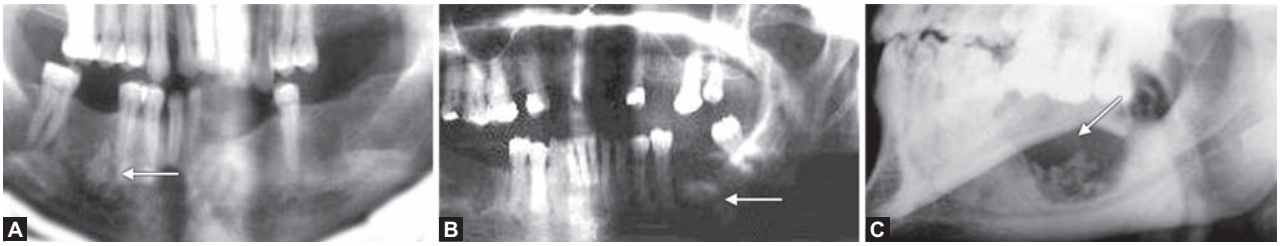
Sequestra often prevented from spontaneous discharge through sinus, in overlying soft tissue by enveloping involucrum and comes to lie in granulation tissue and pus-filled cavities between involucrum and surviving mandibular bone. At this stage, there is a risk of pathological fracture.

Once OML is well established, radiographical changes usually demonstrate one of the following sets of characteristics, as suggested by Worth (1969) **(Figs 43.6 to 43.9)**.

- Scattered areas of bone destruction, separated by variable distances. The appearance is one of increased radiolucency, which may be uniform or patchy. There is a "moth-eaten" appearance, because of enlargement of medullary spaces and widening of Volkmann's canals.
- Bone destruction of varied extent, in which there are "sequestra" with a trabecular pattern and marrow spaces. A sheath of new bone, "involucrum", is often found separated from sequestra by a zone of radiolucency. (There are areas of radiopacity within the radiolucency. The radiopaque areas represent islands of bone that have not been resorbed-sequestrum).



Figs 43.8A to E: (A) Lateral oblique view of left mandible showing chronic osteomyelitis due to odontogenic infection. Note that the extraction of left second and third lower molars has been done. First lower molar shows periapical pathology; (B) CT scan showing the presence of sequestrum; (C) Intraoral picture of the patient showing swelling, draining sinus and pus discharge; (D) Surgical exposure of sequestrum; (E) Big sequestrum removed



Figs 43.9A to C: Chronic osteomyelitis of the mandible due to odontogenic cause. Arrows on OPGs and lateral view mandible is showing sequestrum formation with surrounding radiolucent zone

- Stippled or granular densifications of bone caused by subperiosteal depositions of new bone obscuring intrinsic bone structure or depositions of new bone on the surfaces of existing trabeculae, at the expense of marrow spaces **(Fig. 43.10)**.

B. **Imaging**: Specialized radiographic techniques—the other radiographic techniques employed for diagnosis are: (1) Computerized tomography (CT), (2) Radioisotope scanning, (3) Positron emission tomography (PET)
   - **Computerized tomography**: It gives a more definitive picture of calcified tissue involvement, especially with regard to disruptions of cortical plates.



Fig. 43.10: Subperiosteal deposit of new bone

- **Radioisotope scanning**: Radioisotope Tc-99m methylene diphosphonate bone scanning can identify occult areas of involvement and has previously been used to identify margins or extent of calcified tissue involvement. However, due to poor resolutions, this has not been proved to be effective.
- **Positron emission tomography**: More recently, PET, using radioisotopes of physiologically active compounds such as glucose, ammonia and fluoride has shown greater promise in mapping out varying margins of metabolic activity. Changes in the bone are seen as early as 3 days, after the onset of symptoms of OML. (a) Confirms the diagnosis of very early OML. (b) Early interceptive antibiotic and supportive therapy can be instituted. (c) Establishment of the typical, fulminating disease can be prevented. (d) Useful in chronic OML, when a decision is to be taken regarding the prolonged duration of antibiotic therapy. A negative evidence indicates that bone activity has ceased and supports discontinuing therapy. (e) In those patients, who show early symptoms suggestive of relapse, a positive scan allows early diagnosis and immediate resumption of therapy, before symptoms worsen.

Diagnosis: It is made on basis of: (1) Presence of sequestra, (2) Areas of suppuration involving the tooth-bearing area of jaw bone, not responding to debridement and conservative therapy, (3) Regional or systemic compromise of immune response, microvascular decompensation or both.

Treatment: The treatment measures remain the same as for acute as well as for chronic OML.

In certain circumstances, after performing the necessary surgical procedures, where the soft tissues cannot be closed without leaving dead space, or because of rigid fibrosis; the wound may be packed with 2" ribbon gauze soaked with Whiteheads varnish.

A differentiation has to be made between the types of bone encountered. The necrotic but unsequestrectomized bone, the cortex has dirty-white color; while the living cortical bone has a yellowish hue. The viable cortex shows tiny red bleeding spots on cut surfaces.

Chronic external sinuses require irrigation.

Resection: It is rarely required. When full thickness of segment of jaw is involved and a conservative approach has failed to cure, resection of the involved part should be considered. However, the only soft tissue related to the necrotic bone should be elevated, to avoid devitalization of the adjoining cortex.

Table 43.5: The treatment guidelines for acute or chronic OML (Marx, 1992)

1.	Disrupt infectious foci
2.	Debride any foreign bodies, necrotic tissue, or sequestra
3.	Culture and identify specific pathogens for eventual definitive antibiotic treatment
4.	Drain and irrigate the region
5.	Begin empiric antibiotics based on Gram stain
6.	Stabilize calcified tissue regionally
7.	Consider adjunctive treatments to enhance microvascular reperfusion: (a) Trephination, and (b) Decortication. These may be accomplished during debridement, (c) Vascular flaps (muscle), and (d) Hyperbaric oxygen (HBO) therapy.
8.	*Reconstruction:* As necessary following resolution of infection.

Secondary bone grafting: This should be considered when the wound has healed completely and is free of infection.

Management: The management includes:

(A) Conservative treatment, and (B) Surgical treatment.

The goal of the management is to: (i) Attenuate and eradicate proliferating pathological organisms, (ii) promote healing and (iii) re-establish vascular permeability **(Table 43.5)**.

Successful treatment is based on the following fundamental principles: (1) Early diagnosis, (2) Bacterial culture and sensitivity testing, (3) Adequate, appropriate, and prompt antibiotic therapy, (4) Adequate pain control, (5) Proper surgical intervention, (6) Reconstruction, where indicated.

A. **Conservative management**: It includes: (1) Complete bed rest, (2) Supportive therapy, (3) Dehydration, (4) Blood transfusion, (5) Control of pain, (6) IV antimicrobial agents, (7) Postoperative care, (8) Hyperbaric oxygen (HBO therapy), and (9) Special treatment for specific needs.

B. **Surgical management**: The various surgical treatment modalities reported in literature, are adjunct to medical treatment; and include: (1) Extraction of offending teeth, (2) Incision and drainage, (3) Continuous or intermittent indwelling closed catheter irrigation, (4) Sequestrectomy and saucerization, decortication, (5) Resection of jaw with or without immediate or delayed reconstruction with bone graft and (6) Postoperative care.

A. Conservative management:

- Complete bed rest
- **Supportive therapy**: It includes, nutritional support, in the form of high protein and high caloric diet; and adequate multivitamins
- **Dehydration**: Hydration orally or through administration of IV fluids
- **Blood transfusion**: In case, RBCs and hemoglobin is low
- **Control of pain**: It is controlled with analgesics. Sedation may be employed for keeping patient comfortable and allow to sleep
- **IV antimicrobial agents**: Penicillin remains the time honoured empiric antibiotic of choice for OML of jaws (Vibhagool, 1993).

Since streptococci and penicillin sensitive anaerobes are organisms frequently involved. Antibiotics of value in treatment of OML include: penicillins, penicillinase-resistant penicillins, clindamycin, cephalosporins, and erythromycins. Some of the newer antibiotics which provide effective coverage include: metronidazole, clindamycin, ticarcillin, clavulanic acid, cephalosporins, vancomycin in combination with other antibiotics, and fluoroquinolones.

Another unique pharmacological measure that has been tried experimentally; is the use of prostaglandin-inhibiting salicylate therapy. This is in an attempt to diminish osteolytic destruction (Dekel and Francis, 1981).

Hudson (1993), in his 50 years perspective on OML of jaws, described various methods to augment systemic host immune response to reach the site of infection. (1) Intra-arterial antibiotic therapy, (2) Local implantation of antibiotic saturated beads [Nakajima et al. (1977), and Goodell et al. (1986)], and (3) HBO therapy.

Recommended antibiotic regimens for OML of jaws are as follows:

1. **Regimen I**: (1st choice): As Empirical therapy, Penicillin (Penicillin V) is given.
   a. **Aqueous Penicillin**: 2 million units IV every 4 hourly.
   b. **Oxacillin**: 1 g IV every 4 hourly.

   When the patient has been asymptomatic for 48–72 hours, then switch to— Penicillin V orally 500 mg. Every 4 hourly with dicloxacilin 250 mg. Orally every 4 hourly for 2–4 weeks.
2. **Regimen II**: It is based on culture and sensitivity results. Penicillinase-resistant penicillins, such as oxacillin, cloxacillin, dicloxacillin, or flucloxacillin may be given.

   In case of allergy to penicillin, the following antibiotics are prescribed, in order of preference: (i) Clindamycin 300–600 mg orally 6 hourly. (ii) Cephalosporin 250–500 mg orally every 6 hourly: (a) Cefazolin 500 mg 8 hourly, or (b) Cephalexin 500 mg 6 hourly. (iii) Erythromycin 2 g every 6 hourly IV, then 500 mg every 6 hourly orally.

   Second choice: Clindamycin: It is effective against penicillinase producing staphylococci, streptococci and anaerobic bacteria including *Bacteroides*. It is used because of its ability to diffuse widely in bone. It is not recommended as first choice; as it is bacteriostatic, and causes diarrhea due to pseudomembranous colitis.

   Third choice: Cefazolin or Cephalexin: It is effective against most cocci including penicillinase-producing staphylococci, Gram-negative aerobic bacilli viz. *E. coli*, *Klebsiella*, and *Proteus*.

   Cephalosporins are not recommended as first choice; because: (i) these are moderately effective against anaerobes, and (ii) because of broad spectrum coverage, which increases antibiotic complications (Bacterial resistance and superinfection).

   Fourth choice: Erythromycin: These drugs cannot be used as first choice, as these are: (i) bacteriostatic, and (ii) rapidly develop resistant strains.

   The dose and duration of antimicrobial therapy is dependent upon severity of infection and its response to treatment. Usually with the disruption of the organized foci and with potent, sustained and penetrating bactericidal antimicrobial therapy, most cases of suppurative and nonsuppurative OML will rapidly resolve.
7. **Special treatment for specific needs**: Anemia, diabetes mellitus, and malnutrition need specific treatment.

   Specific infective forms of chronic OML include: tuberculosis, syphilis, and actinomycosis. Their management is the same, as in chronic OML; and in addition, their respective appropriate medications have to be instituted. Tuberculosis may require therapy for up to a year, while actinomycosis may require for 2–3 months.

Complications: Several sequalae/complications can occur as a result of OML of jaws.

1. **Neoplastic transformation**: With chronic OML, neoplastic conversion of inflammatory metaplasia to squamous cell carcinoma is noted. The incidence reported is 0.2–1.5%.
2. **Discontinuity defects**: The defects can be (a) spontaneous or (b) surgically induced; necessitating

jaw reconstruction; once infection is resolved **(Figs 43.11A to D)**.

3. **Progressive diffuse sclerosis**: It involves the medullary and cortical portions of maxillofacial skeleton; especially mandible, over a period of time.

A. **Hyperbaric oxygen in treatment of OML: (Fig. 43.12)**: Hyperbaric oxygen therapy involves the intermittent, usually daily, inhalation of 100% humidified oxygen under pressure, greater than one atmospheric absolute pressure (ATA). Patient is placed in a chamber; O_2 is given by mask or by hood. Each "dive" is 90 minutes in length. The treatment is given 5 days/week for 30, 60, or more dives in monoplace chamber at 2.4 ATA for 90 minutes while breathing 100% oxygen twice daily.

Over the last several decades, HBO therapy has emerged as (i) a potent alternative to surgical reperfusion; and (ii) as an adjunctive enhancement to host-immune response. Its use has increased in the treatment of OML and osteoradionecrosis (ORN).

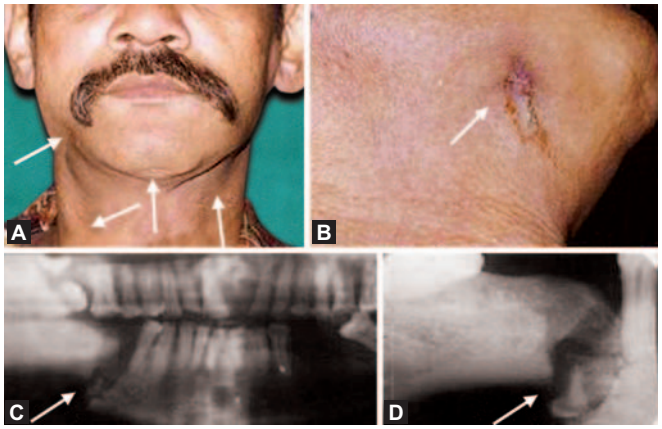
HBO therapy increases a dose of oxygen dissolved in the plasma and delivered to the tissues. It reduces hypoxia within the affected tissues and stimulates angiogenesis in the hypovascular tissues. The mechanism of HBO on nonhealing wounds is complex. Regular, periodic elevation of the oxygen within hypoxic tissues has shown to enhance the phagocytic ability of leukocytes to stimulate fibroblast growth, increase collagen formation and promote growth of new capillaries.

Five aspects of the action of HBO are beneficial:

- HBO therapy enhancement of lysosomal degradation potential of polymorphonuclear leukocytes and O_2 radicals; which are major components of catabolic enzymes of macrophage lysosome. Formation of these enzymes is decreased in hypoxic environment, as in OML.
- Free radicals of O_2 are toxic to many pathogenic anaerobes (bactericidal).
- Many exotoxins liberated by microorganisms are rendered inert by exposure to elevated partial pressure of O_2.
- Tissue hypoxia is intermittently reversed by HBO therapy mimicking tissue level during wound healing.
- Positive enhancement of neoangiogenesis, in the aerobic portion of proliferative phase of wound healing.

The beneficial effects presumably result from:

- An increased vascular supply, and
- Increased O_2 perfusion to ischemic areas of infection,
- Bactericidal or bacteristatic action of increased O_2 levels [(Bornside, (1967); Gottlieb and Pakman (1968)].



Figs 43.11A to D: (A) Front view of a patient with multiple facial scars due to trauma six months back; (B) Chronic draining extraoral sinus on the Right side of the lower border of the mandible; (C) After multiple surgical exploration and prolonged antibiotic therapy also the chronic osteomyelitis with sequestrum formation is seen in OPG. The osteomyelitis is developed following compound fracture of right body mandible; (D) Intraoral periapical X-ray of the same area. Thorough curettage with extraction of lower right first premolar, excision of cutaneous tract and stabilization of fracture with reconstruction plate and stepping up of appropriate antibiotic cover resulted in good healing



Fig. 43.12: Hyperbaric oxygen chamber

Adequate tissue O_2 tension also facilitates fibroblast proliferation, new capillaries formation (Hunt et al. 1975), osteogenesis (Makley et al. 1967, Penttinen et al. 1971), and optimal polymorphonuclear leukocyte function (Mandell, 1974; McRiplet and Sbarra, 1967).

The therapeutic and detrimental effects result from features of this treatment: (i) The mechanical effects of increased pressure; and (ii) the physiological effects of hyperoxia (Grim et al. 1990). HBO therapy produces improved tissue oxygenation due to increased arterial oxygen tension and increased dissolved plasma oxygen content. The therapy also produces a vasoconstriction

of arteries related to the degree of pressure (Ricci and Calogero 1988).

Clinical effects: It aids in healing of draining sinus, improves osteogenesis in lytic areas, reduces destruction of bone and soft tissues, sequestra undergo rapid dissolution without suppuration; and healing frequently eliminates the need for surgical intervention.

Clinical application: It has been described by Hart and Mainous, (1976) and Marx, (1983). The protocol they followed is as follows: the patients were treated with 2 ATA of O_2 for a total of 60 sessions (i.e. 120 hours), or until they are asymptomatic, and the defects are closed. Patients with osteoradionecrosis (ORN) are subjected to second course of series of treatment 6 months later, consisting of 22 hours daily. Mansfield et al. (1981) have described a modified treatment regimen, with alternating 100% O_2 with intermittent O_2 followed by air. This is done to avoid possible O_2 toxicity (Hendricks et al. 1977).

The protocol of Marx (1983b) for ORN is divided into three stages. First stage comprises of 30 initial dives. If patient shows definite improvement clinically, then a full course of 60 dives is completed. Otherwise, sequestrectomy is done and then 30 additional dives are completed. If there is wound dehiscence, resection is done and 60 dives are completed. Then patient receives additional 20 dives, 10 weeks after resection, in preparation for reconstruction with bone graft. Patient with pathological fracture, oro-cutaneous fistula, and resorption of inferior border are given an initial 30 dives prior to undergoing resection.

Due to the effects of increased O_2 tension on cell mitosis and cell proliferation, patients with known as neoplastic disease should not be treated with HBO (Laskin, 1999).

Antioxidation supplementary therapy: Marx (1992) described cellular respiration in a discussion of superoxide dismutase scavenging ability of most aerobic organisms. There are periods of sustained ischemia and hypoxia, which are followed by reperfusion. This allows normal endogenous antioxidant capability resulting in tissue reperfusion injury to occur. The xanthine oxidase enzymatic pathways is responsible for liberation of superoxide radicals.

Control of this destructive activity is appreciated in soft tissue flap transfer, and organ transplantation, and is accomplished by using— (i) allopurinol which blocks xanthine reduction, and (ii) tocopherol (vitamin E) antioxidant supplemental therapy.

Contraindications: The contraindications to HBO therapy; as considered by the HBO Committee of the Undersea Medical Society, Fisher et al. (1988), and Marx et al. (1985) are as follows: (i) Pneumothorax, (ii) Severe chronic obstructive pulmonary disease, (iii) Optic neuritis, (iv) Acute viral infection, (v) Congenital spherocytosis, (vi) Uncontrolled acute seizures disorders, (vii) Upper respiratory tract infection, (viii) Uncontrolled high fever, (ix) Pregnancy (questionable), (x) Psychiatric problems, (xi) History of prior thoracic or ear surgery. (xii) Malignant disease.

Potential complications: Some of the possible complications associated with HBO therapy are listed here. [Gabb and Robbin, (1987), Wirjosemito and Touhey (1988), and Giebfried et al. (1986)].

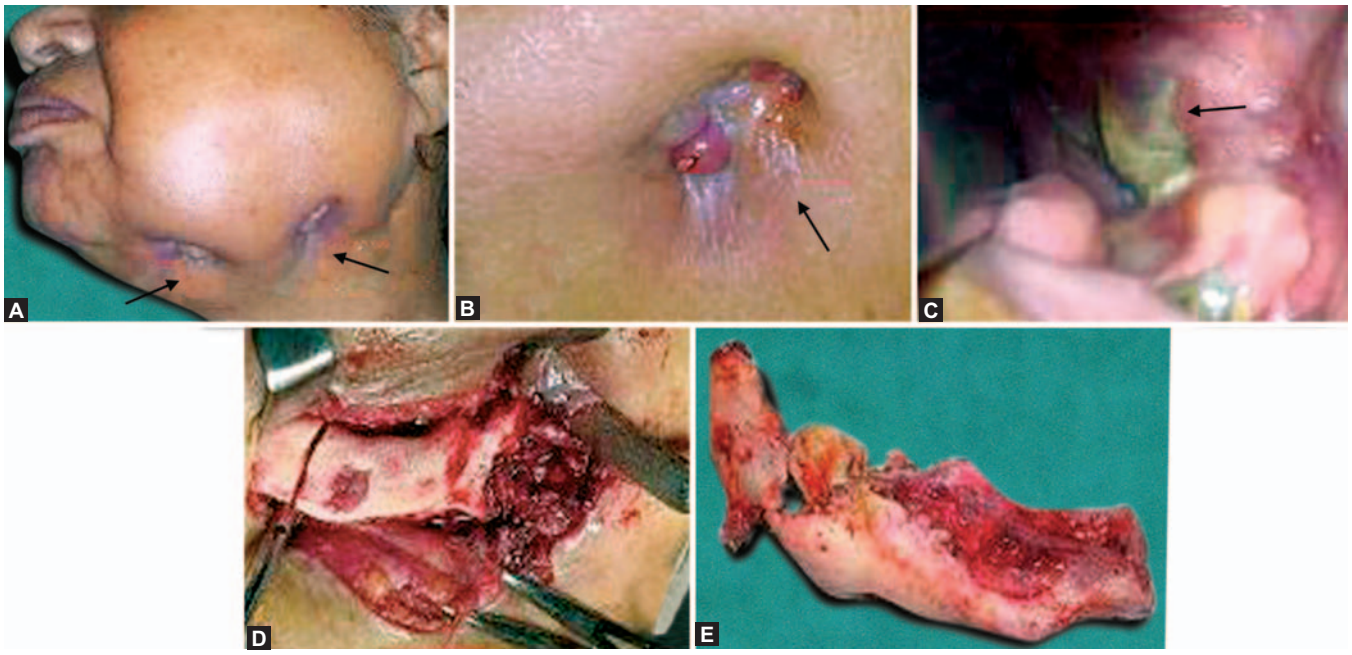
(i) Eustachian tube dysfunction, (ii) Tympanic membrane rupture, (iii) Oxygen toxicity, (iv) Ear, sinus or tooth pain, (v) Decompression sickness, (vi) Pneumothorax, (vii) Arterial gas embolism, (viii) Nitrogen emboli to CNS, lung or joints, (ix) Middle ear hemorrhage, (x) Deafness, (xi) Changes in vision, (xii) Certain hemolytic anemias, (xiii) Fire hazard, (xiv) Nausea, fatigue, claustrophobia, (xv) Equipment malfunction. These complications are rare. Toxic effects of oxygen in the CNS, eye, liver and tracheobronchial tree are reported.

B. **Surgical management**: The surgical treatment modalities include: (1) Incision and drainage, (2) Extraction of loose or offending teeth, (3) Debridement, (4) Decortication, (5) Continuous or Intermittent indwelling closed catheter irrigation, (6) Sequestrectomy, (7) Saucerization, (8) Resection of jaw **(Figs 43.13 and 43.14)**, (9) Trephination, (10) Immediate or delayed reconstruction with bone graft.

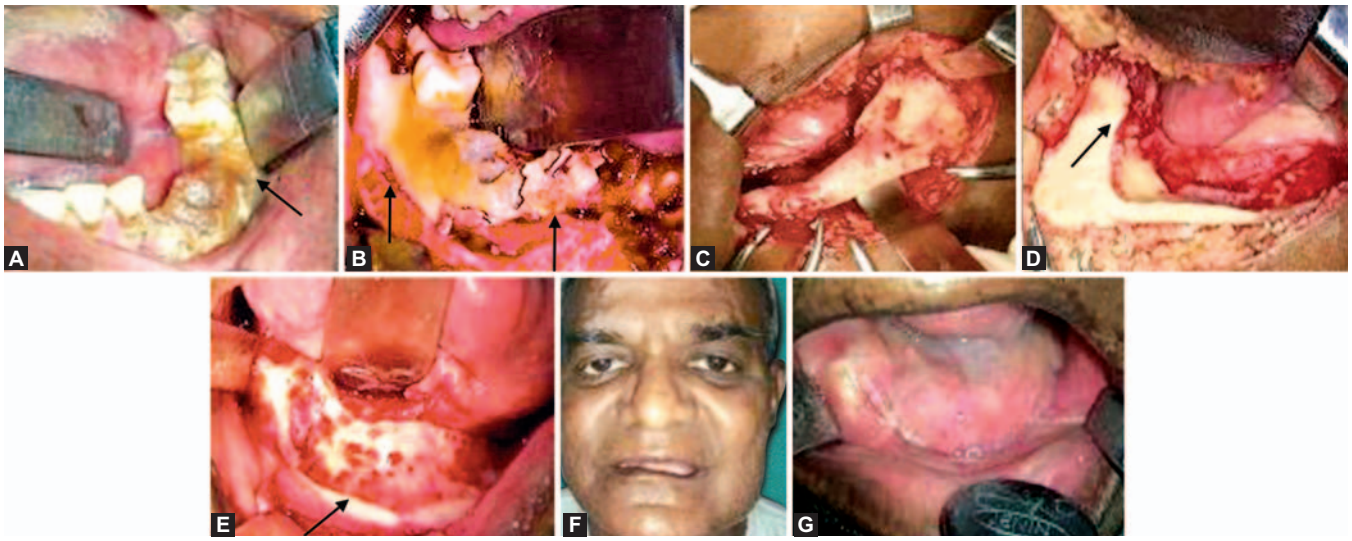
Surgical intervention is done under antibiotic cover, started at least, 1–2 days prior to the procedure.

Immobilization of the part is advocated; generally, a bandage is sufficient. Hot moist compresses should be applied to promote localization of infection. Application of cold is contraindicated. The procedures are to be carried out with minimal trauma.

- **Incision and drainage**: It should be done as soon as possible. It relieves the pressure and pain caused by the accumulation of pus. Incision of abscesses should be carried out intraorally or extraorally depending upon the location. Evacuation of pus, by drainage, lessens absorption of toxic products and prevents further spread of infection in the bone; thus helping in its localization. The consistency, color and odor of the pus may provide important clues to the diagnosis and initial treatment. Patients with compromised systemic



Figs 43.13A to E: (A) Extraoral clinical picture of a patient with uncontrolled diabetes mellitus. Multiple draining sinuses with pus discharge for 2 years; (B) Close-up view of one of the draining sinuses; (C) Intraoral picture showing the exposed sequestrum in the oral cavity; (D) After controlling the diabetes, surgical resection (hemimandibulectomy) was planned. Extraoral surgical picture of resection of hemimandible being carried out, (E) Resected specimen



Figs 43.14A to G: Unusual case of osteonecrosis: (A) A 60-year-old patient came with complaint of foul smell and chronic pus discharge intraorally and dull pain in left mandibular region. Intraoral examination revealed the presence of dead, necrosed bone from midline to left angle mandible. Patient gave history of stroke on the left side one year back, for which he received treatment and recovered. No other systemic cause could be attributed to avascular necrosis of left hemimandible; (B) Surgical resection of the necrosed bone was planned, using both extraoral and intraoral incisions. Intraorally, clear demarcation between the necrosed and normal bone was seen; (C) Extraorally, the necrosed bone was separated from normal bone; (D and E) Peripheral osteotomy and saucerization was carried out; (F and G) Extraoral and intraoral clinical picture of the patient postoperatively

conditions or toxemia, surgical interference may be postponed for 2–3 days.

The various methods employed for causing drainage from the bone include: (i) Opening up the pulp chamber, (ii) By making fenestration through cortical plate over the apical area with a drill, (iii) In an edentulous area, especially, posterior maxilla or maxillary tuberosity region, by making an incision over the alveolar crest, and by making a window, pus is evacuated, and (iv) OML at the angle of mandible or ascending ramus, drainage can be achieved by a small incision made over the point of the greatest tenderness, or just below the mandible.

- **Extraction of loose or offending teeth**: Sometimes, drainage is achieved by extraction of offending teeth.
- **Debridement**: Followed by incision and drainage (I/D), thorough debridement of affected area should be carried out. The area may be irrigated with hydrogen peroxide and saline. Any foreign body, necrotic tissue or small sequestrum should be removed.
- **Decortication**: Removal of chronically infected lateral and inferior cortical plates of bone 1–2 cm beyond the area of involvement. Thus an access is provided to medullary cavity. Obwegeser, (1960) advocated this procedure, as it shortens healing time.

  Decortication and mobilization of muscle flaps to achieve or improve regional and systemic vascular supply to the involved area have been used to bring the overlying vascular soft tissue envelope to a closer proximity to infected spongiosa.

  Decortication should be performed in subacute or chronic stage. It is based on the principle, that the involved cortical bone is avascular and harbors microorganisms, while an abscess exists within the medullary cavity, where antibiotics cannot penetrate. This procedure should be performed, where initial conservative regimes have failed. The steps in decortication are:
  - Creation of buccal flap by crestal incision extending along the necks of the teeth.
  - Reflection of mucoperiosteal flap to the inferior border.
  - Removal of teeth in the involved area.
  - Removal of cortical plates—lateral and inferior border, with chisel in one piece. Bone must be cut back to uninvolved areas.
  - Bony bed should be thoroughly debrided and flap should be closed primarily and dead space is eliminated by applying pressure bandage placed to keep vascularized soft tissue in contact with bony bed.
  - Irrigation tubes should be placed through separate stab incision and closed suction should be employed.
- **Continuous or intermittent indwelling closed catheter irrigation**: After intraoral sequestrectomy and saucerization or decortication, two small pediatric nasogastric feeding tubes, catheters or polythelene drain tubes, 3–4 mm in diameter and 6–10 inches long in length are placed against the bony bed through separate skin incisions at some distance and secured with sutures. One tube is connected to the low pressure suction to allow drainage of pus and serum and another is kept patent to provide a route through which locally antibiotics may be instilled in very high concentrations. Daily, first saline irrigation followed by antibiotic instillation should be repeated, until negative cultures are obtained. Systemic antibiotics are also continued for at least 2–3 months following cessation of clinical evidence of disease.
- ***Sequestrectomy:*** An integral part of definitive therapy. It helps in establishment of local microvascular proliferation. It should be undertaken through an intraoral incision; or extraoral (submandibular) approach, depending upon the site of sequestrum.

  Sequestra, are (i) usually cortical; and may be (ii) cancellous, or (iii) corticocancellous. Usually, are not seen until 2 weeks after onset of infection. These are avascular and therefore, poorly penetrated by antibiotics (Khosla, 1970). Small sequestra may undergo resorption or may get expelled spontaneously from the mucosal or skin surface. Resorption occurs by lytic activity of osteoclasts contained within the granulation tissue, which can ingrow sequestra. Sequestra are avascular, therefore are not penetrated by antibiotics. Pathological fractures can occur in the region of the sequestrum due to bone loss or because of diminution in bone strength.

  In chronic form, the involucrum is perforated by tracts (cloacae), through which pus escapes to epithelial surfaces. Rarely, sterile abscesses (Brodie's abscesses) common to long bones occur in jaws. Once the sequestrum is formed, it should be removed with minimum amount of surgical trauma.

  Prior to sequestrectomy; an assessment should be done for the need to splint and immobilize the mandible to support it, so as to avoid a surgical fracture;

or to avoid displacement of fragments if pathological fracture is already present. The form of fixation is decided on the basis of dentition and site of fracture. Feeding the patient with a nasogastric tube, should be considered; if jaw movements are restricted.

The preoperative radiograph showing the location of sequestrum is an important guide for deciding the site of incision, which may be intraoral or extraoral. The sequestrum can be classified as—(a) small and accessible— intraoral approach, (b) large and inaccessible—extraoral approach.

Involved teeth should be removed at the same time. Intraoral wounds should be packed with iodoform gauze soaked in betadine to permit observation, as the defect fills up with granulation tissue and to allow the removal of small sequestrum, if it forms again. Extraoral submandibular incision is needed to expose the inferior border and posterior parts of the mandibular ramus. Condyle, if involved can be reached via preauricular incision. Generally, the sequestrum lies on the surface of the bone and can be removed with little effort after the periosteum has been incised and retracted. If the sequestrum is encased by the involucrum, a window must be made to allow it to be taken out. The window is cut with a sharp curette, chisel or drill may be used to outline the natural perforation created by the disease process. The cavity that is exposed almost always contains granulation tissue in which the sequestrum lies. The contents are carefully curetted out until the healthy bone is exposed to the view. If the suppuration is present, then the wound is partly closed with sutures and a rubber drain is inserted through the skin. Otherwise the wound is completely closed and antibiotic therapy is continued for at least 2 weeks.

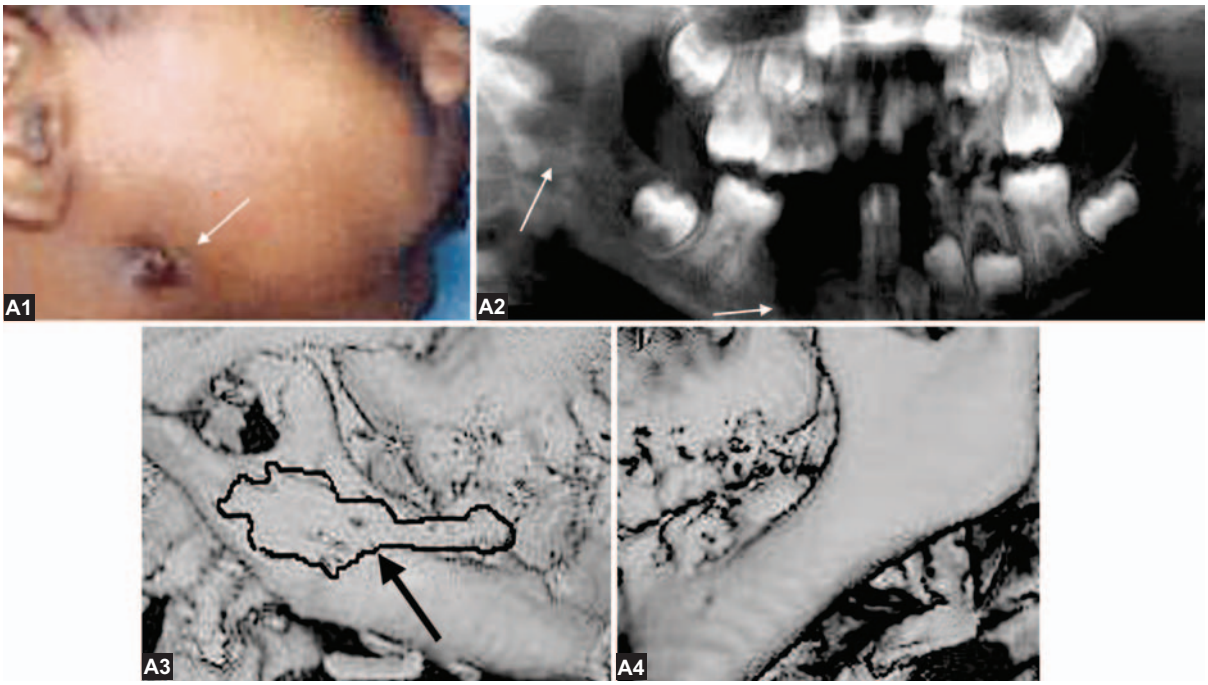
- **Saucerization**: Excision of margins of necrotic bone overlying a focus of OML. It is useful in chronic form, since it permits removal of formed and forming sequestra with better visualization. It is performed when removal of sequestrum leaves a large cavity; and to eliminate the dead space to avoid reinfection of extensive clot. It is performed with a large round bur, so that when wound is closed, the soft tissues eliminate a dead space. The buccal cortex is reduced to the level of unattached mucosa, producing a saucer like defect.

  Sequestrectomy and saucerization are to be carried out after the acute phase has subsided; and the defense mechanism of host and antimicrobial therapy have overcome the virulence of organisms.

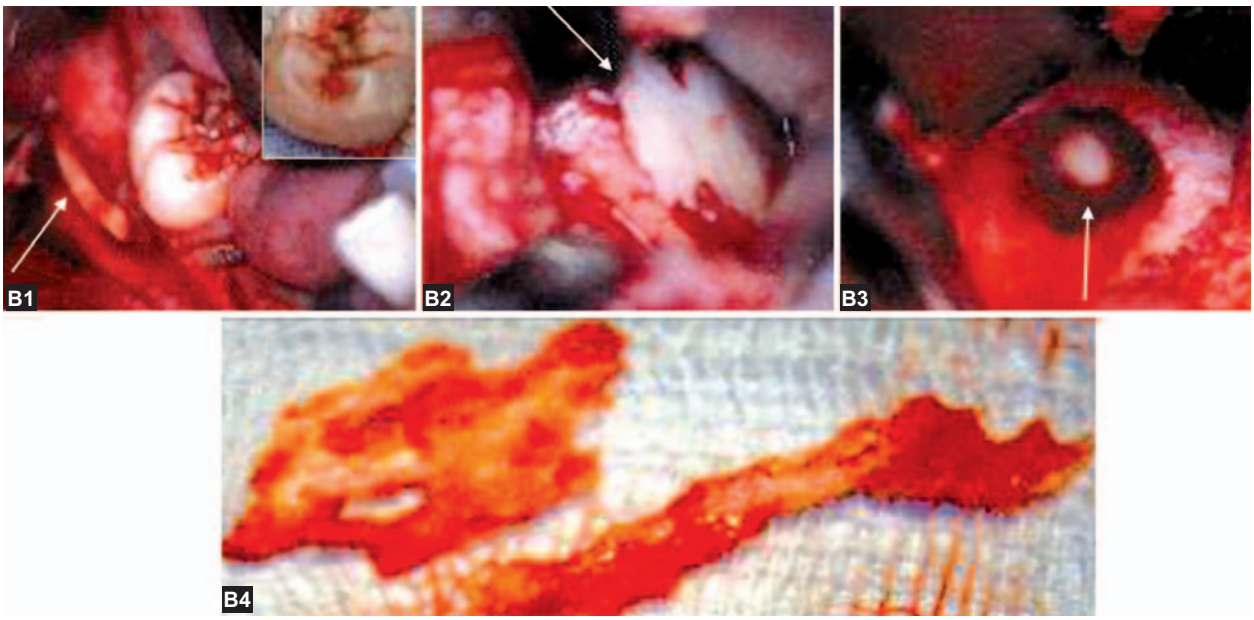
- **Trephination or fenestration** is the creation of bony holes or windows in the overlying cortical bone adjacent to the infectious process for tissue ammoniation and decompression of the medullary compartment. Drilling of holes into cortex and reaching medulla provide multiple surgical transcortical ports, that allow vascular communication between the periosteum and the medullary cavity.
- **Resection**: When extensive portion of the bone is involved in the disease process, then resection of the jaw bone is advocated. Following resection, reconstruction is advocated: (a) to maintain the continuity of the fragments, (b) to prevent pathological fracture. (c) to prevent facial deformity and (d) to provide attachment of the soft tissues.
- **Immediate and/or delayed reconstruction**: It is controversial. It has been used successfully in cases of (i) pathological fracture, (ii) persistence of infection after decortication, and (iii) when both cortical plates are markedly diseased. IIiac crest is a desirable graft. A block of corticocancellous iliac crest can be used or cancellous marrow is used. Stabilization may be achieved with vitallium or titanium mesh that also serves as a tray to contain the graft. Immediate reconstruction offers the obvious advantage of shortening the period of illness and speeding recovery and rehabilitation. In cases, where immediate bone grafting is contra-indicated, a reconstruction plate is fixed as a spacer.
- **Postoperative care**: It includes the following: (i) Continued use of antibiotics, analgesics, and hot saline mouth rinses, (ii) Adequate hydration, complete rest, removal of sequestrae, in case they are in the alveolar part of bone. The wound is closed preferably primarily, with a drain.

Prognosis: If proper aggressive and comprehensive therapy is instituted on time, then the recovery of acute and chronic OML is always good. But, in cases of chronic refractory or diffuse sclerosing OML, associated with regional or systemic disease, such as microvascular or immunosuppressive disorders, the treatment may be worse than the disease itself. In these cases attempt should be done to provide long-term conservative therapy than major surgical debridement. Long-term use of salicylates, nonsteroidals or steroids with laboratory monitoring is advised in some of these cases.

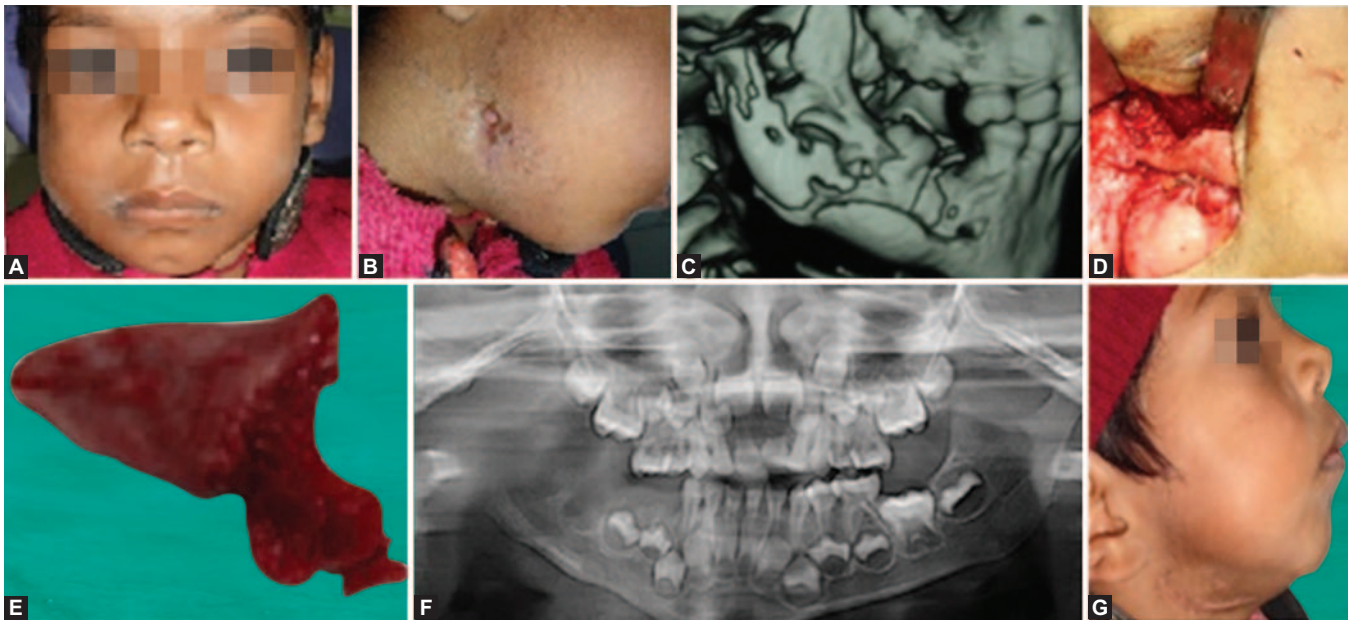
The treatment regime will have to be modified depending on the status of general health of the patient **(Figs 43.15A and B to 43.21)** and **(Table 43.6)**.



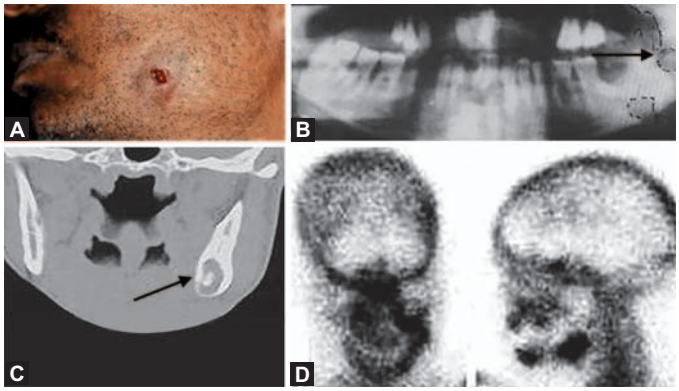
Figs 43.15A1 to A4: Chronic osteomyelitis: (A1) A 6-year-old boy came with the complaints of extraoral draining sinus for the last 3 months. He gave history of high fever following swelling of right body mandibular region. He also gave history of extraction of right side lower teeth with surgical curettage. He had pathologic fracture in right body mandible, which was treated conservatively, six months back; (A2) Present OPG showed healed pathological fracture and multiple radiolucent areas in the ascending ramus on the right side; (A3) Three-dimensional CT scan of right mandible showing the sequestrum at the ascending ramus and external oblique ridge; (A4) Left side 3D CT scan picture of healthy ascending ramus for comparison



Figs 43.15B1 to B4: Chronic osteomyelitis due to systemic high fever. Surgical sequestrectomy procedure for the boy seen in Figure 41.15 A: (B1) Intraoral exposure of the sequestrum; (B2) Extraoral postramal incision to expose the sequestrum involving the external cortex of the ascending ramus (white in color); (B3) Developing tooth bud of right second molar was removed as it was leading to cutaneous tract and was enveloped in granulation tissue; (B4) Large pieces of sequestrum were removed



Figs 43.16A to G: (A and B) Another young boy with history of high fever, swelling and discharging sinus in right angle region; (C) CT Scan showing the involvement of ascending ramus; (D) Surgical exposure; (E) Big sequestrum including coronoid process and ascending ramus; (F) OPG showing postoperative healing but loss of right ascending ramus; (G) postoperative healing



Figs 43.17A to D: Chronic osteomyelitis of odontogenic origin: (A) A 50-year-old male patient complaint of draining persistent cutaneous sinus and on and off swelling left mandible. History of persistent sinus since last 8 months, following extraction of left lower third molar. Earlier multiple times extraoral curettage was done by a private practitioner; (B) OPG showing multiple radiolucent areas in the ascending ramus and at the angle of left mandible. Poor periodontal status of the teeth; (C) CT scan showing the involvement at the left angle region with sequestrum formation; (D) Bone scan is showing increased uptake at the left side of the mandible, suggestive of increased vascularity, inflammatory, infective pathology. Extraoral submandibular approach for sequestrectomy and saucerization was taken. Excision of the extraoral sinus tract with curettage was done

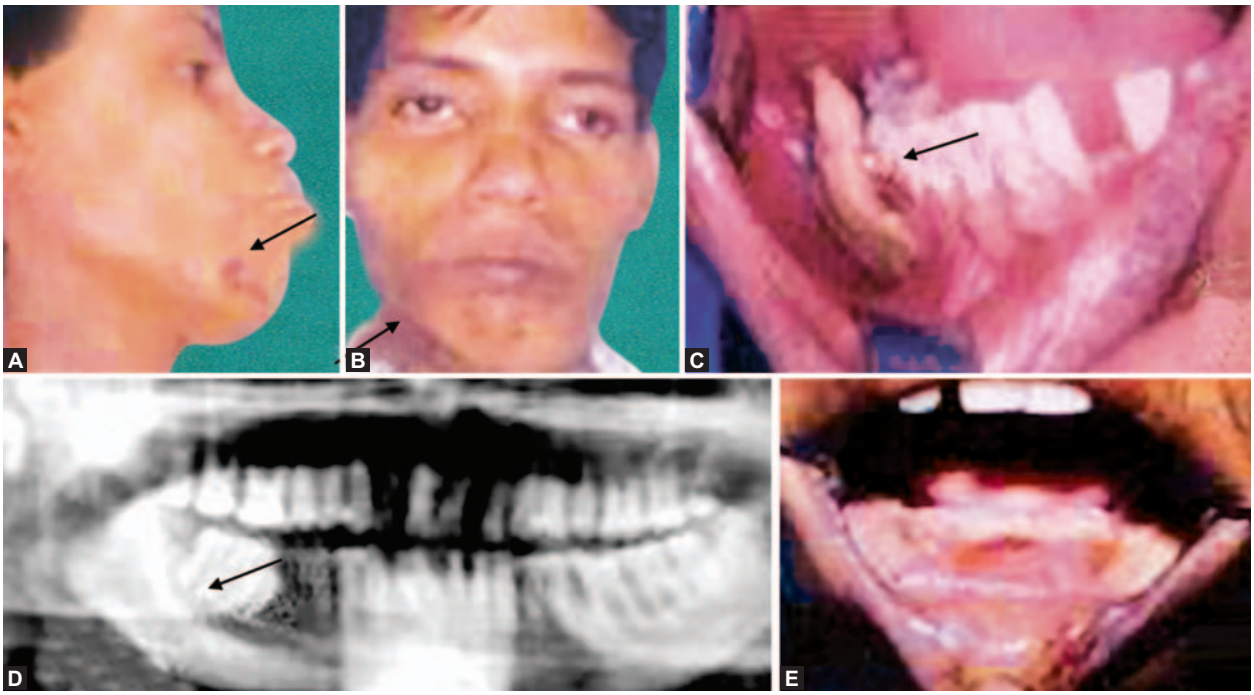
TYPES OF OSTEOMYELITIS

Infantile OML (OML Maxillaries Neonatorum, Maxillitis of Infancy)

It is a rare type of OML seen in infants involving maxilla.

Wilensky, (1932) described OML in infants in a comprehensive manner. Subsequently, cases have been reported by Hitchin and Naylor, (1957), Cavanagh, (1960) and Norgaard and Pindborg (1959). It deserves special mention because of its seriousness and potential for facial deformities resulting from delayed or inappropriate treatment.

Etiology: (1) Trauma: The access may be through a break in the mucosa. Perinatal trauma caused to oral mucosa during delivery. When obstetrician's finger is inserted into child's mouth, or injury to the mucosa caused by



Figs 43.18A to E: Osteomyelitis secondary to sickle cell thalassemia minor. In this disorder the sickle red cell become adherent to vascular endothelium and erythrostasis is seen, which increases blood viscosity and decreases the blood flow. This brings about hypoxia to the affected region: (A and B) Extraoral draining sinus in a male patient aged 21 years; (C) Exposed large sequestrum on the right side body of the mandible. Poor oral hygiene; (D) OPG showing radiopaque sequestrum involving right ascending ramus and body; (E) Total mandibular extractions with sequestrectomy resulted in good healing



Figs 43.19A and B: Extensive bone loss due to osteomyelitis following aspergillosis infection of the right upper jaw: (A) An 80-year-old male gave history of on and off swelling on the right upper jaw and purulent discharge from right nostril, fever and general debility. Intraoral draining sinuses were present through which small sequestras used to come out. For six months patient was treated by various doctors. At our center, patient was diagnosed having aspergillosis infection. Extraoral Weber Fergusson incision was taken. Large pieces of sequestrae were removed. Postoperative photo showing the extensive bone loss in right maxilla and nasal bones; (B) Intraoral healing showing the defect following sequestrectomy

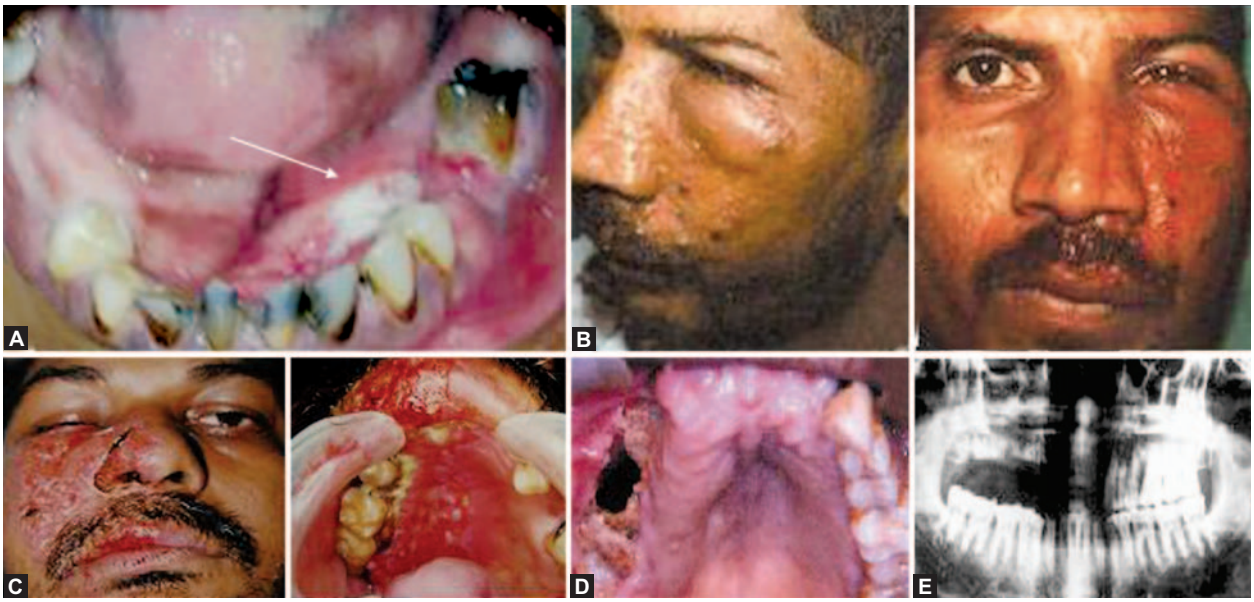
mucous suction bulb, used to clear airway soon after birth. (2) Infection of maxillary sinus. (3) Contaminated human or artificial nipples. (4) Paunz, (1926) and Ramon et al. (1977) believe that the disease is caused by infections from the nose. (5) Hematogenous invasion by streptococci and pneumococci is also reported.

Clinical features: Almost seen a few weeks after birth. The disease shows considerable variation in severity. There is sudden onset and acute course. The disease may also have slow onset and a chronic course. In acute stage, severe pain and high fever; and with chronic course there is moderate pain and slight fever.

- **General constitutional manifestations**: Pyrexia, anorexia, dehydration, convulsions, or vomiting may occur.
- **Extraoral examination**: Facial cellulitis seen centered around orbit. Inner canthal swelling, palpebral edema, closure of eye, conjunctivitis, and proptosis may result.



Figs 43.20A to I: (A) A 65-year-old lady came with complaint of draining extraoral sinus in the right cheek area and pus discharge from right tuberosity region; (B) Intraoral picture shows the extensive sequestrum exposed in the oral cavity in right maxillary region from right tuberosity to right canine region; (C) CT scan-occlusal view shows much more extensive destruction of maxillary bone from right tuberosity till left premolar area involving complete palatal vault; (D) Coronal view CT scan shows pathological fracture of right infraorbital rim, involvement of right maxillary sinus and separation of sequestrum from the nasal floor; (E) Extraoral Weber Fergusson incision was planned; (F) Complete maxilla along with the teeth showed necrotic bone and its separation from the normal bone. Downfracturing of maxillary sequestrum carried out; (G) Surgical defect after sequestrectomy; (H) Tissue was sent for fungal culture-report was Aspergillus fumigatus infection. Fungal hyphae were seen; (I) Fungal hyphae seen in GMS (Gomori's Methenamine Silver) stained slide



Figs 43.21A to E: Osteomyelitis following herpes zoster infection of face: (A) Intraoral picture showing the exfoliation of mandibular left side teeth and sequestrum in the body; (B) Extraoral picture of the patient; (C) Another patient with herpes zoster infection of the face; (D) Intraoral exfoliation of right maxillary teeth with sequestration of bone; (E) OPG showing the bone and teeth loss on right side maxilla

Table 43.6: Hudson, 2000: Osteomyelitis treatment plan

Acute Osteomyelitis Healthy Host	***Acute Osteomyelitis Compromised Host***
1. Conservative decompression and debridement of infection with extractions	1. Stabilize condition of host especially nutrition status
2. Drainage and irrigation, if pus present	2. Aggressive debridement and decompression with disruption of the involved periosteal rind
3. Culture and sensitivity of infected foci	3. Culture and sensitivity of infected foci
4. Antibiotic treatment for 3–4 weeks, duration based on Gram's stain, culture and sensitivity, blood culture, and ESR	4. Sustained antibiotic treatment 6–12 weeks, duration based on Gram's stain, culture and sensitivity, blood culture findings
5. Regional bony stabilization, if necessary	5. Regional bony stabilization, if necessary.
Chronic Osteomyelitis	
Chronic infection present more than 1 month.	
1. Host almost always compromised, if only by infectious process.	
2. CT, nuclear medicine scan, perfusion studies.	
3. Stabilize condition of host, especially nutrition status.	
4. Wide bony sequestrectomy and decortication to normal bleeding bone and disruption of the involved periosteal rind, core out sinus tracts with extended culture and sensitivity of sequestrum specimen.	
5. If purulent, consider drainage and irrigation.	
6. Sustained antibiotic therapy 3–6 months, possibly longer, via central line as necessary. Duration based on Gram's stain, culture and sensitivity findings.	
7. Consider nonsteroidals versus steroids.	
8. Regional bony stabilization.	
9. Perioperative hyperbaric oxygen therapy 20–40 dives bid on 100% O_2 for 90 @2.5 ATA.	
10. Reconstruction as necessary.	

- **Intraoral examination would reveal**: (i) Maxilla usually affected; especially molar region, (ii) Subperiosteal abscesses in alveolar region. These are seen as buccal or palatal swellings. (iii) Fluctuation is often present, (iv) Fistulae or pus draining tracts may exist in alveolar mucosa.
- **Laboratory findings**: Leukocytosis is generally present.
- **Microbiology**: Organisms implicated are *S. aureus* and also streptococci.
- **Radiological findings**: In early stage, the radiographs are of a little value, as there is minimal bone involvement. In late stages, intraoral films help to locate sequestra and necrotic tooth germs.
- **Risks**: Prior to preantibiotic era, mortality and morbidity were very high. With the advent of the antibiotics, it is considerably reduced. Death usually occurs due to spread of infection to brain (Cavernous sinus thrombophlebitis).

  The risks involved are: (i) Permanent optic damage, (ii) Neurological complications, (iii) Loss of tooth buds and bone. Instances of extension into dural sinuses has been reported.

Differential diagnosis: (1) Dacrocystitis neonatorum, (2) Orbital cellulitis, (3) Ophthalmia neonatorum and (4) Infantile cortical hyperostosis. The oral manifestations help to distinguish the early condition from these conditions.

Treatment: The treatment should be prompt and aggressive.

- Antibiotics, be preferably given by IV route. Penicillins or penicillinase-resistant penicillins like flucloxacillin, or broad spectrum antibiotics may be given for 2–4 weeks.
- **Culture and sensitivity testing**: Culture is taken from the discharge from sinus tracts; and sensitivity testing should be done. The antibiotic regimen is to be modified accordingly. Many cases of acute OML are cured by antibiotics only. Schenk (1948) was the first to report five cases treated with penicillin. All his patients were cured without loss of tooth germs.
- **Incision and drainage of fluctuant areas**: It is indicated in the presence of periosteal or palatal abscesses.
- **Irrigations**: In case of sinus tracts, irrigations are done frequently.
- **Supportive therapy**: (i) Analgesics and antipyretics, (ii) Fluids, (iii) Proper diet. Proteins and multivitamins should be supplied abundantly.
- **Sequestrectomy or removal of necrotic tooth germs**: Removal of sequestra is undertaken when they are completely separated, and on the basis of clinical and radiological findings. Surgical interference should be conservative; as loss of bone and teeth leads to severe deformities later in life.
- Children who have undergone sequestrectomies, should be followed up by an orthodontist to aid in the development of the arch and maintenance of occlusion.

The development of adult dentition gets disturbed. Teeth may show hypoplasia, similar to those in Turner's syndrome. Some degree of decreased development of affected maxilla is expected.

Garre's Sclerosing Osteomyelitis

Also known as chronic nonsuppurative sclerosing OML, chronic OML with proliferative periostitis, and periostitis ossificans.

It was first described by Carl Garre (1893), as irritation induced focal thickening of periosteum and cortical bone of tibia. It is a nonsuppurative inflammatory process; where there is peripheral subperiosteal bone deposition caused by mild irritation and infection.

Pathogenesis: The etiological agents can be a carious tooth, or the overlying soft tissue infection (Ellis et al. 1977). The infectious process localizes in periosteum or beneath the periosteal covering of cortex and spreads slightly into the interior of bone.

In case of persistence of the causative agent, it causes bony thickening, visible on radiograph (Smith and Farmann, 1977).

Pell et al. (1955) reported the first case in jaws. It generally involves mandible (Lichty et al. 1980). The disease primarily occurs in children and young adults; and occasionally in older individuals.

Clinical features: It is characterized by: (i) localized hard, nontender bony swelling of lateral and inferior aspects of mandible, (ii) lymphadenopathy, hyperpyrexia and leukocytosis usually not found.

Radiography: A focal area of well calcified bone proliferation may be seen that is smooth and that often has a laminated or "onion skin" appearance.

The radiographic appearance is typical. There is condensation of cortical bone, and overgrowth of bony tissue beneath the periosteum. The increase in mass of bone is due to several factors: (i) Mild toxic stimulation of fibroblasts by attenuated infection, (ii) Compensatory thickening of bone as a mechanical adaptation to reinforce the area weakened through disease; and (iii) An exuberant attempt at repair.

When no dental disease exists; or when lesion persists after treatment of dental pathology, biopsy should be considered to establish diagnosis.

Differential diagnosis: It should be differentiated from infantile cortical hyperostosis, or Caffey's disease. It occurs in young infants and involves a number of bones. The clavicles and ulnae are usually affected, and mandible invariably involved. Caffey, (1950) believed that the disease was of infectious origin because of high fever and increased ESR.

No bacteria could be cultured from the tissues. The condition is uninfluenced with antibiotics. The disease usually is self-limiting and eventually regresses.

Treatment: It is directed towards removing sources of inflammation: (a) Removal of infected tooth and curettage of socket, (b) Surgical recontouring: This is done to recontour the cortical expansion of the jaw. This is attempted only if there is obvious expansion, (c) Endodontic therapy, (d) Antibiotics: if signs of infection are present and (e) Follow-up.

Chronic Sclerosing OML (Focal and Diffuse)

The various other names are sclerosing osteitis, ossifying OML, sclerosing cementoma, gigantiform cementoma, and sclerotic cemental masses.

Radiographically: There are two forms: (1) Focal (condensing osteitis), and (2) Diffuse (multiple condensing osteitis). Nonexpansile radiopaque lesion.

1. **Focal form**: (i) Below the age of twenty, (ii) More common in mandible, (iii) Associated with infected pulp of lower molars/premolars, (iv) Appears as circumscribed radiopaque mass of sclerotic bone associated with tooth roots. (v) Margins may be distinct or may blend into surrounding bone.

   It is thought that sclerotic /condensed bone is the body's response to irritation.

   Histopathologically: There is dense mass of bone trabeculae with little interstitial marrow and few lymphocytes.

   Treatment: (i) Endodontic therapy, and/or (ii) Extraction
2. **Multilple form**: These occur in both maxilla and mandible (resembles chronic suppurative OML). Pain is a prominent feature. Suppuration is usually absent.

   Radiographically: It shows dense radiopaque masses.

   Treatment: Much depends upon presentation: debridement, antibiotic therapy, alveolectomy, and HBO_2, etc.

Actinomycotic OML of Jaws

Definition: It is a chronic infection manifesting both granulomatous and suppurative features; and usually involves soft tissues and occasionally bone.

Types: There are three types: (1) Cervicofacial, (2) Thoracic, and (3) Abdominal.

Cervicofacial: About two-thirds of cases are cervicofacial. It involves mandible, overlying soft tissues, parotid gland, tongue and maxillary sinuses. Secondary spread to other areas of head may occur.

Historical background: *J Israel* in 1877, isolated an organism belonging to genus *Actinomyces*. Historically, such organisms were considered to be fungi and are associated with a disease in humans analogous to lumpy jaw disease of cattle.

At least three types of *Actinomyces* have been related to the disease. (i) *A. israelii:* It is responsible for disease in humans. (ii) *A. bovis:* It is responsible for disease in cattle, but rarely in humans. (iii) *A. baudetti:* It is responsible for diseases in cats and dogs.

Several species of Actinomyces are found as normal saprophytes in human oral cavity; including: *A. israelii*, *A. naeslundii*, *A. propionicus* and *A. eriksonii*. Except for *A. Israelii*, the role of these organisms in the disease is not established.

These are endogenous in origin, and are found in (i) Tonsillar crypts, (ii) Salivary and dental calculus, and (iii) Mucosa of oropharyngeal and gastrointestinal regions.

Pathogenecity is attributed to changes in local or general environment.

Characteristic features: It is now recognized that *Actinomyces* are not fungi; but are Gram-positive, microaerophilic, non-spore-forming, and non-acid-fast bacteria.

Like *Nocardia* and Mycobacteria, Actinomycetes, share characteristics of both bacteria and fungi. However, they are not sensitive to antifungal drugs; and unlike fungi, are sensitive to antibiotics.

Cell wall: Electron microscopy and other studies confirm their bacterial nature.

Pathogenesis: Organisms gain entry into soft tissues directly or by extension from bone through (i) Periapical, or (ii) Periodontal lesions and (iii) Fractures, or (iv) Extraction sites.

When established, infection spreads without regard to fascial planes and typically appears on cutaneous rather than mucosal surfaces.

Clinical features: Patients present with the following:

- Soft or firm tissue masses on the skin; which have purplish, dark-red, oily areas with occasional small zones of fluctuation.
- Spontaneous drainage of serous fluid containing granular material. These granules are yellowish substances called sulfur granules, and represent colonies of bacteria.
- Regional lymph nodes are occasionally enlarged.
- **Trismus**: Not common; unless secondary infection.
- **Pyrexia**: Usually the patient is not febrile; and does not feel ill.

Microscopically, it shows closely packed branching filaments 1 μ in diameter.

Radiography: The common findings are (i) radiolucent areas of varying sizes, and (ii) delay in healing of extraction sites.

Periostitis: Diffuse mandibular radiolucencies and marked bone sclerosis.

Sequestra formation is occasionally present.

Laboratory studies: ESR and WBC count may be slightly elevated.

Whenever, a firm mass/infections, which does not respond to conventional antibiotic therapy, then actinomycosis, mycosis, mycobacterial infection, and neoplasms should be considered in diagnosis.

Differential Diagnosis of Actinomycosis: The following conditions should be considered: Parotitis, parotid tumors, cervical tuberculosis, and pyogenic OML.

Diagnosis is based on (1) Culture and sensitivity testing, and (2) Biopsy.

1. **Culture**: Aerobic and anaerobic organisms, and (2) Direct fluorescent antibody test. It is shown to be specific for *A. israelii*.
2. Biopsy of the wall of abscess or fistula is useful when material is not available for smear and culture, or laboratory data.

Management: In the past, many therapeutic agents and techniques were used including: (i) Iodides, (ii) Radiation, (iii) Incision and drainage, and (iv) Excision of soft tissues and bone. Currently, iodides and radiotherapy are considered to be ineffective.

Incision and drainage: All abscesses, regardless of how small they are, should be surgically disrupted with a hemostat and all loculations penetrated.

Hospitalization is required; because, antibiotics are administered parenterally: (i) in high doses, (ii) for protracted periods of time, and (iii) shows temporary resolution and recurrence.

Penicillin is the antibiotic of choice. The dose depends on severity of the disease. 10–20 million units daily for 3–4 months; 3 million units IV every 4 hourly for 2 weeks or longer.

Subsequently; 0.5 g probenecid orally four times daily. This daily 2 g probenecid will increase blood concentration of penicillin 2- to 3-folds by inhibiting its renal excretion.

In patients allergic to penicillin:

a. Tetracycline (especially Minocycline 250 mg 4 times daily for 8–16 weeks, may be prescribed (Martin, 1985).
b. Erythromycin 500 mg 4 times daily for 6 months. The dosages and durations for therapy used are effective for most infections; and result in temporary resolution, only to be followed by recurrence. Therefore, high doses for extended periods are recommended.
c. Sequestrectomy and saucerization may be necessary.

Follow-up: Radiographs are taken periodically to monitor changes in bone.

TUBERCULOUS OSTEOMYELITIS OF THE JAW BONES

Tuberculosis, or the king of diseases, as it was known, was rampant in the Third World Countries way back in the early 1900s. A chronic infectious disease caused by *Mycobacterium tuberculosis*, it was considered to be the single most common cause for death in those days.

Advances in chemotherapy, inoculation with BCG vaccines and improvement in public health and nutritional status led to a drop in the incidence of the disease in the 1980s. But again there has been a resurgence of the disease in the 1990s.

According to the World Health Organization's Survey in 1998, one-third of the world's population is suffering from tuberculosis. Every year 10–12 million new cases are developing worldwide, with approximately 2–2.5 million cases in India alone.

The disease once considered to be nonexistent in developed countries is now being diagnosed more commonly in those countries also. Surprisingly, now it is the musculoskeletal system that is more commonly affected as compared to the respiratory system (Lachenauer CS, Constentinos, 1991). This resurgence of tuberculosis has been attributed to:

- Population explosion in the world leading to poor sanitation and hygiene.

- Failure of patients to complete the long-term Antikoch's therapy, thereby acting as carriers of the disease.
- Complacency of the pharmaceutical companies to develop a new drug in the past two decades leading to the development of drug resistant strains of *Mycobacterium tuberculosis.*
- Increase in the number of AIDS patients.

Tuberculous OML of the maxilla and mandible was earlier considered as a rare disease. But, of late, the incidence is on the rise with isolated presentation in the jaws. The supposed rarity of the disease in the jaws seldom arouses clinical suspicion, especially, when a positive history of systemic infection is absent. The diagnosis is established only after a careful biopsy and microbiological study.

Etiopathogenesis

The tuberculous microorganism belongs to the *Mycobacterium* genus. This genus includes a group of aerobic, nonsporulating, nonmotile bacilli with a high cell wall lipid content and a slow growth rate. *M.tuberculosis* is classified as an acid fast *Bacillus*, because it retains the carbol fuchsin red dye after washing with acid, alcohol or both. It is transmitted from person to person by inhalation of infective droplets that result from aerosolization of respiratory secretions.

In tuberculous OML of the maxilla and the mandible, there are three possible methods of inoculation of the bacteria into the bone.

- Direct inoculation of the bacilli into the oral mucosa through an ulcer or break in the continuity of the mucosa.
- Spread to the bone via an extraction socket or an infected fracture line.
- Hematogenous or lymphatic spread from a primary focus elsewhere in the body.

The disease progresses slowly, with the formation of a tubercle in the bone marrow. There is an increased vascularity of the periosteum with initial subperiosteal resorption of bone, followed by laying down of a new layer of reactive bone. As the disease progresses, there is caseation in the central portion of the bone. Ultimately, the pus extends peripherally and a subperiosteal abscess is formed. If the disease progresses, the periosteum gives way and the tuberculous debris are expelled into the soft tissues, from where they follow the path of least resistance. The infection tracks along the fascial planes to the surface of the skin. The abscess reddens, but is not warm and is therefore called a "cold abscess". The skin becomes progressively thinner and ultimately yields in such a way that a tuberculous sinus is formed.

Clinical Presentation of Tuberculous Osteomyelitis of the Jaw Bones

The sites most commonly involved are the ramus and body of the mandible. The age group is around 15–40 years. The patient may show clinical features similar to a subperiosteal abscess, which may have initially be drained resulting in a nonhealing sinus tract formation. There may be two types of presentation of tuberculous OML of the jaw bones.

Closed Lesions (Lumpy Jaw) (Fig. 43.22)

The lesion is located centrally in the bone. The patient will present only with a swelling and no draining sinuses. There is usually an absence of any oral septic focus. This lesion is usually seen in the ramus of the mandible. When the lesion is in the ramus, it may mimic a parotid swelling or submasseteric abscess.

Open Lesions (Fig. 43.23)

There is a presence of multiple extraoral and intraoral sinuses with mucopurulent discharge. Oral septic focus may or may not be present.

Diagnosis and Treatment

Ten-Point Protocol Formulated for the Management of Tuberculous Osteomyelitis of the Jaw Bones (Figs 43.24 and 43.25)

1. **Aspiration for smear and culture studies**: In cases of closed lesions in the jaws, in the absence of an oral septic focus, aspiration is a must to identify and differentiate between a cystic lesion, neoplasm, odontogenic infection, and cold abscess. Aspiration is done using a 5-cc syringe and a disposable 18-G needle. Using aseptic precautions, the skin is pierced to enter the abscess cavity. The aspirate is then collected in a sterile test tube and sent to the microbiology laboratory for smear and culture studies. The smear is tested for acid fast bacilli. Culture is done on Lowenstein Jensen medium. The time taken for the colonies to develop varies from 48 hours to 8 weeks.
2. **Radiographs**: The commonly used views to visualize the mandible and the maxilla are:
   - Orthopantomogram
   - Posteroanterior view of mandible



Fig. 43.22: Tuberculous osteomyelitis—closed lesion or lumpy jaw



Fig. 43.23: Tuberculous osteomyelitis—open lesion

- Posteroanterior view- Water`s position
- Lateral oblique view of the mandible closed lesions of the jaws are usually seen as a small well-defined radiolucency, usually in the ascending ramus with destruction of the buccal or medial cortical plate.

Chest radiographs are a must to rule out pulmonary involvement. Both posteroanterior and lateral views are indicated.

Full body radiographs are taken, only when a scintigram shows a "hotspot" in any other area of the body apart from the affected site.

3. **Scintigraphy**: It is indicative of the metabolic changes within the bone. These metabolic changes preceed the changes seen on the radiograph. Scintigraphy though not specific, is a sensitive indicator of bone disease with a range of 89–100% sensitivity. A full body scan with technetium-99m diphosphonate dye is done to rule out systemic involvement.

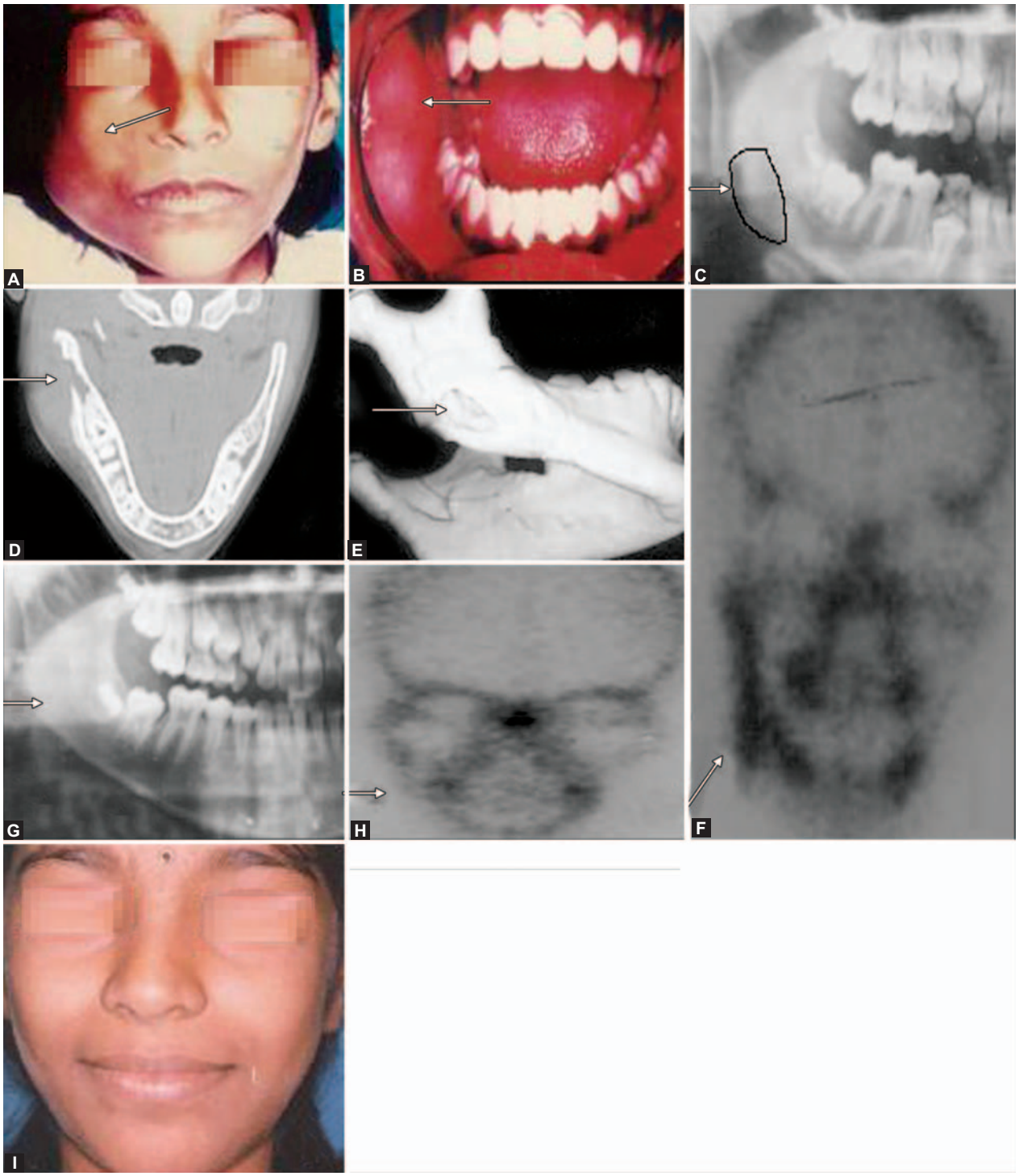
   Areas of increased activity are seen as "Hot spots" on the scan.
4. **Computed tomography**: This is a very useful and accurate imaging system, which shows not only bony, but also soft tissue changes. The advantages over routine radiographs are:
   - The extent of the disease can be accurately determined.
   - Medullary involvement can be identified.
   - A medial rotation of the mandible can be done to visualize the medial cortex (which is very often the site for involvement for closed lesions.)
   - Diagnosis of subperiosteal abscess, muscle involvement and lymph node involvement is facilitated.
5. **Mantoux testing**: An intradermal injection of 5 tuberculin units (5TU) in a 0.1 mL solution of purified protein derivative is given using a 27-G needle.

   A positive reaction may be seen clinically after 48 hours as erythema and induration measuring greater than 5–10 mm.

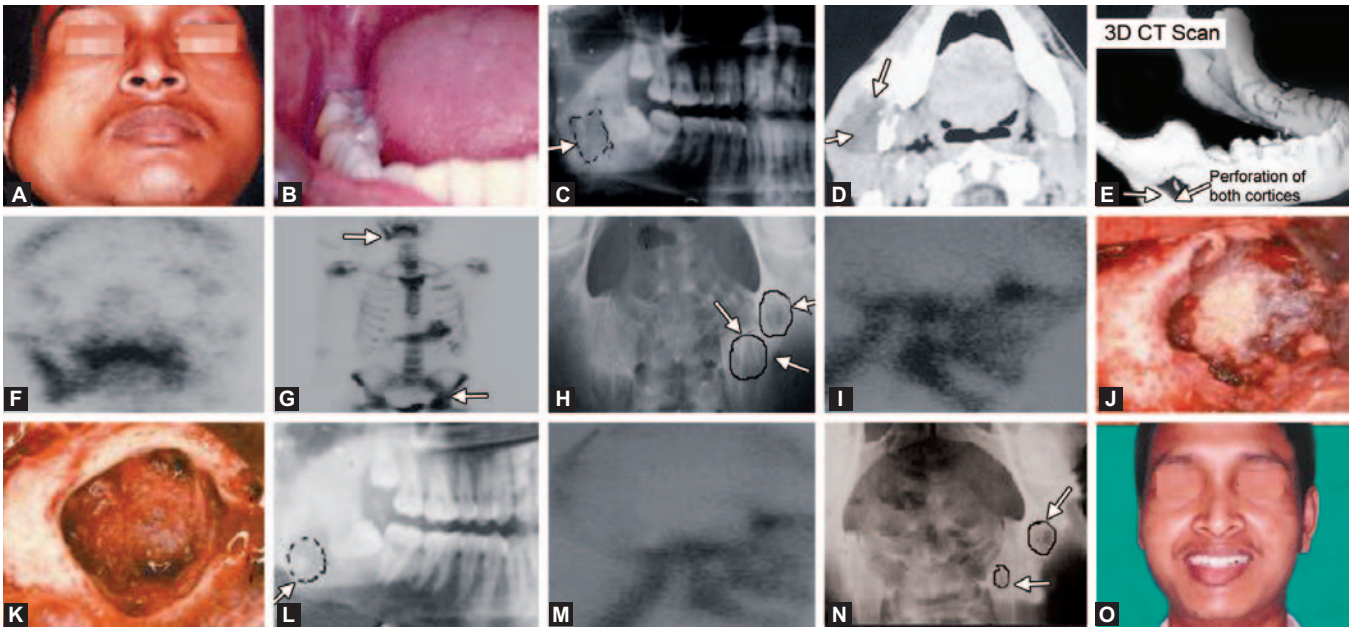
   A negative mantoux test does not exclude tuberculosis. Similarly a positive mantoux is not confirmatory for tuberculosis.
6. **Sputum for acid fast bacilli (AFB)**: Early morning sputum samples are collected on three consecutive days and sent to the laboratory for smear and culture. A positive report may indicate involvement of the lungs or the nasopharynx. A nasopharyngeal swab and scraping may be required to rule out involvement of the latter.

   Detection of sputum AFB under fluorescent microscopy is a more sensitive test.
7. **Biopsy**: An incisional biopsy is done only for open cases. Aspiration is done for closed cases.

   Tissue curetted from the sinus tract and deeper tissues is sent immediately in normal saline for smear and culture. Tissue is also sent in 5% formalin for histopathological evaluation to identify tuberculoma, early caseation, Langhans giant cells, and lymphoid activity. These features are pathognomonic of tuberculosis. A positive biopsy is confirmatory for tuberculous infection.
8. **Surgical treatment**
   a. **Closed lesions**: Usually no oral septic focus is present.
      i. **Aspirate positive for AFB**: In these cases, the patient is started on a suitable antikoch's



Figs 43.24A to I: (A) Pretreatment frontal view of an 11-year-old girl with right lumpy jaw; (B) Pretreatment intraoral view. Note the swelling on the right side and fair oral hygiene; (C) Pre-OPG showing unicystic radiolucency at right angle and ramus mandible; (D) Preoperative axial CT scan—destruction of the buccal cortex of ascending ramus; (E) Pre-3D reconstruction CT scan perforation of buccal cortex; (F) Pretreatment bone scan. Increased uptake in right ramus mandible; (G) Post-AKT regime-16 months later. Regeneration of bone seen in OPG; (H) Post-AKT regime-16 months later. Decreased uptake in Right ramus mandible; (I) Post-AKT front view after 16 months



Figs 43.25A to O: (A) Preoperative front view showing right ramus swelling: Lumpy jaw; (B) Preoperative intraoral view showing fair oral hygiene; (C) Preoperative OPG—unicystic radiolucent lesion in right ramus; (D) Preoperative axial CT scan: Note the abscess in masseter muscle and destruction of buccal and lingual cortices; (E) Three-dimensional CT scan showing perforation of both cortices; (F) Preoperative bone scan: Hot spot in right ramus; (G) Preoperative whole body bone scan: Hot spot in right ramus and left pelvic region; (H) Preoperative X-ray pelvis—radiolucencies in left pelvic region; (I) Preoperative bone scan mandible; (J) Intraoperative caseated necrotic tissue, perforation of buccal and lingual cortex; (K) Intraoperative picture after complete curettage. Medial pterygoid muscle is seen through the perforation; (L) Postoperative OPG-after 6 months of AKT following surgery. Note the decrease in size of the lesion; (M) Postoperative and post-AKT bone scan after 6 months; (N) Post-AKT (after 6 months) X-ray of pelvis showing regression of the radiolucencies; (O) Postoperative post-AKT (after 6 months) front view of the face

regimen. After 6–8 weeks the lesion is reviewed both clinically and radiographically to evaluate the need for surgical debridement.

ii. **Aspirate negative for AFB**: If the aspirate is negative for AFB, no incisional biopsy is indicated. A complete excisional biopsy and debridement of the tissues is done. The tissue is sent for histopathological studies. If positive for tuberculosis, the patient is started on Antikoch's therapy.

b. **Open lesions**: For open lesions, a biopsy of the tissue from the sinus tract and the deeper tissues is sent for histopathological studies. If the tissue is positive for tuberculosis, a suitable Antikoch's regimen is started, and no surgery is performed immediately. This to prevent dissemination of the disease, that is, milliary spread of tuberculosis by the hematogenous route.

After 6–8 weeks of Antikoch's treatment, the patient is reassessed clinically as well as radiographically to decide upon the need for surgery.

9. **Antikoch's treatment**: Depending on the severity of the disease, and the patient's body weight, the physician starts on a suitable Antikoch's therapy. Usually a 6 months regimen with four drugs is advised.

   Intensive treatment: In the first 4 months, all four drugs, that is, isoniazide, rifampicin, ethambutol, and pyrizinamide are given.

   Continuation phase: Isoniazide and rifampicin are given for the next 4 months.

   In addition, ciprofloxacin may be added to the regimen as it is known to be extremely effective in bone tuberculosis.

   During the therapy, the patient is advised to have high protein and carbohydrate diet. As these drugs are hepatotoxic, the patient is monitored for signs of hepatotoxicity. Liver function tests are done every 6 weeks.

10. **Long-term follow-up**: It is advised to ensure patient compliance in taking the drugs. A periodic monitoring of the patient clinically and radiographically to assess the course of the disease is a must. Adjustments in the

AKT (Anti-Koch`s treatment) regimen must be done accordingly. The patients must be followed up for recurrence.

OSTEORADIONECROSIS OF THE FACIAL BONES (ORN)

Osteoradionecrosis (ORN) is also known as radiation OML. It is known as the most serious, late complication of therapeutic radiotherapy (RT) for head and neck (H and N) cancer, as it produces considerable morbidity.

The cancers of oral and maxillofacial region are treated by (i) Radiation therapy, and (ii) Surgery, or (iii) Both. This complication of ORN is seen to be dependent on the technique of the RT used, in particular—the radiation dose to the bone. A total dosage of approximately 6,500–7,000 uGy or greater, particularly to the floor of the mouth and mandible significantly show elevated incidence of ORN of the mandible. Dose rates in excess of 0. 55 uGy/hour have also been seen to elevate the risk of ORN. Increased dosages and dose rates are usually given in the treatment of T2, T3 and T4 neoplastic lesions. Radioactive implants given within a tissue tumor also shows a higher incidence of ORN.

Ionizing radiation destroys malignant neoplasms by damaging the chromosomes; so that, the cell division is impaired. Irradiation induces inflammatory response in soft tissue with erythema, desquamation and pigmentation of overlying skin. Radiation injuries include hard and soft tissues, because of the damage to tissue cells and the vascular system. These changes are progressive and may result in gradual devitalization of bone tissue, which may lead to bone and/or soft tissue necrosis in a small percent of patients.

Major salivary glands—which are within the field of irradiation show changes in the salivary function. Fractionated irradiation impairs the flow of saliva by slowly destroying salivary gland tissue. Salivation is suppressed; the saliva is scanty and sticky. Xerostomia is the principal long-term symptom of impairment of salivary flow in irradiated tissue. Decreases of 83% or more of mean whole salivary flow rates have been recorded. Possible sequelae to xerostomia include an alteration of the chemical composition of saliva and increased potential for traumatic injury due to dry oral mucosa.

Periodontal disease: It is exacerbated; some degree of atrophy of periodontal membrane, gingival recession occurs without pocketing, exposing the necks of teeth.

Widespread radiation caries: Affecting smooth surfaces of the crowns of teeth. The most damaging effect of xerostomia, is the rapid shift of the oral microflora to highly cariogenic bacteria. This is because of decreased salivary flow, which compromises the body‘s defenses against increased growth rates of cariogenic microorganisms. Many of the patients develop a highly destructive type of dental caries and saliva recalcification of early (white spot) enamel lesions cannot occur.

Definition

Osteoradionecrosis is an exposure of nonviable, nonhealing, nonseptic lesion in the irradiated bone, which fails to heal without intervention. It is a sequelae of irradiation-induced tissue injury, in which hypocellularity, hypovascularity and hypoxia are the underlying causes.

Clinically, ORN may appear as a sequestrum or dead bone, osteopenic and fibrotic in nature. Although ORN lesions may be infected, this is usually a secondary event to the true pathophysiologic process of radiation necrosis, which provides a host medium opportunity for the infecting bacteria. Role of microorganisms is that of, not the causative factor, but they complicate the process and the extent of the treatment.

Exposed bone, however, is not necessarily radiation compromised or dead. It may be due to the soft tissue envelope insult and if conservatively supported, may heal without bone debridement. This is generally seen in cases, in which the total radiation dosage is below 500 uGy. Glabrous skin is a reliable sign of at least radiation induced soft tissue injury and should promote suspicion of underlying bony sequestrum.

Incidence

The reported incidence of ORN of the facial bones varies widely. Incidence of involvement of the mandible ranges from 2–3%. A key factor in ORN, particularly of the mandible refers to trauma, especially tooth extraction. Extraction has been reported as the trigger for ORN in 60–89% of cases. ORN of the maxilla is extremely rare. The second most common facial bone involved with ORN is the temporal bone, in which it usually develops spontaneously with a long latency period.

The time period between the RT and the development of ORN has been reported as a mean of 7. 5 years and up to 20 years.

Etiopathology (Pathological Changes)

1. Marx, (1983) described its causes, as the "Three H" principle of irradiated tissue. (i) Hypocellularity, (ii) Hypovascularity of the irradiated tissues and (iii) Hypoxia. This comprises of all the elements of bone; including marrow and periosteum, as well as the investing soft tissues. 2. Failure of osteoclastic activity. The hypoxic tissue, when damaged, is unable to respond metabolically to the injury. Due to hypoxia, the injured tissue macrophages are unable to phagocytose bacteria or dead tissue in wounds, fibroblasts fail to lay down new collagen and a chronic nonhealing wound develops. (Wound, whose oxygen and metabolic requirements for healing exceed the available supply).

Mechanism

Therapeutic doses of irradiation cause endothelial death, thrombosis and hyalinization of blood vessels. It is described as progressive obliterative endarteritis, periarteritis, hyalinization; and fibrosis, and thrombosis of vessels that leads to a decreased microcirculation (ischemia and reduction in viable osteocyte population). Periosteum undergoes fibrosis, osteoblasts and osteocytes are destroyed and marrow spaces in bone become filled with fibrous tissue. There is a decrease of cellularity of all tissues and vascularity is markedly decreased. These changes lead to a measurable hypoxia in irradiated tissues compared with normal.

Pathological Changes

Effects of radiation on soft and hard tissue: (i) Mucositis, (ii) Atrophic mucosa, (iii) Xerostomia, and (iv) Radiation caries. Bone absorbs more energy than soft tissues, because of its mineral composition; and is more susceptible to secondary radiation.

Effects of radiation on bone depend upon: (i) Quality and quantity of radiation, (ii) Size of portals used, (iii) Location and extent of lesion, and (iv) Condition of teeth and periosteum.

The irradiated bone may become necrotic (aseptic necrosis), and the regenerative capacity of bone-forming tissues is destroyed. The effects are: (i) Direct effects on the osteoblasts and osteoclasts, (ii) Occlusion of blood vessels by thrombosis or by fibrosis of surrounding structures.

The mandible is more commonly subjected to thrombosis, because inferior alveolar artery is the main arterial supply. Maxilla has multiple blood supply, hence it develops aseptic necrosis less frequently. The presence of aseptic necrosis predisposes to ORN; which can be initiated by trauma, infection or both. The trauma is usually the result of extraction of teeth after irradiation; or the result of ulceration from a denture.

The preradiation extraction of teeth in a neglected mouth in the affected segment is strongly recommended.

It is advisable to delay irradiation for 7–10 days to allow healing of extraction sockets. If necessary, the patient may be hospitalized and the teeth should be removed in one session preferably under antibiotic cover.

Alveoloplasty, at this stage is also recommended to allow proper wound closure. All prominent interdental septa are ground off and sharp bony margins are removed or filed off.

Factors Involved in ORN

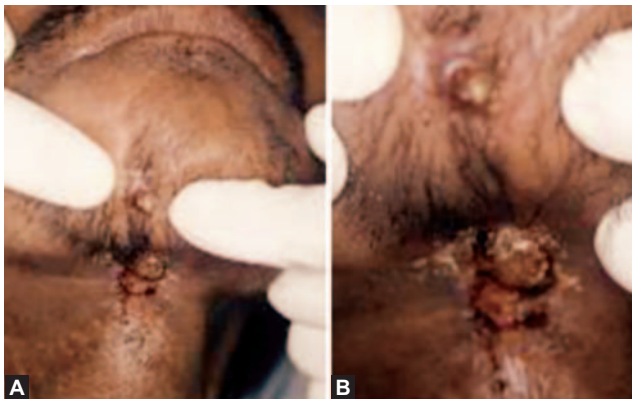
Problems caused by irradiation of tumors

- In children, it can cause: (i) Interference with normal growth and development of jaws, (ii) Irregularities in the formation and eruption of teeth (Pietrokovski and Menczel; 1966).
- **In adults, it causes**: (i) Demineralization of teeth; known as "irradiation caries". It usually affects the cervical margins of teeth. del Regato et al. (1985) and Meyer, (1958 and 1970) have discussed the effects of irradiation caries.
- Decreased salivary flow and reduced salivary pH have been implicated and contributes to irradiation caries.
- **Mucositis**: (i) This leads to poor oral hygiene, and predisposes to infection of periodontal structures. (ii) The integrity and resistance of oral mucosa to injury is impaired, especially gingivae. (iii) Bone-forming and protective function of periosteum is lost if it has been destroyed. (iv) Pressure from a denture may cause ulceration. This may destroy the continuity of gingivae of alveolar process. The failure to heal, the exposed bone is subject to infection and may lead to sequestration.
- Secondary candidiasis.
- **Skin**: It becomes inflammed, resulting in dermatitis; which is extremely painful. When recovery occurs, there is destruction of hair follicles resulting in partial baldness of the face. The subcutaneous tissues along with the skin; also undergo breakdown similar to mucosa; this may complicate the situation, if infection develops, and if surgical procedures are undertaken.

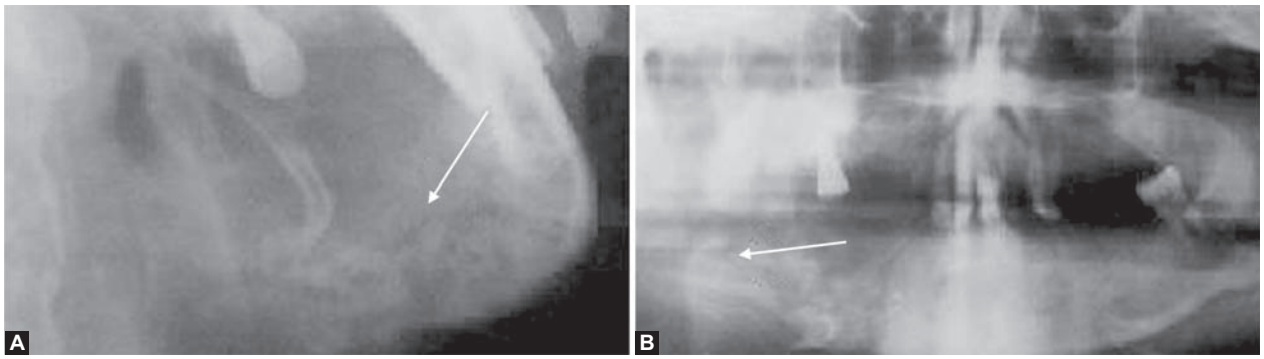
With the modern methods of therapeutic irradiation, ORN is less frequent now. (i) Recently, megavoltage has



Fig. 43.26: Clinical picture of chronic osteoradionecrosis. Note the multiple draining sinuses with exposure of bone



Figs 43.27A and B: Chronic osteoradionecrosis following radiation which was given following surgery for malignancy of lower jaw



Figs 43.28A and B: Osteoradionecrosis, Radiographs of the patient seen in Figure 41.27: (A) Lateral oblique view mandible showing moth-eaten appearance of the bone all over; (B) OPG showing pathological fracture

replaced orthovoltage. The megavoltage is thought to be bone-sparing. Other factors are effective in reduction of its occurrence. (ii) Dose fractionation, (iii) Meticulous collimation, (iv) Shielding normal tissues, and (v) Maintaining pre- and postirradiation dental health.

Clinical Features

Osteoradionecrosis has a varied clinical and radiographic presentation and there is no single diagnostic sign or test. ORN is painful, debilitating and frequently refractory to treatment: (1) Severe, deep, boring pain which may continue for weeks or months. (2) Swelling of face when infection develops, (3) soft tissue abscesses and persistently draining sinuses, (4) exposed bone; in association with intraoral or extraoral fistulae **(Figs 43.26 to 43.30)**, (5) trismus, (6) fetid odor, (7) pyrexia, (8) pathological fracture may be present.

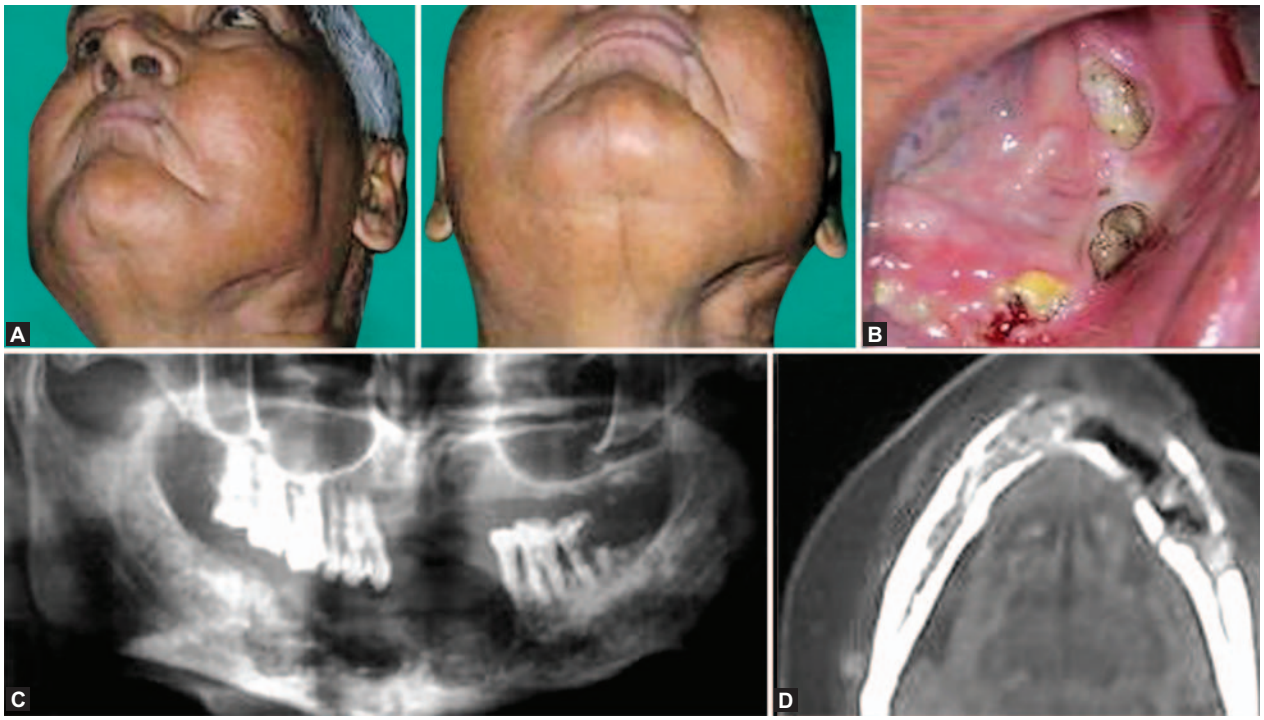
The signs and symptoms would vary depending upon the cause: (i) If extraction of tooth is the cause, an area of denuded bone may be seen on alveolar process, which may be viable. The mucosa may show sloughing, and the area of exposed bone shows tendency to become larger.

There is slow sequestration; because not only the osteoblastic, but also osteoclastic activity is destroyed. When sequestration occurs, generally, a large piece of bone is separated from unaffected vital part of mandible.

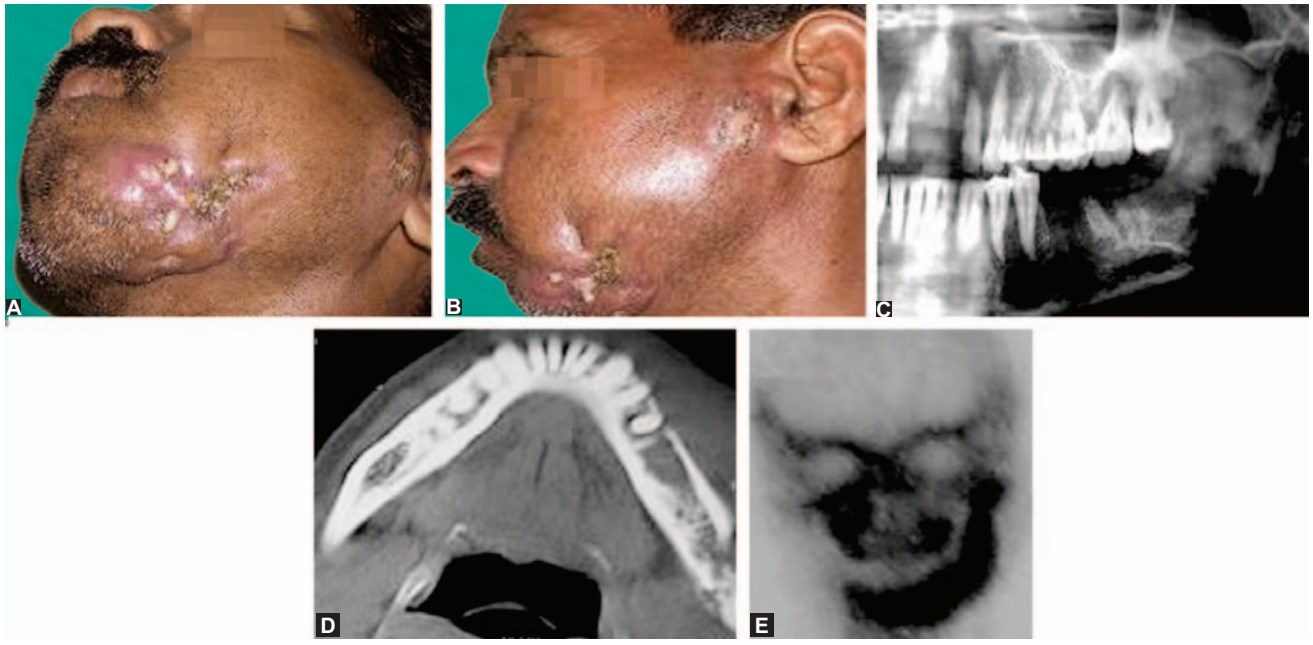
Involvement of fascial spaces of face and neck leading to deep cellulitis. There may be sloughing of adjoining skin and mucosa. Pathological fracture may also occur.

Radiological Features

In the early stage, there is little change. It may appear as radiolucent, modeling with indefinite nonsclerotic borders and occasional areas of radiopacity associated with bony



Figs 43.29A to D: (A) Clinical extraoral pictures of a 60-year-old patient, who underwent neck dissection and surgery for tongue lesion, followed by radiation three years back, (B) He complaint of multiple draining sinuses and dull pain in the left side of the jaw, (C) OPG showing moth-eaten destruction of body mandible, (D) CT scan picture also showing extensive osteoradionecrosis changes in the body mandible



Figs 43.30A to E: Typical presentation of osteoradionecrosis: (A and B) Extraoral nonhealing, chronic multiple draining sinuses, nonresponsive to medication; (C) OPG showing complete involvement of left body and ramus of the mandible; (D) CT scan confirms the destruction, involvement of left hemimandibular bone; (E) Bone scan shows the "Hot spot" involving the hemimandible

sequestrum. Sequestra and involucra occur late or not at all; because of severely compromised blood supply. Initial blood flow assays with nuclear isotope technetium-99 methylene diphosphate scanning can be of some benefit in assessing regional perfusion of the afflicted areas.

Treatment

There is no universally accepted treatment for ORN of the jaws. The management of ORN remains controversial, both radical and conservative treatments have been reported. *Conservative treatment*—systemic antibiotics, selective rinsing with topical antiseptics, selective removal of small sequestra, curetting and local debridement and/or burring it out until normal bleeding bone appears.

Radical treatment is indicated, where acute and progressive ORN is refractory to conservative treatment.

Recent treatment is directed to supporting and salvaging viable but compromised tissue and not attempting to resurrect dead tissue and is aimed at reversing the hypoxia and increasing the vascularity and cellularity of the tissues. It is focused on revascularization of irradiated bone by certain techniques, such as HBO and microvascular free flaps. However, the choice depends on the general condition of the host, severity and location of the disease and availability of the techniques **(Tables 43.7 and 43.8)**.

Table 43.7: Recent development in treatment plan of ORN

1973	Greenwood and Gilchrist—First reported the benefits of HBO in postirradiated patients.
1975	Mainous and Hart—14 cases of refractory ORN of mandible treated with HBO and hemimandibulectomy.
1981	Mansfield— reported complete healing with HBO in 12 patients.
1993	Mckenzie— reported resolution of ORN following HBO in 69% of patients.

Table 43.8: Hudson, 2000: Treatment of radionecrotic wounds

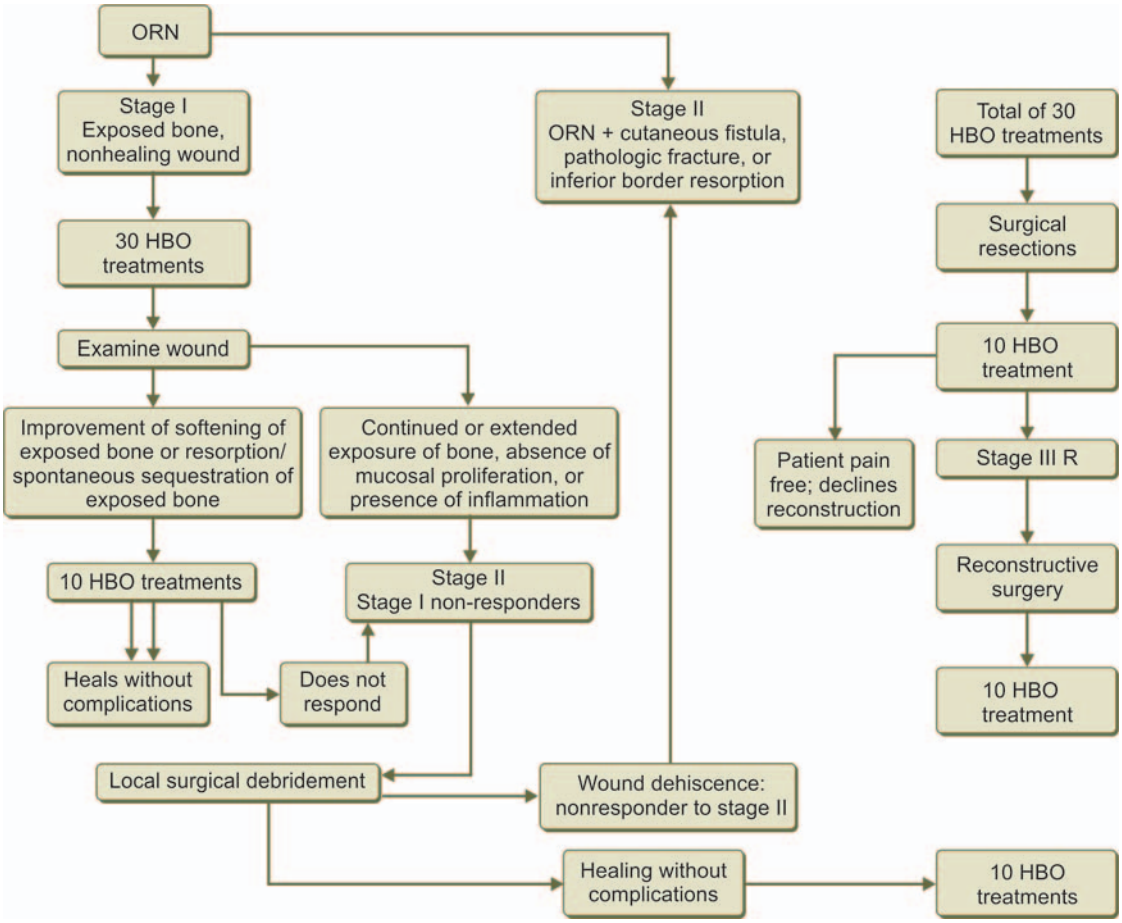
1.	Rule out recurrence of neoplastic disease.
2.	Stabilize patient condition metabolically, especially nutritional status.
3.	Administer preoperative hyperbaric oxygen treatment.
4.	Debride soft and bony radionecrotic tissues as necessary.
5.	Provide postoperative hyperbaric oxygen treatment.
6.	Consider soft tissue vascular flap support.
7.	Perform bony reconstruction as warranted.

In general, the treatment comprises of:

- Debridement.
- ***Control of infection:*** Antibiotics are administered to control acute infection, if present. However, since there is no circulation in the necrotic bone, antibiotics do not penetrate it.
- Hospitalization.
- **Other supportive treatment**: (i) Hydration: fluid therapy, (ii) High protein and vitamin diet.
- ***Analgesics:*** Narcotic and nonnarcotic analgesics. Bupivacaine (Marcaine), alcohol nerve blocks, nerve avulsion, rhizotomy.
- **Good oral hygiene**: Oral rinses, such as 1% sodium fluoride gel, 1% chlorhexidine gluconate and plain water help to prevent radiation induced caries from the xerostomia and mucositis by providing some local augmentation of the host immune antimicrobial activity.
- Frequent irrigations of wounds.
- **Exposed dead bone**: (i) Small pieces of bone may become loose and can be removed easily.
- Treatment of small areas by drilling multiple holes into vital bone is recommended by Hahn and Corgill, (1967) as a means to encourage sequestration.
- Sequestrectomy, is preferrably performed intraorally, because of skin and vascular damage resulting from irradiation.
- Pathological fractures are not so common. These may occur from minor injuries. The fractures do not heal readily. The best form of treatment is excision of necrotic ends of both fragments and replacement with a large graft. Reconstruction of bone defects usually warrants major soft tissue flap revascularization support.
- Bone resection is performed, if there is persistent pain, infection or pathological fracture. It is preferrably done intraorally, to avoid possibility of orocutaneous fistula in radiation-compromised skin.
- HBO therapy is a useful adjunct. It may not be sufficient alone, in its neovascularization influence to recruit the vascular support, necessary for sustaining bone graft healing, but may be useful in supporting soft tissue graft healing while minimizing compartmentalization.

Rationale for the use of HBO in association with surgery in irradiated tissues is to increase blood to tissue oxygen tension, which enhances the diffusion of oxygen into the tissues. This revascularizes the irradiated tissue and improves the fibroblastic cellular density, thus limiting the amount of nonviable tissue to be surgically removed.

Flowchart 43.1: Staging and treatment algorithm



Staging and Treatment Algorithm

This is a dynamic process with staging and treatment decisions being made on clinical response grounds. The number of HBO treatments is recommended minimum and more are given if the response is slow. (Royal Adelaide Hospital, Australia, modification of the MARX protocol **(Flowchart 43.1)**.

Vudiniabola S, Goss AN et al. modified MARX protocol for the treatment of ORN and proposed staging of ORN depending on its clinical presentation and progression or on a clinical presentation plus response to treatment with hyperbaric oxygen (HBO) with or without surgery. They advocated clinical response-based treatment.

Stage I: Exposed bone with nonhealing wound-30 HBO treatment and review. Those patients, who have responded well— further 10 HBO.

Stage I: Nonrespondent— considered as Stage II ORN.

Stage II: Local debridement to induce fresh bleeding followed by 10 HBO.

Stage III: Nonrespondent stage II ORN or those patients with cutaneous fistula, pathologic fracture or inferior border resorption.

Total 30 HBO treatment followed by surgical resection with stabilization of the remaining jaw by external fixation or IMF.

Stage III R: If reconstruction is required, then they enter Stage III R. —further 10 HBO.

Reconstruction with a free-bone graft followed by 10 HBO.

They have recommended to rely on clinical observation to ensure optimum treatment, rather than strictly follow a fixed number of protocol treatment.

Daland, (1949) advised: (i) Electrocoagulation of exposed bone to expedite sequestration, (ii) Drainage of subcutaneous abscesses, to prevent sloughing of skin.

These should possibly be drained intraorally, (iii) Control of pain by judicious use of analgesics. Alcohol block to nerve; in case of severe pain.

OML (i) may follow months or years after radiotherapy, but 30% of cases develop within 6 months, (ii) OML heralded by pain and swelling; (iii) Area of bone involved is often small (less than 2 cm in diameter), (iv) With antibiotics, the signs and symptoms of inflammation may subside within a few weeks, and (v) Complete resolution: It takes 2 or more years in spite of intensive treatment with antimicrobials.

Prevention of ORN

Preirradiation Dental Care

- **Extraction of teeth**: The teeth in direct beam of radiation should be extracted; which include: (i) nonrestorable teeth, (ii) teeth with considerable periodontal disease, (iii) patients with poor oral health and motivation. The radiation therapy is delayed by 10–14 days to allow for initial healing.
- The prominent interdental septa, sharp socket margins should be trimmed as remodeling resorption of alveolar process will not occur after irradiation.
- Unerupted and deeply buried teeth are best left *in situ*.
- **Restoration of teeth**: The remaining teeth should be restored and periodontal therapy should be completed in this 2-week period. Oral hygiene instructions are given. The application of topical fluoride is carried out 0.4% stannous fluoride gel, or 1% acidulated fluorophosphates gel is applied for 15 minutes twice a day for 2 weeks, followed by once daily thereafter.
- **During therapy**: (i) Mouthwash: 0.2% aqueous chlorhexidine decreases secondary infection of any ulcerated mucosa, reduces plaque accumulation and caries. (ii) Supervised cleaning of all the teeth by an hygienist on regular basis. (iii) Oral hygiene instructions: with fluoride toothpaste is essential, and use of daily fluoride mouthwash is important. (iv) Dietary advice: reduce the intake of characteristic in food and drinks and (v) Improve general health of the patient.

Postirradiation Dental Care

- **Avoidance of dentures**: The dentures should not be worn in the irradiated jaw for 1 year after therapy.
- Maintenance of oral hygiene.
- Application of topical fluoride as for preirradiation care.
- Saliva substitutes. They perform the following functions: (i) Lubricate mucosa to replace diminished flow from irradiated mucous and salivary glands, (ii) Facilitate rehardening of tooth surfaces, (iii) Minimize xerostomia-induced soft tissue disorders (Shannon, 1977).
- Restoration of teeth with postirradiation pulpitis. Patients requiring endodontic treatment for postirradiation pulpitis, caution should be exercised not to introduce organisms beyond the apex by instrumentation. It is advisable to carry out such treatment under antibiotic prophylaxis.
- Extraction as a last resort: The number of necessary extraction should be limited to a minimum of one or two per appointment. Teeth should be removed atraumatically. Sharp bony margins should be trimmed off, without raising extensive flaps. Extractions to be done under antibiotic prophylaxis.

Beumer et al. reported that the most common factors associated with ORN were postradiation extractions (26.5%), spontaneous bone exposure associated directly with the dentition secondary to dental disease (22.8%). Marx et al. proposed prophylaxis with hyperbaric oxygen HBO before postradiation dental extractions. But, some clinicians believe that the high cost and limited availability of HBO precludes recommending its universal application for ORN prophylaxis. The risk of ORN though highest during first 4–12 months after RT, has been found to persist for the remainder of the patient's life. Therefore, atraumatic extractions are advocated.

Points to Remember

- Osteomyelitis of the jaw bones
- Types of osteomyelitis-predisposing factors,etiology and pathogenesis for them
- Signs and symptoms of acute and chronic osteomyelitis-radiologic pictures and treatment
- Tuberculous osteomyelitis of the jaw bones
- Osteoradionecrosis of the facial bones and treatment protocols.

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Section 14

Facial Neuropathology

44. Trigeminal Neuralgia and its Management
45. Sensory Disturbances of Face and Jaws
46. Facial Nerve and Motor Disturbances of Face and Jaws

CHAPTER 44 Trigeminal Neuralgia and its Management

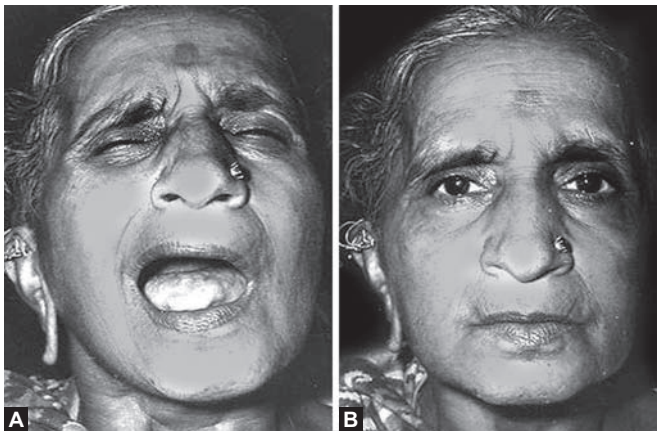
INTRODUCTION

Trigeminal neuralgia is a truly agonizing condition, in which patient may clutch the hand over the face and experience severe, lancinating pain associated with spasmodic contractions of the facial muscles during attacks—a feature that led to the use of the term (its archaic name) "Tic Douloureux" (painful jerking) **(Figs 44.1A and B)**.

DEFINITION

Trigeminal neuralgia (TN) is defined as sudden, usually unilateral, severe, brief, stabbing, lancinating, paroxysmal, recurring pain in the distribution of one or more branches of 5th cranial nerve.

- John Locke, in 1677, gave the first full description with its treatment.
- Nicholaus Andre, in 1756, coined the term "Tic Douloureux".



Figs 44.1A and B: (A) Patient's photograph during the attack of trigeminal neuralgic pain; (B) Patient's photograph after diagnostic injection with local anesthetic agent

- John Fothergill, in 1773, published detailed description of TN, since then, it has been referred to as "Fothergill's disease".

In spite of the condition being known since centuries, it still continues to baffle the clinician and its pathogenesis remains as enigma to the medical profession. Multiple views have been hypothecated regarding its etiology generating nothing, but confusion, and simultaneously opting for many different therapies in an effort to treat this ongoing condition.

ETIOLOGY AND PATHOGENESIS

The cause of this disease process is unknown. It is usually idiopathic. However, the fact that benign tumors and vascular anomalies that compress the trigeminal nerve root can produce symptoms clinically indistinguishable from classic TN strongly implies that injury to the nerve root is an important initiating factor in the disease.

Vascular factors such as transient ischemia and autoimmune hypersensitivity responses have been proposed as causes of the demyelination of the nerve.

Mechanical factors have also been postulated such as the pressure of aneurysms of the intrapetrous portion of the internal carotid artery that may erode through the floor of the intracranial fossa to exert a pulsatile irritation on the ventral side of the trigeminal ganglion.

Anomaly of the superior cerebellar artery has been more recently blamed for causing TN. The artery lies in contact with the sensory root of the trigeminal nerve and its anomaly has been implicated as a cause of demyelination. Surgical elevation of the artery or decompression of the sensory root has been highly successful in relieving paroxysmal pain in cases of idiopathic TN.

The probable etiologic factors are listed below:

- **Dental etiology:** According to Westrum and Black (1976), differentiation from loss of teeth and

degeneration of nerve is not restricted to peripheral parts of the ganglia, but proceeds proximally to involve areas of spinal nucleus. This can partly explain the affliction in the maxillary and mandibular divisions of 5th cranial nerve.

- **Infections:** Various granulomatous and nongranulomatous infections involving the 5th cranial nerve can bring about neuralgic pain.
- **Ratner's jaw bone cavities (1979):** Cavities found in the alveolar and jaw bones are the causative factor. Patients with neuralgia inducing cavitational osteonecrosis also can be candidates.
- **Multiple sclerosis:** Olfson (1966) suggested the presence of sclerotic plaque located at the root entry zone of the trigeminal nerve. Usually patients will have an established diagnosis of multiple sclerosis with demyelinating disease.
- **Petrous ridge (basilar) compression:** Lee (1937) suggested that trigeminal neuralgia may be caused by compression of the nerve at the dural foramen or over the petrous tip and advocated decompression by performing removal of the bony rim of petrous bone.
- **Post-traumatic neuralgia:** The most common types of traumatic neuromas involving the trigeminal branch are those following trauma and those resulting from some dental procedures. These may lead towards neuralgic pain.

  Based on the morphologic and physiologic changes following partial nerve injury, Devor et al. proposed an "ignition hypothesis" to explain the main signs and symptoms of TN. In this model, a trigeminal injury induces physiologic changes that result in a population of hyperexcitable and functionally linked primary sensory neurons. The discharge of any individual neuron in this group can quickly spread to activate the entire population. Such a sudden synchronous discharge could underlie the sudden jolt of pain characteristic of a TN pain attack.
- **Intracranial tumors:** Many lesions such as epidermoid tumors, meningiomas of cerebello-pontine angle and Meckel's cave, arteriovenous malformations, aneurysms and vascular compression have been suggested as the causes. Trigeminal neuromas in the middle cranial or the posterior fossa may be also the causative factor. These intracranial tumors or vascular malformations may impinge on the nerve.
- **Intracranial vascular abnormalities:** Compression—Jannetta et al. showed that vascular compression is a common finding in patients with TN and that surgical decompression of the nerve root often effectively alleviates TN symptoms.

  Distortion of the root entry zone of the trigeminal nerve at the pons by an arterial loop, usually of the superior cerebellar artery, or by venous compression by arteriovenous malformations, etc. Compression of the intracranial retrogasserian portion of the 5th cranial nerve by a displaced vein or artery may be also a cause. Aneurysm of the internal carotid artery may cause TN.
- **Viral etiology:** Postherpetic neuralgia is seen in elderly patients. History of a previous episode of infection by varicella zoster virus may be present in these patients. Viral lesions of the ganglion can be the etiological factor.

GENERAL CHARACTERISTICS

- *Incidence:* It is a rare affliction, seen in about 4 in 100,000 persons.
- *Age of occurrence:* Late middle age or later in life (5th or 6th decade).
- *Sex predilection:* With female predisposition (58%).
- *Affliction for sides:* Predilection for the right side is noted (60%).
- *Division of trigeminal nerve involvement:* V_3 is more commonly involved than V2 division. Very rarely V1 ophthalmic division is involved in about 5% of cases (only sensory division is affected).

CLINICAL CHARACTERISTICS

Trigeminal neuralgic pain typically arises in the persons, who have no abnormal neurologic deficit such as loss of corneal reflexes, anesthesia, paresthesia, muscular atrophy or weakness, etc.

- Trigeminal neuralgia typically manifests as a sudden, unilateral, intermittent paroxysmal, sharp, shooting, lancinating, shock like pain, elicited by slight touching superficial "trigger points" which radiates from that point, across the distribution of one or more branches of the trigeminal nerve.
- Pain is usually confined to one part of one division of trigeminal nerve—mandibular or maxillary, but may occasionally spread to an adjacent division or rarely involve all three divisions.
- *Pain rarely crosses the midline:* The pain is of short duration and lasts for a few seconds, but may recur with variable frequency. Even though there is a refractory period (complete lack of pain) between the attacks, some patients report a dull ache in between the attacks.

- During an attack, the patient grimaces with pain, clutches his hands over the affected side of the face, stopping all the activities and holds or rubs his face, which may redden or the eyes water until the attack subsides. Male patients avoid shaving. The oral hygiene is poor, as patient avoids brushing of teeth.
- The paroxysms occur in cycles, each cycle lasting for weeks or months and with time, the cycle appears closer and closer. With each attack, the pain seems to become more intense and unbearable.
- In extreme cases, the patient will have a motionless face—the "frozen or mask like face".
- Presence of an intraoral or extraoral trigger points provocable by obvious stimuli is seen in TN. Trigger zone is an area of facial skin or oral mucosa, where low intensity mechanical stimulation such as light touch, an air puff, or even touching face at a particular site or by chewing or even by speaking or smiling, brushing, shaving or even washing the face, etc. can elicit a typical pain attack.
- The location of the trigger points depends on which division of trigeminal nerve is involved.
  - In V_2—points are located on the skin of the upper lip, ala nasi or cheek or on the upper gums.
  - In V3—this is the most frequently involved branch. Trigger points are seen over the lower lip, teeth or gums of the lower jaw. Tongue is rarely involved.
  - In V1—the trigger zone usually lies over the supraorbital ridge of the affected side.
- It is characteristic of the disorder that attacks do not occur during sleep.
- Many patients will lead a very poor quality of life, because of excruciating pain.
- It is very common for these patients to undergo indiscriminate dental extractions on the affected side without any relief from pain, because the pain of the trigger zone and pain fiber distributions often mimic pain of odontogenic origin.
- More than 50% of patients experience early remissions of greater than 6 months before return of active pain.

DIAGNOSIS

The diagnosis of TN rests on the clinician's ability in recognizing a distinctive series of signs and symptoms that define this disorder. Although the hallmark findings of TN were known for centuries, White and Sweet made a significant contribution by articulating precise diagnostic criteria for TN. These "Sweet Criteria" are used worldwide **(Table 44.1)**.

The White and Sweet criteria were incorporated into the official research by the International Association for the Study of Pain—IASP and the International Headache Society—IHS. The current IHS recommended classification for TN is listed in "International Classification of Headache Disorders II—ICHD-II". It subdivides TN into "Classic idiopathic TN" and "Symptomatic TN" **(Tables 44.2 and 44.3)**.

Diagnosis is made from a well-taken history. The classic clinical pattern will lead towards the diagnosis. Sometimes, if symptoms may be less classic and may mimic toothache, sinusitis, stomatitis or other inflammatory conditions. Proper clinical examination along with history is mandatory. The neuralgic symptoms in younger group of patients (< 35 years of age) should alert the clinician to a possible intracranial space occupying lesion or intracranial arteriovenous anomalies. Other differential diagnosis should include acaustic neurilemoma, multiple sclerosis,

Table 44.1: Sweet diagnostic 5 major criteria for TN

- The pain is paroxysmal
- The pain may be provoked by light touch to the face (trigger zones)
- The pain is confined to trigeminal distribution
- The pain is unilateral
- The clinical sensory examination is normal.

Table 44.2: International classification of headache disorders (ICHD) criteria for classical TN

- Paroxysmal attacks of pain, lasting from a fraction of a second to 2 minutes, affecting one or more divisions of the trigeminal nerve and fulfilling criteria B and C.
- Pain has at least one of the following characteristics:
  - Intense, sharp, superficial or stabbing
  - Precipitated from trigger areas or by trigger factors
- Attacks are stereotyped in the individual patient
- There is no clinically evident neurological deficit
- Not attributed to another disorder.

Table 44.3: International classification of headache disorders (ICHD) criteria for symptomatic TN

- Paroxysmal attacks of pain, lasting from a fraction of a second to 2 minutes, with or without persistence of aching between paroxysms, affecting one or more divisions of the trigeminal nerve and fulfilling criteria B and C
- Pain has at least one of the following characteristics:
  - Intense, sharp, superficial or stabbing
  - Precipitated from trigger areas or by trigger factors
- Attacks are stereotyped in the individual patient
- A causative lesion, other than vascular compression, has been demonstrated by special investigations and/or posterior fossa exploration.

postherpetic neuroma or posttraumatic neuralgias. All patients should ideally have MRI scanning or at least a CT scan. Preoperative localization of compressive vessels at the root entry zone is done by MRI scanning.

Response to treatment with tablet carbamazepine is universal in trigeminal neuralgia, as in other types of facial pain it is not useful. Many clinicians use this response as a step in definitive diagnosis of the condition. Failure to obtain any improvement with this treatment should bring the diagnosis into question.

Diagnostic injections of a local anesthetic agent into the patient's trigger zone should temporarily eliminate all pain. Mathews and Scrivani have proposed a simple algorithm for the differential diagnosis and management of TN **(Flowchart 44.1)**.

Protocol for Diagnostic Local Anesthetic Peripheral Nerve Blocks

Majority of TN patients have an extremely sensitive trigger zone in the perioral region. A standard local block that anesthetizes the facial region containing the trigger often results in an immediate reduction in TN attacks. This allows the patient to talk and provides a practical way for the clinician to get a full history before making decisions regarding definitive treatment. Local anesthetic blocks have also been reported to eliminate the bouts of pain for prolonged time, outlasting the duration of the particular anesthetic agent utilized.

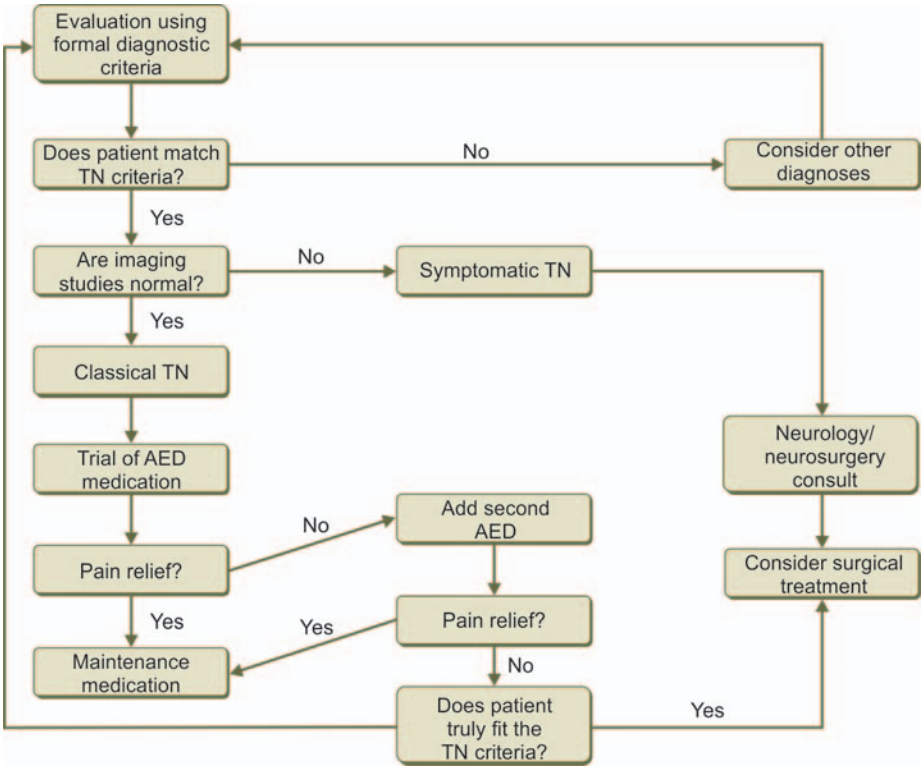
Material Required

- 3–1 cc syringes
- 3–25 gauge needles
- Sterile normal saline
- 2% lignocaine without adrenaline
- Several alcohol wipes.

Procedure

- Always begin injections at surface site of pain and then move proximally. For example, if the pain is perceived in the lower lip, then inject lower lip, then mental nerve and then inferior alveolar nerve.
- Inject 0.5 cc of normal saline at test site. Wait for 5 minutes. If pain is relieved, then psychogenic pain is likely.

Flowchart 44.1: Diagnostic algorithm for TN by Scrivani, Mathews



***Abbreviations*:** TN, trigeminal neuralgia; AED, antiepileptic drugs.

- If the pain persists, then inject 0.5 mL of 2% lignocaine without adrenaline at surface site and wait for 5 minutes. If pain is relieved, then direct therapy at small nociceptor fibers.
- If the pain persists—inject little deeper and wait for 5 minutes. If pain is relieved, then consider musculoskeletal origin of pain.
- If pain is not relieved, inject at more proximal portion of nerve—if pain is relieved, direct therapy at site, when relief occurred.
- Thus, selective inferior alveolar, lingual, buccal, infraorbital, posterior superior alveolar blocks can be given to know the involvement of the branch of the trigeminal nerve.

TREATMENT

Once the diagnosis of trigeminal neuralgia is established, then the treatment regime is started. First medicinal management is advocated. If the patient does not respond to it, then only surgical management is opted **(Flowchart 44.2)**.

Medicinal Management

Medicinal Line of Treatment (Modification of the Paroxysmal Pain at Cortical Level)

This is the first-line approach for most of the patients. TN does not respond to analgesics including opiates.

The attacks of pain in TN are probably caused by a group of pathologically "hyperexcitable" sensory trigeminal neurons that discharge spontaneously, exhibit abnormal after discharges, and demonstrate abnormal spread of excitation to adjacent primary afferents. Similar mechanisms occur in epilepsy, therefore, many antiepileptic drugs (AEDs) are used to suppress pain attacks in TN.

Bourguignon (1942) used anticonvulsant phenytoin to effectively control attacks of pain in TN.

Flowchart 44.2: Various treatment modalities implicated for the treatment of trigeminal neuralgia

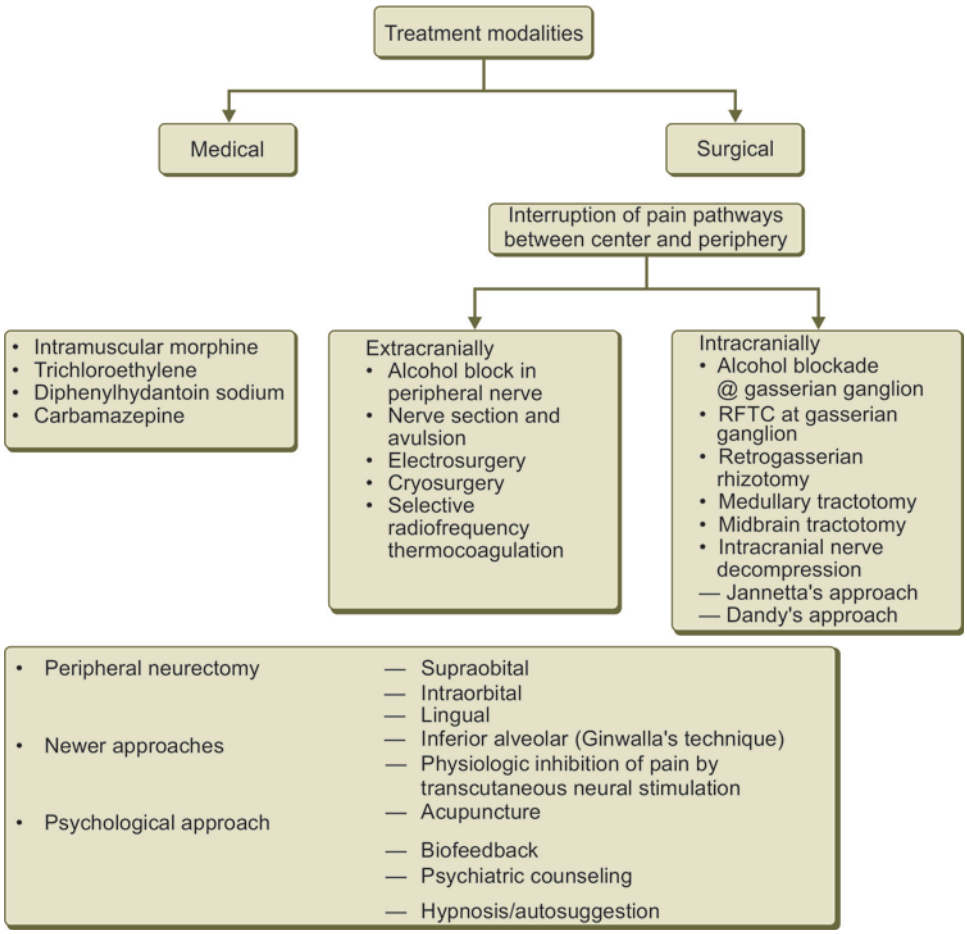


Table 44.4: Drug therapy for trigeminal neuralgia (TN)

Drug	*Initial dose*	*Maintenance Maximum dose*
Gabapentin	300 mg TID	1,800 mg
Baclofen	5 mg BID-TID	80 mg maximum dose
Clonazepam	0.5 mg TID	4 mg, maximum 20 mg
Lamotrigine	50 mg QD	300–500 mg
Oxcarbazepine	300 mg BID	1,200 mg BID
Toprimate	50 mg QD	200 mg BID
Carbamazepine	100 mg BID	1,200–2,400 mg

Blom (1962) showed a response to anticonvulsants **(Table 44.4)**.

Carbamazepine is highly specific in only relieving pain of TN and not any other type of facial pain. It has, therefore, suggested that its response can be used as a diagnostic indicator.

In TN, most clinicians usually initiate antiepileptic drug (AED) therapy with a low dose of a single AED. This dose is gradually escalated over subsequent days until the patient achieves satisfactory pain relief or until significant drug-related side effects emerge.

- Carbamazepine (tegretol) and phenytoin (dilantin) are the traditional anticonvulsants used primarily as soon as the diagnosis is done. This therapy consists of titration and maintenance with anticonvulsant drugs.
- Carbamazepine 100 mg three times a day is introduced and titrated over 1–5 weeks period until either remission is achieved or side effects or toxicity are unacceptable. (Commercially, tegretol 100 mg, 200 mg or 400 mg tablets are available. Controlled or slow release tablets are available).

The dosage of the drug used initially should be kept small to minimum, especially in elderly patients to avoid nausea, vomiting and gastric irritation. More of daily drug dosage should be taken at night, so that adequate serum concentration can be present in early morning, when pain most occurs. Complete blood count with platelet count, liver function screening should be done prior to treatment, a month after treatment and at 3–4 months intervals, particularly, if patient continues to receive a high dose (1,000–1,500 mg/day).

Side effects: Visual blurring, dizziness, somnolence, skin rashes and ataxia and in rare cases hepatic dysfunction, leukopenia, thrombocytopenia—aplastic anemia (It is known to suppress the bone marrow. Patients should be monitored to avoid agranulocytosis). Whenever the side effects appear, a reduction of 200 mg of drug will often eliminate them. Once the pain remission has been achieved, the drug dose should be kept at maintenance level or withdrawn and restarted if symptoms appear.

If carbamazepine does not control symptoms adequately, then another anticonvulsant like sodium valproate 600 mg/day can be added or amitriptyline can be added. Co-administration of phenytoin or baclofen is also advocated.

When carbamazepine is contraindicated, clonazepam 1.5 mg/day can be used.

Clonazepam side effects: Drowsiness, fatigue, lethargy.

- **Tablet phenytoin:** Dose—100 mg three times a day.
  Side effects: Slurred speech, abnormal movements, swelling of lymph glands, gingival hypertrophy, hirsutism, folate deficiency.
- **Tablet oxcarbazepine**—1,200 mg/day.
  Side effects: Hyponatremia, double vision.
- **Valproic acid**—600 mg/day.
  Side effects: Irritability, tremors, confusion, hepatoxicity, weight gain.
- **Mephenesin carbamate (tolceram)**—5–15 mL/5 times a day to every 3 hours.
- Other less toxic agents:
  - Baclofen (lioresal)—10 mg tds
    Side effects: Fatigue, vomiting
  - Gabapentin (neurontin) recently introduced drug
  - Lamotrigine
  - Felbamate
  - Topiramate
  - Vigabatrin
  - Clonazepam
  - Levetiracetam
  - Zonisamide.

Multiple Drug Therapy

- When a patient only partially responds to single drug therapy at dosages that evoke side effects, adding a second AED may enhance the therapeutic response. Because AEDs have differing mechanisms of action as well as differing side effect patterns, combining agents is a good approach. However, when patient do not satisfactorily responds to 2 AEDs, there is little chance of success for additional third drug.
- A better strategy entails a careful reappraisal of the case, including a critical re-evaluation of the TN diagnosis. If the diagnosis of TN is confirmed, such patients should be considered for surgical interventions.

Surgical Treatments (Fig. 44.2) (Peripheral Nerve Surgical Treatments)

Peripheral Nerve Injections

For several years, it has been known that injections of destructive substances into peripheral branches of trigeminal nerve, produce anesthesia in the trigger zones or in areas of distribution of spontaneous pain, and this procedure can be effective in relieving this syndrome, usually as long as the anesthesia persists. Care should be taken to ensure that IV injections are avoided. This method is successful, when there is well localized trigger area.

- *Long-acting anesthetic agents* without adrenaline such as bupivacaine with or without corticosteroids may be injected at the most proximal possible nerve site. The selective nerve blocks can be given as an emergency measure, where the patient is suffering quite a lot, but the pain free period will be very short lived. The injection can be repeated, when the pain recurs.
- *Alcohol injections*—peripheral branches of trigeminal nerve can be blocked by the intraoral injection of 95% absolute alcohol in small quantities (0.5–2 mL). This produces anesthesia of the region, supplied by the branch. Repeated alcohol injections should be avoided, as it causes local tissue toxicity, inflammation and fibrosis. It can also cause a complication of burning alcohol neuritis. The results are variable. Sometimes it provides relief for a period of 6–12 months or sometimes patient comes back with pain immediately within short time span. Extraoral injections into maxillary and mandibular division of the trigeminal nerve at the level of the base of the skull also can be given. Peripheral injections—infraorbital, mental, inferior alveolar nerve blocks can be given depending on the involvement.

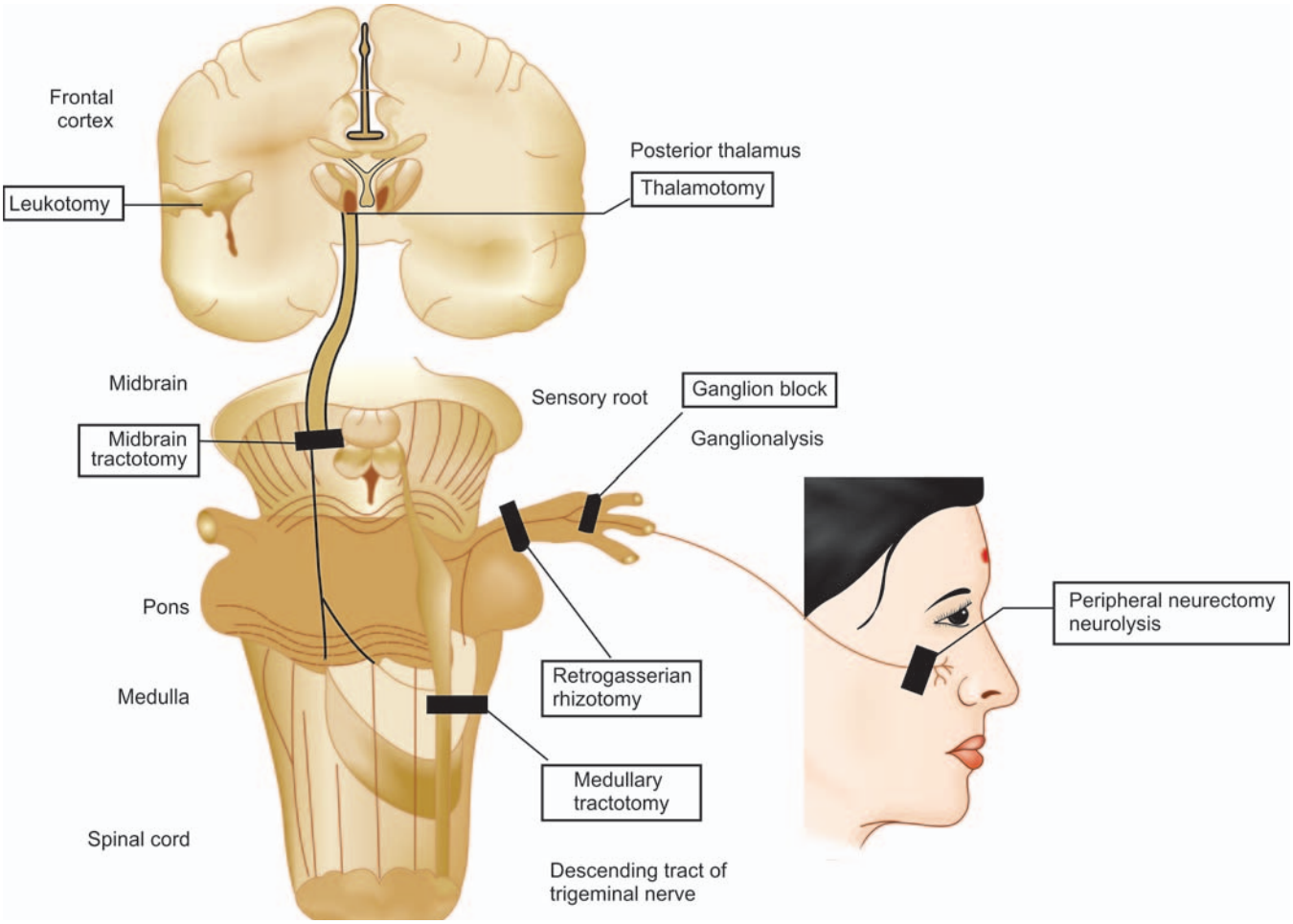


Fig. 44.2: Various sites of surgical control for maxillofacial pain

Peripheral Neurectomy (Nerve Avulsion)

- Oldest and most effective peripheral nerve destructive technique
- Simple procedure can be repeated and relatively reliable technique
- It acts by interrupting the flow of a significant number of afferent impulses to central trigeminal apparatus
- Indicated in patients, in whom craniotomy, a more extensive procedure is contraindicated, because of age, debility or significant systemic diseases, limited life expectancy
- Performed most commonly on infraorbital, inferior alveolar mental and rarely lingual nerves
- It has a disadvantage of producing full anesthesia or deep hypoesthesia related dysfunction
- There is also the expected eventual return of pain with proliferation of amputed nerve stump neuromas
- To achieve better results, the peripheral nerve is always avulsed both from the bone as well as from the soft tissues
- The duration of pain remission after neurectomy may be lengthened, if the cut nerve end is cauterized or redirected and sutured into viable muscle, periosteum or bone tissue to prevent active neuroma formation
- The bony foramen may be plugged with nonabsorbable material or by the bone piece itself
- The procedure is carried out under general anesthesia to ensure successful avulsion.

Infraorbital neurectomy: It can be performed through (1) conventional intraoral approach or (2) through Braun's transantral approach.

1. **Intraoral conventional approach (Figs 44.3 and 44.4):** A U-shaped Caldwell-Luc incision is made in the upper buccal vestibule in the canine fossa region. Mucoperiosteal flap is reflected superiorly to locate the infraorbital foramen. Once the nerve is exposed, all the peripheral branches are held with the hemostat and avulsed from the skin surface intraorally. Then, the entire trunk is separated from the skin surface, is held with the hemostat at the exit point from the foramen and is removed by winding it around a hemostat and pulling it out from the foramen. The infraorbital foramen may be plugged with polyethylene plug and wound is closed with interrupted sutures.
2. **Braun's transantral approach (1977):** It has got the potential to have sound treatment for intractable V_2 neuralgia, because of the direct access and visualization it provides. The key to this approach is a thorough knowledge of anatomy. With sectioning of the maxillary nerve, anesthesia is created over its entire distribution.

An intraoral incision is made from the maxillary tuberosity to the midline in the maxillary vestibule. The mucoperiosteal flap is reflected to expose the anterior and lateral maxillary antral wall, the zygoma and the infraorbital nerve. A 3-cm window is made in the anterolateral wall of the maxillary sinus **(Fig. 44.5)**. The operating microscope

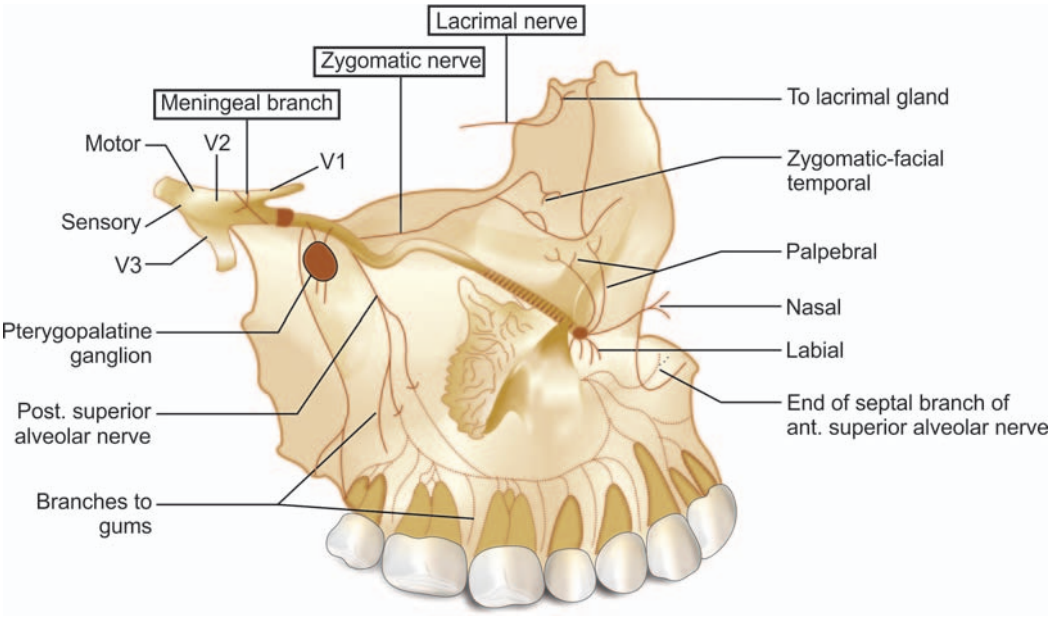


Fig. 44.3: Course of maxillary nerve

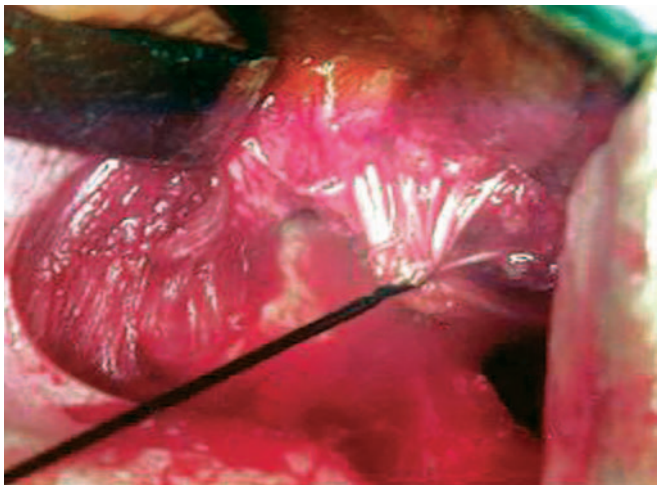


Fig. 44.4: Intraoral conventional neurectomy procedure for infraorbital nerve: exposure of infraorbital nerve at the infraorbital foramen

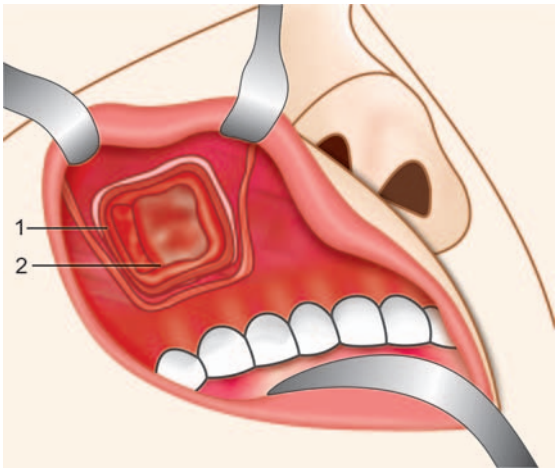


Fig. 44.5: Surgical approach to pterygomaxillary fossa (1) anterior antral wall, (2) posterior antral wall

is usually required for the remainder of the procedure. The lining in the posterosuperior portion of the antrum is carefully excised and bone is removed to create a posterior window. Careful dissection is now performed to expose the descending palatine branches of V_2, which are then traced superiorly to the sphenopalatine ganglion **(Fig. 44.6)**. In order to provide anatomical verification, the infraorbital nerve is identified in the roof of the maxillary sinus and is carefully followed posteriorly to the trunk of V_2 near the sphenopalatine ganglion. Dissection is then completed by isolating and identifying the trunk of V_2 superiorly and posteriorly to the sphenopalatine ganglion. The trunk of the maxillary nerve (V_2) is then sectioned posterior to the sphenopalatine ganglion near the foramen rotundum and close to the inferior orbital fissure **(Figs 44.7A and B)**. The antral mucoperiosteal flap in the vestibule is repositioned and sutured back.

Complications (1) inadvertent section of the vessels in the pterygopalatine fossa (2) inadvertent sectioning of the branches of the sphenopalatine ganglion or the vidian nerve, entering the posterior aspect of the ganglion.

Inferior alveolar neurectomy: It can be performed via intraoral or extraoral approach. The intraoral approach is preferred as it is simple and more cosmetic.

- **The extraoral approach:** It is through Risdon's incision, where after reflection of masseter, a bony window is drilled in outer cortex and nerve is lifted with nerve hook and avulsed from its superior attachment and mental nerve is avulsed anteriorly through the same approach.

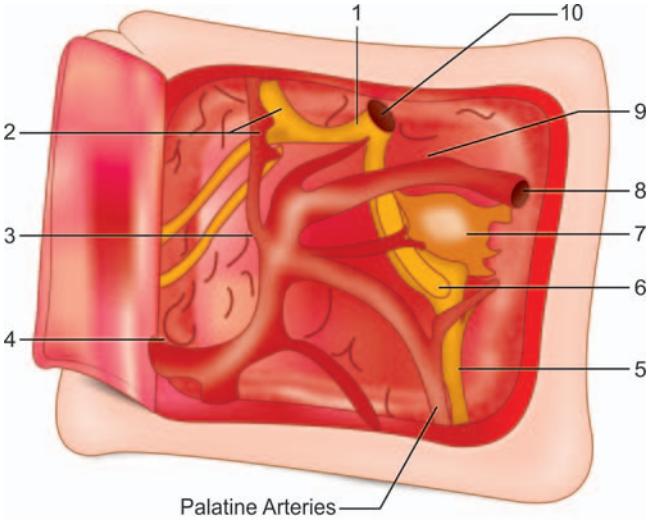
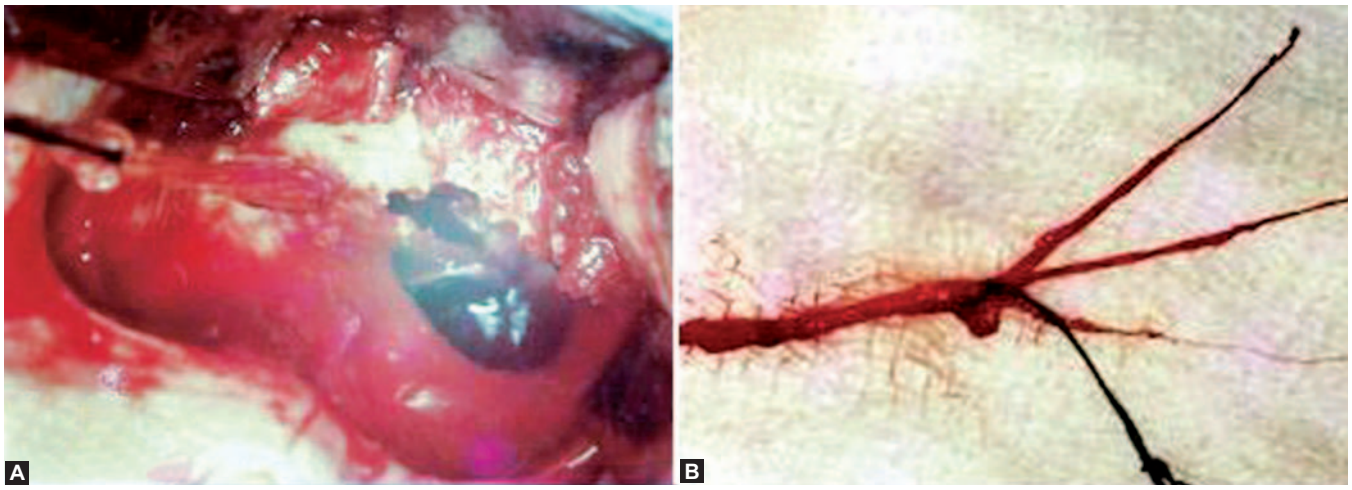
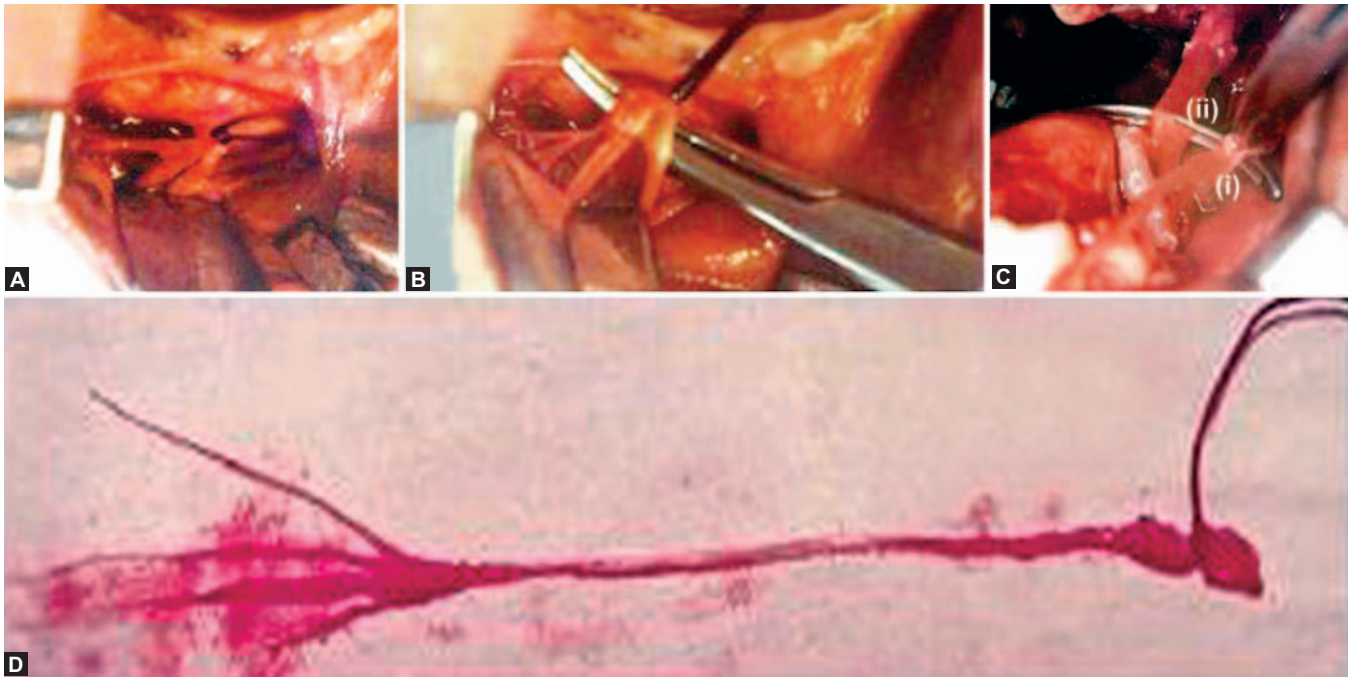


Fig. 44.6: View of the contents of pterygomaxillary fossa (1) maxillary nerve, (2) infraorbital nerve and artery, (3) maxillary artery, (4) posterior superior alveolar artery, (5) palatine nerves, (6) vidian nerve, (7) sphenopalatine ganglion, (8) sphenopalatine foramen, (9) sphenopalatine artery and (10) foramen rotundum

- **Intraoral approach–via Dr Ginwalla's incision (Figs 44.8A to D):** it is mainly used in dentulous cases. Incision is made along the anterior border of ascending ramus, extending lingually and buccally and ending in a fork like an inverted Y (Dr Ginwalla's incision). Such incision provides better exposure of the field. The incision is then deepened on the medial aspect of the ascending ramus by means of blunt and sharp dissection. The temporalis and medial pterygoid



Figs 44.7A and B: (A) surgical exposure of infraorbital nerve via transantral approach; (B) avulsed nerve



Figs 44.8A to D: Inferior alveolar neurectomy. Dr Ginwalla's procedure—(A) exposure of mental nerve; (B) peripheral branches of mental nerve ready for avulsion; (C) exposure of (i) inferior alveolar nerve and (ii) lingual nerve, via Dr Ginwalla's intraoral incision; (D) Inferior alveolar nerve avulsed

muscles are split, rather than divided at their insertion and the inferior alveolar nerve is located. Two heavy black linen threads are then looped around the nerve using nerve hook and then divided between the two threads. This is done as high as possible and the upper end is cauterized, while dividing and lower end is held with the hemostat. Another linear incision is made in the buccal vestibule overlying the mental foramen. A mucoperiosteal flap is reflected to expose the mental nerve. It is then tied with heavy black linen just little away from the foramen. The nerve is then caught with the hemostat distal to the knot and is divided between

the two. The distal part held between the hemostat and is wound around it and the peripheral branches entering the mucosa are avulsed out. There is puckering of the skin surface seen during this procedure.

Now, after the mental nerve is freed, then at the mandibular foramen, the distal part of the nerve which is held with the hemostat is pulled until the entire nerve length of the canal is avulsed out. If any obstruction is encountered, a window may be made in the buccal cortex posterior to the mental foramen, along the level of the inferior alveolar canal and the nerve is lifted out of the canal through the window. The wound is closed with interrupted sutures.

Lingual neurectomy (Fig. 44.9): A vertical incision is made at the inner border of the ascending ramus, extending from the coronoid process down the level of the floor of the mouth. Keeping the two sides of the incision retracted, the dissection is continued downwards until the lingual nerve comes into view at the border of the medial pterygoid muscle. In the region of the floor of the mouth, the nerve lies even more superficially and it can be easily found between the anterior pillar of the fauces at the root of the tongue. After dissection, the nerve is grasped with a hemostat and is then either avulsed or cauterized and cut. The wound is closed with interrupted sutures.

Cryotherapy or Cryoneurolysis for Peripheral Nerves

Direct applications of cryotherapy probe at temperatures colder than –60°C are known to produce Wallerian degeneration without destroying the nerve sheath itself.

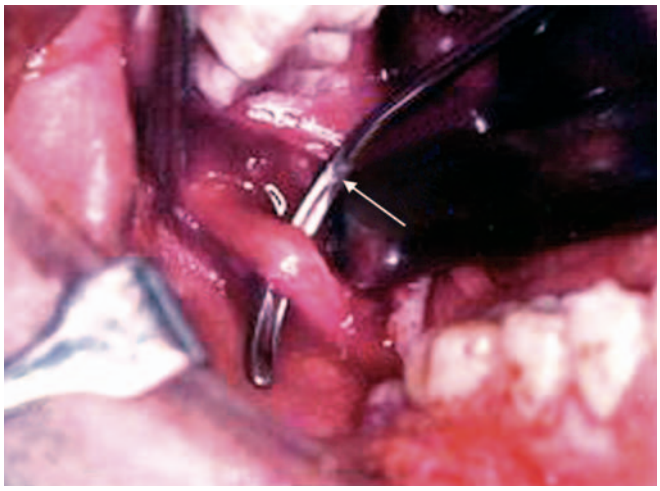


Fig. 44.9: Exposure of the lingual nerve. Arrow—nerve hook

For this procedure, the nerve is exposed as described in peripheral neurectomy procedure and is frozen with a cryoprobe (Nitrous oxide probe) for a period of 1–2 minutes followed by 3 minutes thaw, to be repeated three times. The pain remission follows the procedure. But regeneration of axons is expected. No large series are available for comparison with peripheral cryotherapy techniques. But the procedure is relatively simple.

Peripheral Radiofrequency Neurolysis (Thermocoagulation)

Gregg and Small, in 1986, reported surgical management of trigeminal pain with radiofrequency lesions of the peripheral nerves. A radiofrequency electrode that has the capacity to definitely destroy the pain fibers is used in this procedure. The use of radiofrequency (RF) lesioning of trigeminal nerve has been used sparingly, but with success. RF neurolysis has been shown to induce pain remission in 80% of cases with a 20%/year recurrence rate.

Procedure: Topical anesthesia with mild sedation is used. The patient is grounded in an electronic circuit and the 22-gauge lesion probe is positioned adjacent to nerve to be lesioned. Paresthesias are elicited to ensure proximity to the nerve and tissue temperature is measured with the probe tip through the probe thermocouple. Lesioning is then carried out at 65–75°C for 1–2 minutes. Repositioning may be required to ensure adequate RF wave effect on the nerve fibers.

Advantages: Low morbidity in high risk/elderly patients.

Disadvantages: Needs specific electronic armamentarium and reasonable patient cooperation. In case of inaccessibility of some pain triggering nerve trunks, the technique will fail to achieve pain relief.

Gasserian Ganglion Procedures

Around 1900—first open surgeries were performed on the gasserian ganglion for TN. These were recorded as hazardous procedures

- 1910—Harris, Tapatas and Hartel separately introduced percutaneous approaches to the ganglion via the foramen ovale. Absolute alcohol or phenol-glycerol mixture was used as the neurolytic agent.
- 1931—Kirschner introduced percutaneous electro-coagulation of the gasserian ganglion.
- Since then, three main percutaneous gasserian ganglion procedures are being used with variable success rate: (i) glycerol injection, (ii) thermocoagulation, (iii) balloon compression.

The technique of needle placement is common to all of these. Initial pioneering procedures were performed free hand, but now hard copy X-ray or image intensification on monitors is used first for visualization of position of the foramen ovale and then for confirmation of the depth of penetration of the needle and the position of any contrast medium used.

Technique for Percutaneous Approach to the Gasserian Ganglion: Anesthesia Protocol

Patient is admitted on the day of surgery and kept nil by mouth for at least 4 hours prior to surgery. Injection atropine (0.6 mg IM) is given 1 hour prior to surgery to reduce oral secretions and to prevent intraoperative bradycardia.

Injection methahexitone: Ultrashort acting barbiturate (brevital) is administered intravenously in dose of 1.5–2 mg/kg body weight in increments, so as to maintain an adequate level of unconsciousness during lesion production and during painful part of the procedure, like when needle/electrode comes in contact with the base of the skull, when it penetrates foramen ovale. Pulse oximeter, oxygen saturation, vital signs including systolic and diastolic blood pressure, respiratory rate, pulse rates as well as ECGs are monitored throughout the procedure. The duration of procedure is usually of 1 hour. Patient should be given intranasal oxygen and intravenous fluids.

Procedure: The patient is made to lie on a table with neck well extended. The foramen ovale is best visualized with the X-ray tube placed for a submentovertex position. Infiltration of the skin and cheek is done with local anesthetic agent on the affected side. Three points of Hartel are marked on the side of the face using marking ink **(Fig. 44.10)**.

First point is marked at lateral orbital rim and a perpendicular line is drawn till the inferior border of the mandible.

Second point is marked at about 15 mm (3 inches) lateral to the angle of the mouth on the perpendicular first line. This is a point of penetration of needle/electrode.

Third point is marked at the level of TMJ. 2.5 cm from the center of external auditory meatus. This point is joined with the second point of Hartel. This line will form a plane, which is the plane of elevation. When the patient is positioned in supine position with head extended, the plane of elevation is perpendicular to the floor (a flat pillow is kept under the shoulder). The needle/electrode is passed through the cheek from the point of penetration



Fig. 44.10: Hartel's three-point markings

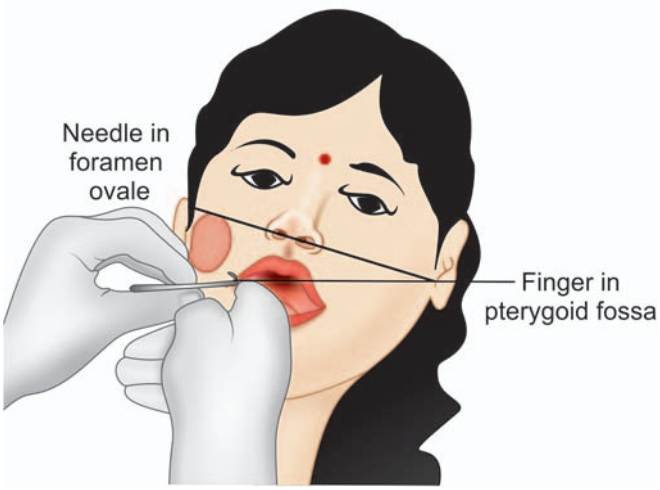


Fig. 44.11: Prevention of inadevertent penetration of needle in the oral cavity, while injecting into the gasserian ganglion

(second point). The finger of gloved hand is placed inside the oral cavity to prevent inadvertent penetration of needle/electrode in the oral cavity **(Fig. 44.11)**.

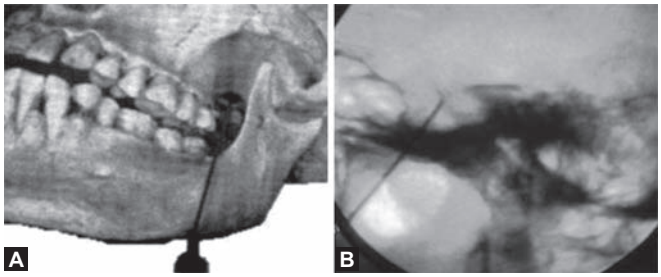
Pass the needle/electrode along the plane of elevation till it reaches the anterior border of ramus of mandible, then turn the needle medial to ramus, pass it upwards to the base of the skull in pupillary plane.

During this phase, the needle/electrode lies below the orbit, medial to ramus of the mandible and lateral to maxilla. Engagement of the needle/electrode in the foramen ovale is best confirmed by biplanar radiology or image intensifier **(Figs 44.12A and B)**.

The final position of the needle/electrode is then pushed for another half a centimeter.

Glycerol injection: Glycerol or absolute alcohol can be used for percutaneous ganglion neurolysis. The agent is injected into Meckel's cave or in the ganglion **(Fig. 44.13)**. The agent then diffuses throughout the ventral ganglion, producing low-grade damage to nerve cells, presumably through dehydration. This technique induces pain relief in around 80% of cases, it can be repeated if required and it prevents gross facial sensation with lower levels of anesthesia. It also spares the important ophthalmic division and the motor root.

For this injection, a 16-gauge spinal needle is used and inserted through the foramen ovale into the ganglion till CSF is obtained on withdrawal of the stylet **(Fig. 44.14)**. Contrast medium is injected to check the position of the needle. The contrast is evacuated and replaced by 0.5–0.75 mL of pure glycerol or 0.5 mL of absolute alcohol. The patient is sent to ward and kept there with head extended for 2 hours. The relief obtained varies from 6 months to 2 years. In this procedure patient cooperation is needed, if it is done under local anesthesia.



Figs 44.12A and B: (A) Pathway of the needle towards foramen ovale; (B) Needle/electrode point at the clivus seen on image intensifier screen

Controlled radiofrequency thermocoagulation (Fig. 44.15): A radiofrequency electrode that has the capacity to definitely destroy pain fibers is now used.

Electrocoagulation of gasserian ganglion was introduced first by Kirschner (1931) and later modified by Sweet (1970).

Advantages

- Avoidance of denervation of cornea
- Comparative lower rate of recurrence
- Procedure can be repeated in case of recurrence
- Zero mortality
- Well tolerated by elderly and medically compromised patient
- Patient will prefer thermocoagulation rather than opting for neurectomy, which leads to facial numbness
- Where facilities permit, it can be performed on outpatient basis
- Thermocoagulation preserves the motor function of trigeminal nerve
- Simple, accurate procedure, less time consuming and less expensive, and comfortable for the patient.

Indications

- Toxicity of drugs
- Failure of response to other modalities

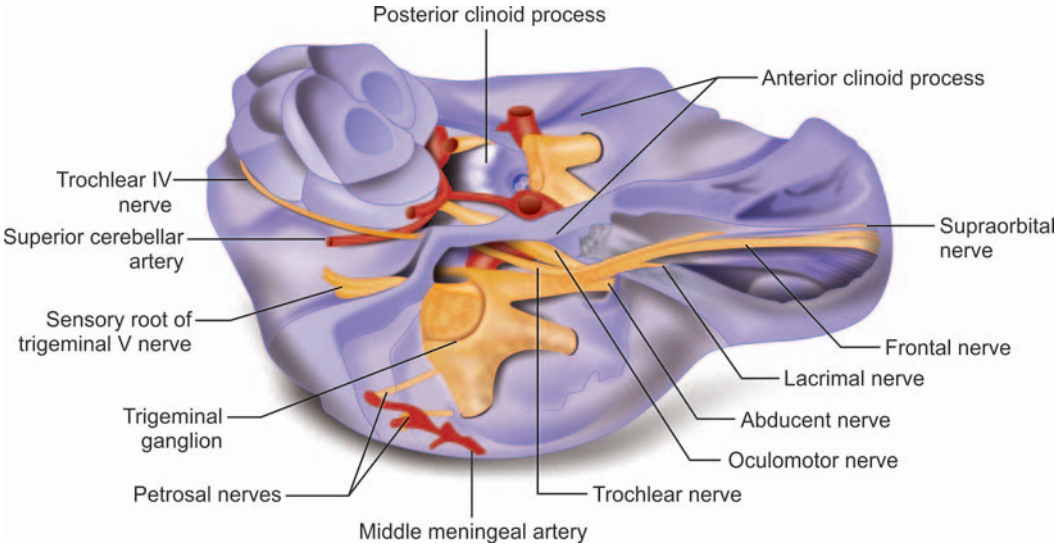


Fig. 44.13: Gasserian ganglion and its relations



Fig. 44.14: Gasserian ganglion injection technique preparation. A 16-gauge spinal needle is inserted through the foramen ovale into the ganglion. Arrow—CSF flow



Fig. 44.16: Patient in position for radiofrequency thermocoagulation procedure

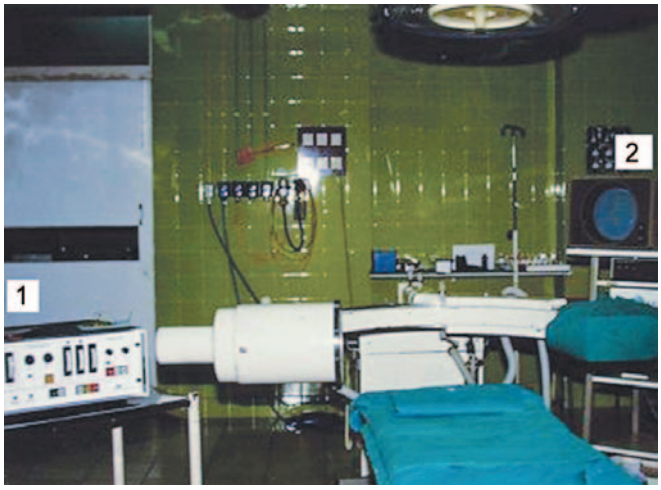


Fig. 44.15: (1) Owl's radiofrequency system; (2) C-arm image intensifier screen

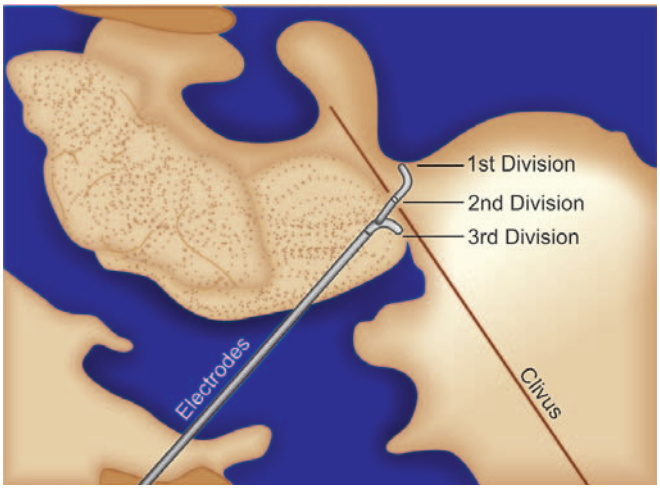


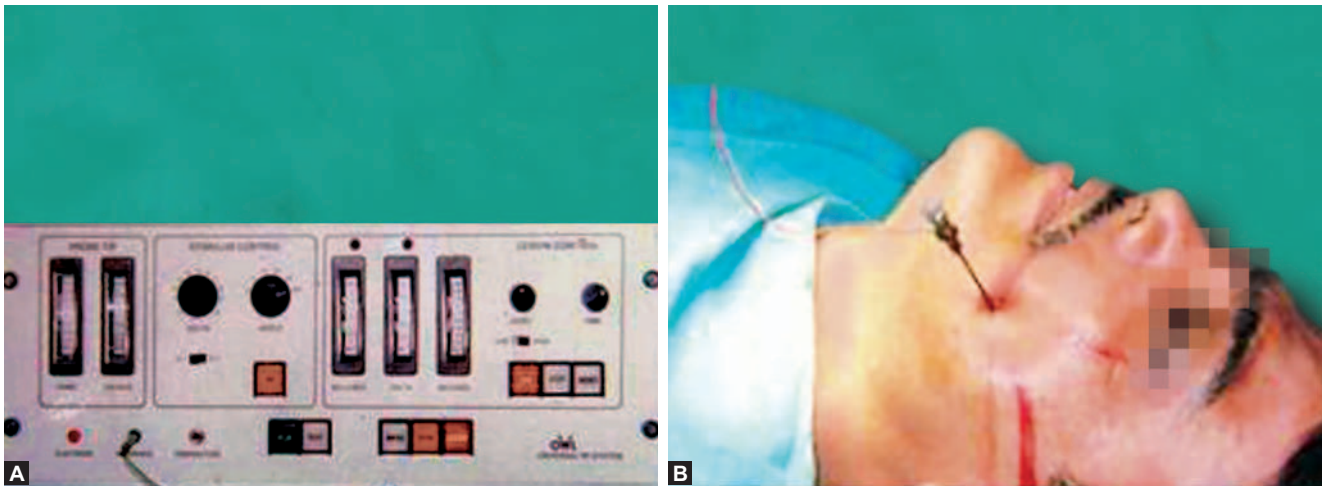
Fig. 44.17: Position of the electrode is adjusted as per the division of the trigeminal nerve involved on clival plane

- Dependence on drug for lifetime
- Elderly patients
- Medically compromised patients
- Recurrence cases—previously treated by intracranial surgery, neurectomies, etc.

Procedure

The trigeminal ganglion may be approached through the foramen ovale by percutaneously placing a 22-gauge probe under fluoroscopic guidance. The image intensifier is used and middle cranial fossa is focussed in the center of screen, the contrast is adjusted to sharpen the bony landmarks **(Fig. 44.16)**. Clear visualization of foramen ovale is obtained by adjusting the position. The probe used should have an insulated shaft and a bore sufficient for the passage of a radiofrequency electrode **(Fig. 44.17)**. When the probe is placed correctly in the foramen ovale and advanced into the trigeminal ganglion, cerebrospinal fluid (CSF) should emerge on removal of the stylet as the ganglion contains CSF (in patients who have undergone previous surgeries or chemical injections, you will not get CSF flow). The electrode is inserted then just beyond the tip of the probe and a low-amplitude current is applied using a lesion generator **(Figs 44.18A and B)**.

Patient at this stage should be awake and cooperative, is asked whether on the face the stimulation is felt (electric



Figs 44.18A and B: (A) Owl's radiofrequency system; (B) Electrode with generator cable attached

like impulse). The position of the probe is adjusted until stimulation is experienced by the patient in the area where trigeminal neuralgia pain was present. Stimulation is initiated utilizing square wave pulses at 50 cycles per second slowly raising the voltage until full areas of pain covered.

Lesion production: Patient at this stage should be given neurolept anesthesia. Thermal lesions of 30–90 second duration are then made at 65–75°C using RF generator of microwave energies.

Power 25 watts, voltage 40–45 volts. Current 120–140 mA. With these parameters a temperature range of 65–75°C is achieved. A 5-mm bare tip electrode with 2 mm diameter will produce a lesion of 10 mm x 6 mm within the trigeminal root at 75°C.

A radiofrequency current when an alternating current of high frequency is passed through the electrode, it produces ionization in biological tissues. Heat results from "ionic friction", which leads to coagulation of tissues. Great care is exercised to avoid over shooting to preserve the sense of touch. After partial result is produced, it is mostly possible to complete the lesion without additional short acting anesthetic agent. A facial blush usually appears at this point and helps to localize the region of nerve root undergoing thermal destruction. This is due to the vasodilator system emerging from the brainstem and passing to the facial vasculature with trigeminal nerve.

At the end of the procedure, patient is asked to perform those maneuvers that characteristically trigger the TN. Once the patient and operator satisfied with the desired RF lesion production, the electrode is removed and patient is sent to recovery room.

Balloon compression: It is done under general anesthesia. It is a mechanical technique to destroy root fibers partially by advancing 4FG Fogarty catheter 1–2 cm within Meckel's cave and inflating the balloon at the ventral aspect of the ganglion root.

A 12-gauge spinal needle is passed first to the foramen ovale and the balloon catheter is passed through it. Once it is in position the balloon is inflated with X-ray contrast medium up to 0.75 mL. When inflated, the balloon should take up the pear shape of Meckel's cave and it should remain inflated for 1 minute.

Open Procedures (Intracranial Procedures)

Microvascular decompression of the sensory root (posterior fossa decompression—PFD)

- Procedure popularized in 1967–1976 by Jannetta
- Most commonly performed intracranial open procedure
- Open craniotomy approach is used to gain access to the trigeminal root entry zone and adjacent brainstem
- The root is examined under the microscope. A compressing branch of the superior cerebellar artery will be seen medial to the nerve at the root entry zone.
- The artery is carefully separated from the nerve and interpositioned by using sponge or Teflon wool.
- Patient usually retains good facial sensation without anesthetic dysfunction.
- 75–80% of patients are pain free for at least 5 years
- Overall mortality rate is 2%. It can be associated with infrequent hearing loss, vertigo, cranial nerve VII weakness.
- Contraindicated in elderly patients and medically compromised patients.

Trigeminal Root Section

- **Extradural sensory root section:** *Frazier's approach (1901)*—The subtemporal extradural route retrogasserian rhizotomy (root sectioning).
  Here sensory root is divided, sparing the motor root, as close to the brainstem as possible.
  This procedure is rarely used now and it is of historical value, because of the profound sensory loss and high incidence of anesthesia dolorosa. Sensory loss involving ophthalmic division leads to keratitis.
- **Intradural root section:** Described by Wilkins (1966), is superior to extradural approach, as it has less chances of damage to superior petrosal nerve and facial nerve, less chance of bleeding.
  In 1932, Dandy recommended posterior fossa surgery, but technique is more difficult than Frazier's approach and it can damage 5th, 7th or 8th cranial nerves, because of excessive retraction or manipulation, vascular damage, etc.
  Advantages of posterior fossa approach are unsuspected tumors or vascular malformation is more readily delineated and handled.
- **Trigeminal tractotomy (medullary tractotomy):** Incision of descending trigeminal tract near the cervicomedullary junction will reliably cause the loss of pain and temperature sensation in the ipsilateral face and pharynx and usually will relieve the pain of TN. It is helpful in patients with pain perceived in both glossopharyngeal and trigeminal distribution. It can be also used for intractable facial pain and should not be routinely used.

Update

Three surgical approaches are commonly used at present to treat TN. All of these techniques produce relief of TN symptoms in large majority of patients—80–90%. The incidence of complications is low.

- Percutaneous stereotactic radiofrequency thermal lesioning of the trigeminal ganglion and/or root (RFL).
  - This technique produces mild injury to the sensory fibers in the trigeminal root. It is minimally invasive and successfully controls pain in over 85% of TN cases and can be performed as day care procedure. Specific side effect is sensory loss and occasional dysesthesia in the distribution of the damaged trigeminal fibers.
  - Recommended for patients, who are elderly and medically frail.
- Posterior fossa exploration and microvascular decompression (MVD) of the trigeminal root.
  - It is a more complex and invasive therapy. But, this directly treats a hypothetical cause of the disorder (nerve compression) while minimizing any trigeminal sensory damage.
  - Recommended for young patients, who can tolerate longer, invasive surgical procedure.
- Gamma knife radiation (GKR) to the trigeminal root entry zone.
  - Relatively recent procedure that employs computerized stereotactic methods to concentrate gamma radiation on the trigeminal root entry zone. It has gained wide acceptance, however long-term results of GKR in TN remain to be established. Advocated in old and frail patients.

Points to Remember

- Etiology and pathogenesis of trigeminal neuralgia
- General characteristics of trigeminal neuralgia
- Clinical characteristics of trigeminal neuralgia
- Diagnosis of trigeminal neuralgia
- Treatment of trigeminal neuralgia.

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CHAPTER 45 Sensory Disturbances of Face and Jaws

INTRODUCTION

Injuries to peripheral branches of the fifth (trigeminal) nerve is ever present risk during surgical procedures performed in the oral cavity and associated maxillofacial region. Sensory disturbances of the face due to trigeminal nerve branches injury, usually undergo spontaneous regeneration and sensory recovery, but some will result in incomplete regeneration with "*paresthesia*" or will result in a painful neuropathy—"*dysesthesia*". The resulting loss of sensory function can be distressing to those patients in whom spontaneous return of nerve function does not occur. As per older belief, nerve injuries do not always heal spontaneously. Advances in microsurgical techniques and better understanding of neuroanatomy have made possible, the surgical repair of selected maxillofacial peripheral nerve injuries, when carried out timely by a skilled surgeon **(Fig. 45.1).**

IMPAIRED SENSATION

Sometimes, one or more or all forms of sensation may be impaired. In some cases, the sense of pain is only disturbed, in others the tactile or temperature sense is also affected.

The various terminologies, which are used for expressing the neurological disturbances are listed below:

- **Allodynia**: Pain due to a stimulus that does not normally provoke pain.
- **Analgesia**: Absence of pain in response to stimulation that would normally be painful.
- **Anesthesia**: Total loss of all types of sensation in response to the stimulation that would normally be painful or non-painful. (Total numbness in the distribution of the injured nerve).
- **Paresthesia**: An altered sensation, which is not pleasant, like tingling, crawling, burning, pricking, itching, etc. The area supplied by the nerve is numb. This is due to injury or severance of a nerve. The abnormal sensations are produced by an irritation of the nerve at the site of injury or because of the neuroma formation at the severed nerve end.
- **Dysesthesia**: An unpleasant painful abnormal sensation, either spontaneous or evoked. Patient complains of numbness associated with burning, stabbing or burrowing type or a phantom pain.
- **Hyperesthesia**: An increased sensitivity to stimulus.
- **Hypoesthesia**: Decreased sensitivity to stimulation.
- **Hypo and hyperalgesia**: Decreased or increased response to a stimulus that is normally painful.
- **Ageusia**: Loss of taste.
- **Neuritis**: Designates an inflammation of a nerve.
- **Neuralgia**: Transmission of a pain impulse passed along the course of the nerve.

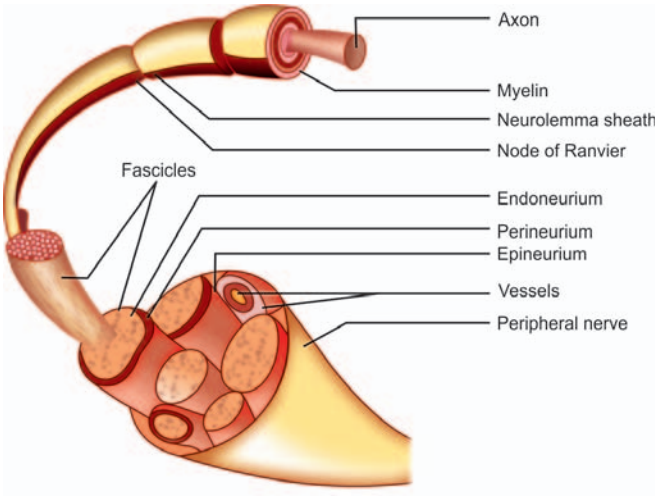


Fig. 45.1: Structure of a myelinated peripheral nerve

ETIOLOGY

Due to the injury to the sensory nerve branches, there can be "*temporary deficit*" or "*permanent deficit*".

Maxillofacial surgical procedures that run the risk of injury to one of the peripheral branches of the trigeminal nerve:

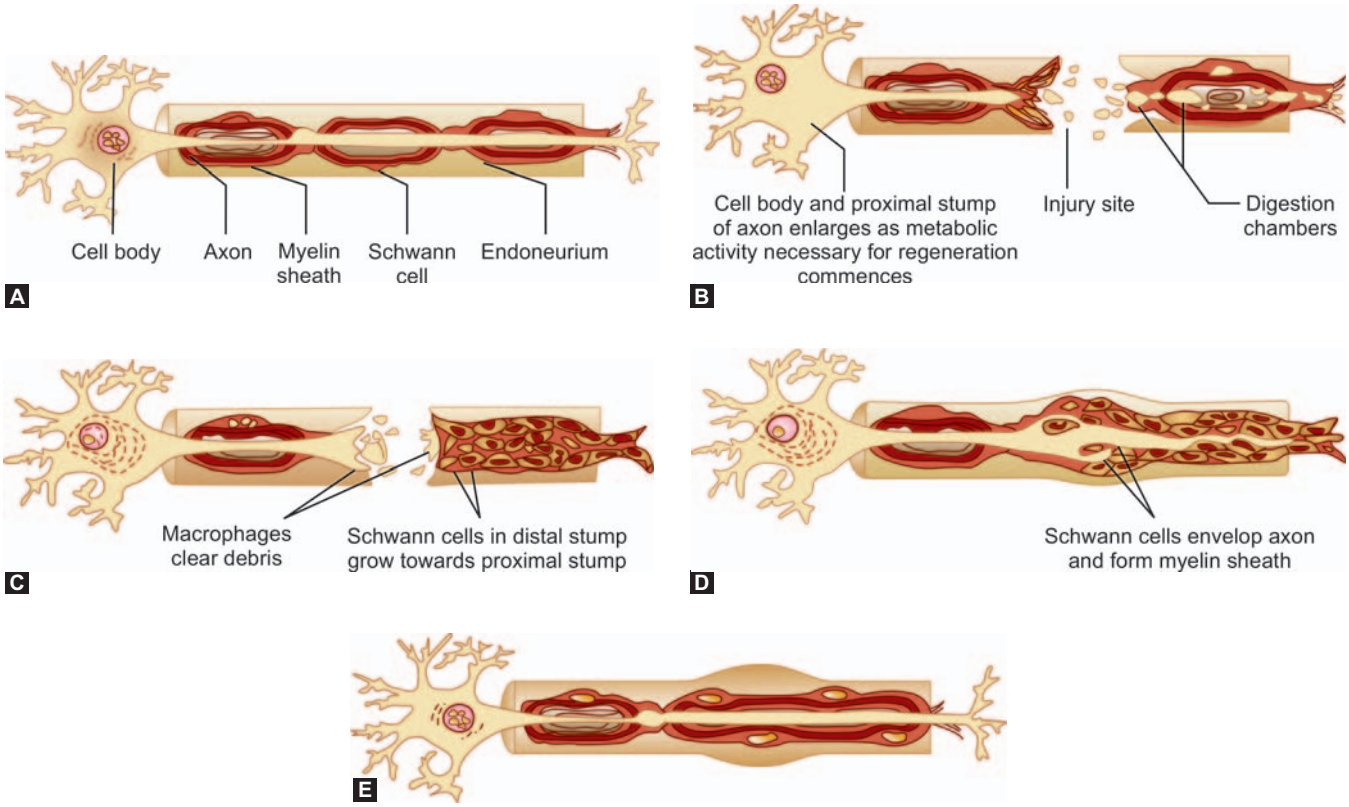
A. **Inferior alveolar nerve**: Mandibular impacted third molars or any impacted mandibular tooth removal, mandibular molar endodontics, endosteal implant placement, visor osteotomies, alveolectomy, mandibular body/ramus/subapical osteotomies, mandibular cyst or tumor removal, mandibular resection, fractures of mandibular body and angle region, preprosthetic surgery, genioplasty, gunshot wounds, osteomyelitis can lead towards anesthesia.
B. **Lingual nerve**: Mandibular third molar removal, excision of the sublingual or submandibular gland, iatrogenic instrumentation of floor of the mouth, sulcoplasties of lingual vestibule, mandibular tumor removal, mandibular ramus osteotomies.
C. **Infraorbital nerve**: LeFort II, III level osteotomies, Caldwell Luc procedure, orbital osteotomies, fractures of the midface and orbits.

INCIDENCE

American Association of Oral and Maxillofacial Surgeons in 1993, reported the removal of impacted third molars is associated with inferior alveolar nerve injury in 1.0–7.1% of patients, whereas the incidence of injury to the lingual nerve is estimated at 0.02–0.06%.

CLASSIFICATION OF MECHANICAL NERVE INJURIES

Classification of nerve injuries helps the clinician in making a diagnosis, developing a rational plan of management, determining the need for and timing of surgical intervention and estimating the prognosis of an injury **(Figs 45.2A to E).**



Figs 45.2A to E: (A) Stages of peripheral nerve healing. Normal nerve cell and axon; (B) Early Wallerian degeneration; (C) Phagocytosis and Schwann cell proliferation; (D) Growth; (E) Repaired nerve fiber

Seddon (1943) and *Sunderland* (1978), have proposed nerve injury classifications, which are most commonly used. "It is applied to both motor as well as sensory nerves".

Seddon's Classification (Table 45.1)

- **Neuropraxia**: Mild, temporary injury caused by compression or retraction of the nerve. There is no axonal degeneration distal to the area of injury. There is a temporary conduction block—sensory loss. Spontaneous recovery usually occurs within 4 weeks or less time. No surgical intervention is required.
- **Axonotmesis—more significant injury**: There is disruption or loss of continuity of some axons, which undergo Wallerian degeneration distal to the site of injury. The general structure of the nerve remains intact. There is prolonged conduction failure. Initial signs of recovery of nerve function do not appear for 1–3 months after injury. Eventual recovery is often less than normal (paresis, hypoesthesia). Sensory nerve injuries may develop persistent painful sensation (dysesthesias).
- **Neurotmesis**: It is complete severance or internal physiologic disruption of all layers of the nerve. Wallerian degeneration of all axons occurs distal to the injury. There is a total permanent conduction block of all impulses (paralysis, anesthesia). The discontinuity gap between proximal and distal nerve stumps becomes filled-up with scar tissue and proximal axonal sprouts are prevented from recannulating distal endoneurial tubules. No recovery is expected without surgical intervention.

Tinel's Sign

It was used earlier as an indication of the start of nerve regeneration. It is elicited by percussion over the divided nerve, which results in a tingling sensation in the part supplied by the peripheral section.

Now "*electroneurography diagnostic studies*" are carried out serially for evidence of reinnervation.

Sunderland's classification It is based on detailed description of pathophysiology and anatomy of the injured nerve. It also incorporates the features of Seddon's scheme that includes the amount of nerve tissue damaged and tissue still intact.

- **A Neuropraxia (Seddon)/first-degree lesion [Sunderland (Fig. 45.3A)]**: It is characterized by a conduction block, the rapid and virtually complete return of sensation or function and no degeneration of axon. There are three types of first-degree nerve injuries based on the proposed mechanism of conduction block.
  - **First-degree type I injury**: It may be the result of nerve trunk manipulation, mild traction or mild compression, such as during sagittal split ramus osteotomy, inferior alveolar nerve repositioning or lingual nerve manipulation during excision of sublingual or submandibular salivary gland. The mechanism of conduction block is presumed to be anoxia from interruption of the segmental or epineurial blood vessels, but there is no axonal degeneration or demyelination. There is a rapid return of normal sensation and function within 24 hours following the restoration of circulation.
  - **First-degree type II injury**: It may be caused by moderate manipulation, traction or compression of a nerve. Trauma of sufficient magnitude to injure the endoneurial capillaries cause intrafascicular edema and results in a conduction block. Normal sensation or function returns within 1–2 days following the resolution of intrafascicular edema, generally 1 week following nerve injury.
  - **First-degree type III injury**: It results from severe nerve manipulation, traction or compression pressure on the nerve, which may result in segmental demyelination or mechanical disruption of the

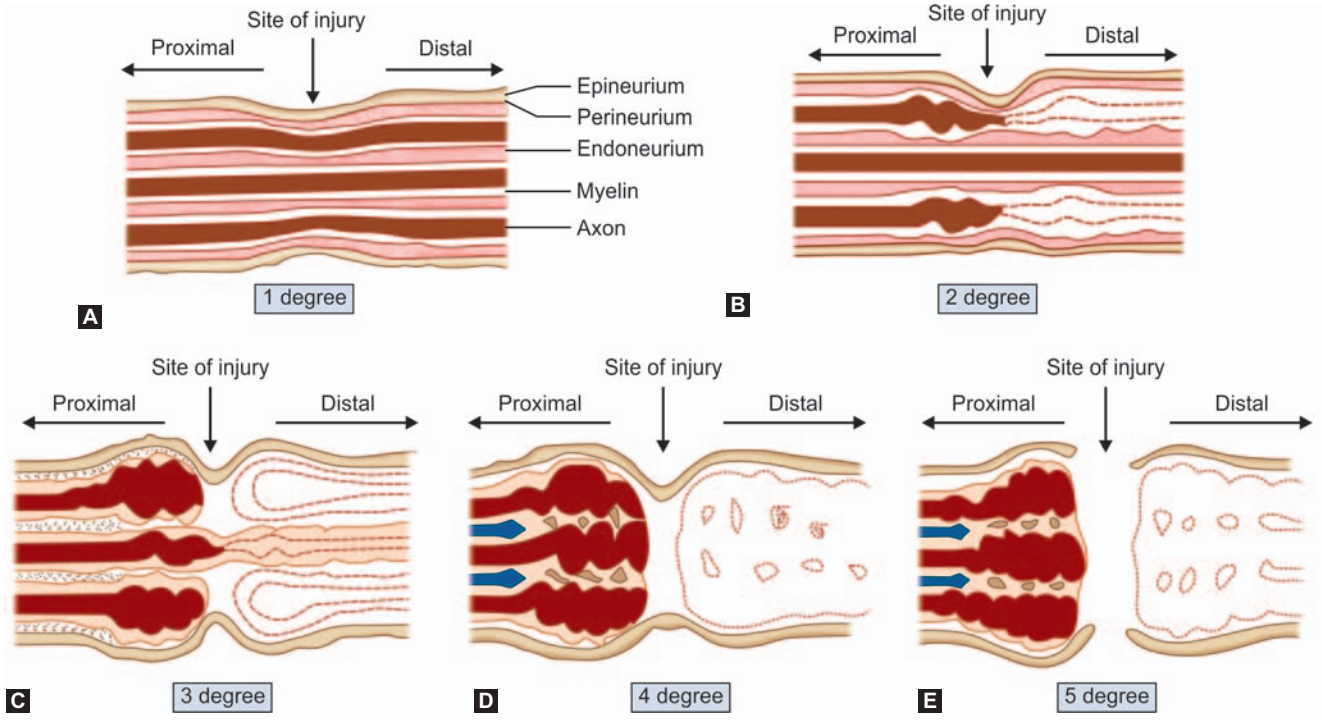
Table 45.1: Seddon's classification of nerve injuries

		Neuropraxia	*Axonotmesis*	*Neurotmesis*
1.	Sunderland classification	1°	2°, 3°, 4°	5°
2.	Nerve sheath	Intact	Intact	Interrupted
3.	Axons	Intact	Interrupted	Interrupted
4.	Wallerian degeneration	None	Yes, partial	Yes, complete
5.	Conduction failure	Transitory	Prolonged	Permanent
6.	Spontaneous recovery	Complete	Partial	Poor to none
7.	Time of recovery	Within 4 weeks	Months	Begins by 3 months, if any

myelin sheath. Sensory and functional recoveries are complete within 1–2 months, far earlier than can be explained by axonal regeneration. The psychophysical response to this type of injury is paresthesia. Surgery is not indicated for first-degree nerve injuries.

- **Axonotmesis (Seddon)/second-degree Sunderland nerve injury**: It is characterized by axonal injury with subsequent degeneration and regeneration. Traction, compressions are the usual mechanism of this type of nerve injury and may cause severe ischemia, intrafascicular edema or demyelination. Even though the axons are damaged, there is no disruption of the endoneurial sheath, perineurium or epineurium. Within 2–4 months following injury, there are signs of sensation or function, which continue to improve over the next 8–10 months. The psychophysical response to an axonotmesis or second-degree injury is an initial anesthesia and Tinel's sign followed by a paresthesia as recovery begins. Complete recovery may take as long as 12 months. Unless there is an extraneurial irritant inhibiting complete recovery, microreconstructive surgery is not indicated for second-degree nerve injuries **(Fig. 45.3B)**.
- **Axonotmesis (Seddon)/third-degree Sunderland nerve injury**: The etiology of a third-degree nerve injury is typically traction or compression. Not only is the axon damaged, but the endoneurial sheath is breached resulting in intrafascicular disorganization, while the perineurium and epineurium remain intact. The first signs of sensation or function are evident within 2–5 months and may take another 10 months or so **(Fig. 45.3C)**.

  Recovery is never complete. There is cross shunting of axons as they enter the distal endoneurial tubes and there is inaccurate localization of cutaneous stimuli. Endoneurial fibrosis may prevent the regeneration of axons to their original targets resulting in an intrafascicular neuroma.
- **Axonotmesis (Seddon)/fourth-degree Sunderland nerve injury**: The etiology of a fourth-degree nerve injury may include traction, compression, injection injury and chemical injury. The injection of chemical agents into the nerve trunk may cause irreversible damage to the axons and connective tissue components of the nerve trunk. Fourth-degree nerve injuries are characterized by disruption of the axon, endoneurium and perineurium with preservation of



Figs 45.3A to E: (A) Neuropraxia—first-degree lesion; (B) Axonotmesis—second-degree lesion; (C) Axonotmesis—third-degree lesion; (D) Axonotmesis—fourth-degree lesion; (E) Neurotmesis—fifth-degree lesion

the continuity of the epineurium, resulting in severe fascicular disorganization. There is poor prognosis for recovery and a high probability of development of central neuroma incontinuity **(Fig. 45.3D)**.

- **Neurotmesis (Seddon) or fifth-degree Sunderland nerve injury**: It is characterized by severe disruption of connective tissue components of the nerve trunks with compromised sensory and functional recovery. There is considerable amount of tissue loss also. The mechanisms of this injury include laceration, avulsion and chemical injury. There is damage to all components of the nerve trunk: axon, endoneurium, perineurium and epineurium **(Fig. 45.3E)**.

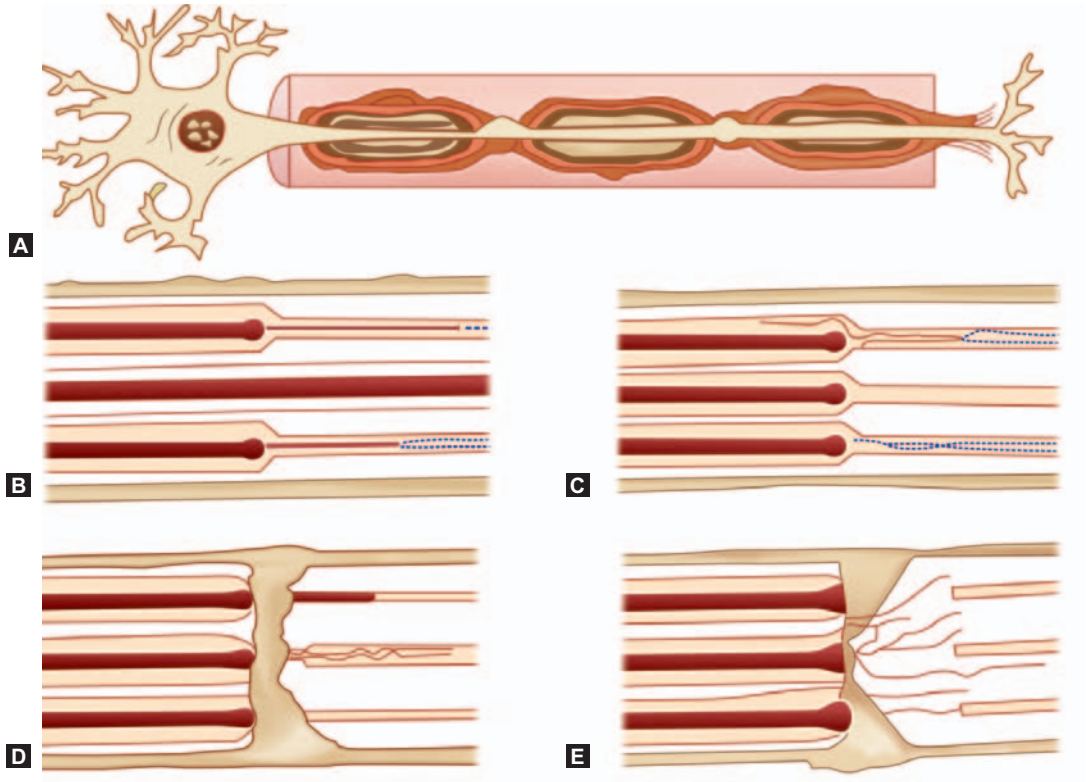
Useful sensory or functional recovery is unlikely and the development of extensive fibrosis and amputation (stump) neuroma is highly likely. The psychophysical response to this group of nerve injuries is an immediate anesthesia. This may be followed by a Tinel's sign and paresthesia or possibly neuropathic responses like allodynia, hyperesthesia, hyperalgesia or sympathetic mediated pain, which may develop into a chronic pain state **(Figs 45.4A to E)**.

The indications for microreconstructive surgery are strongest for neurotmesis or fifth-degree nerve injuries, since the prognosis for useful recovery is poor and the probability of getting symptomatic neuromas are high.

Not all nerve fibers have the same susceptibility to compression injuries and ischemia. Nerve fibers responsible for mechanoreception (touch) are more susceptible to compression and ischemia than the A-δ and C fibers. Following a mild to moderate compression injury, it is quite possible to have a deficit in mechanoreception (light touch and moving touch), but intact nociception (pinprick) and thermal discrimination.

Neuritis

Neuritis designates an inflammation, a disease of a nerve due to variety of conditions like traumatic neuritis, if the nerve is torn, pinched or lacerated and especially if the injury is associated with infection. Inflammation of the nerve also can be caused due to an infectious process—osteomyelitis, etc. Neuritis also occurs in herpes zoster. Toxic neuritis may be seen in arsenic, lead, mercury and alcohol poisoning and in vitamin deficiencies.



Figs 45.4A to E: Recovery group of peripheral nerves: (A) Complete recovery; (B) Satisfactory recovery; (C) Incomplete recovery; (D) Weak recovery; (E) No recovery

Clinical symptoms: There is deep seated pain, diffuse in character and relatively continuous, varying in intensity and functional loss is seen, if a motor nerve is involved. The area supplied by sensory nerves becomes hyperesthetic, unless the affected branch passes through a bony canal causing compression of the nerve due to edema, when hypoesthesia or anesthesia results. The pain or dysfunction may last for several weeks and is treated symptomatically by means of analgesics, narcotics, physiotherapy and vitamin B1, B6, B12 therapy. Hot, moist towels, heated sand bags and more modern electric pads can be used. Infrared lamp also can be used.

Neuropathic events following nerve injury: There are four basic neuropathic events that can occur:

- Collateral macrosprouting
- Peripheral neuroma.
- Cervical sympathetic pathosis
- Central pathosis.

These neuropathic events may be manifested clinically as anesthesia dolorosa, causalgia or sympathetic mediated pain, allodynia and hyperpathia.

Collateral macrosprouting from the injured or more commonly from adjacent uninjured nerves will produce a dysesthetic patterns due to neuroma like collaterals involving the injured zone.

Neuromas

Neuromas are characterized by disorganized microsprouting and formation of a disorganized mass of collagen and randomly oriented small neural fascicles. Peripheral neuromas may be classified as amputation/stump, central, eccentric:

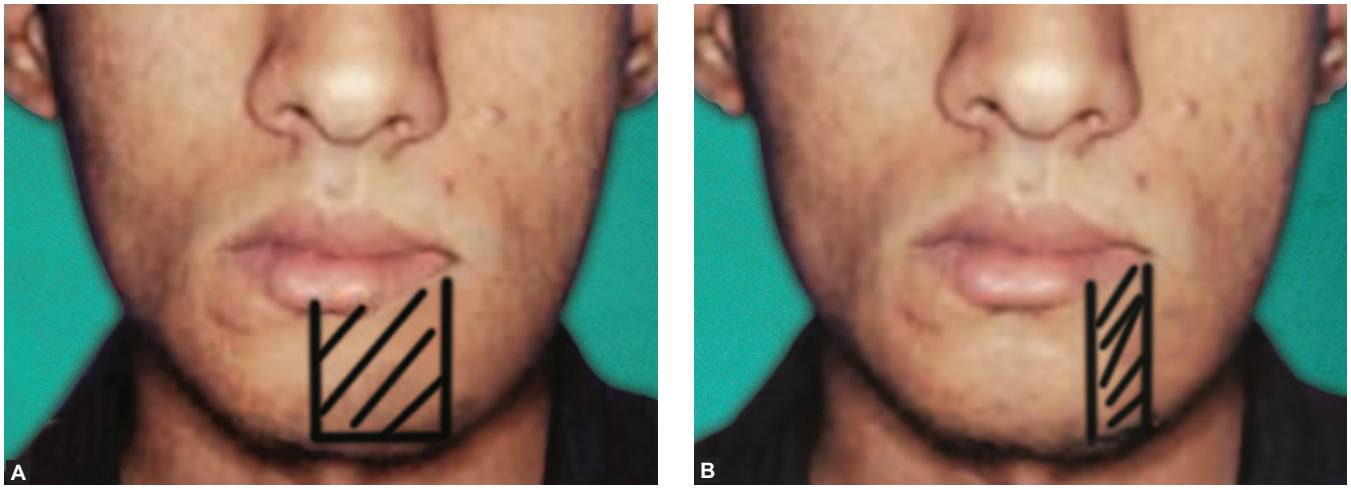
- **Amputation/stump neuromas**: It is a knobby, disorganized mass of axons and collagen associated with the proximal nerve stump and completely separated from the distal nerve stump. It is the result of fifth-degree injury.
- **The central neuroma**: It is a neuroma in continuity. It is a result of fourth-degree injury or fifth-degree injury, in which the continuity between the proximal and distal stump is established and there is no breach of the epineurium. It is a fusiform expansion or fibrotic narrowing of the nerve with varying degrees of fascicular disruption and disorganization.
- **Eccentric neuromas**: Two types of neuromas of inferior alveolar nerves are seen.
  - **Lateral exophytic**: Outgrowth of axons and collagen forming a terminal knoblike structure on an intact nerve. Only a few superficial fascicles are disrupted owing to incomplete transection of the nerve or form a poor coaptation of distal and proximal nerve stumps. There is a recognizable breach of epineurium at the site of lateral exophytic neuroma.
  - **Stellate neuroma**: It has two or more branches at the site of injury ending in adjacent soft tissue or mucosa. The epineurium is intact. 80% of painful neuromas are refractory to any treatment.

EVALUATION

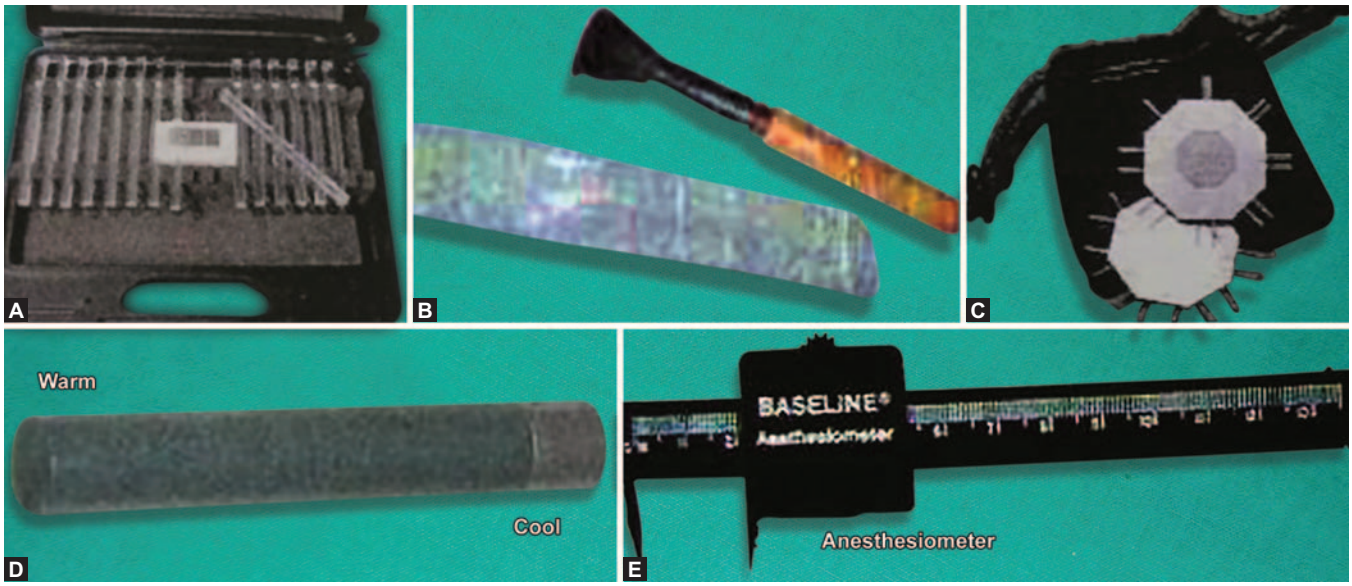
- First step is to ascertain the patient's main complaint—regarding loss of sensation, pain, abnormal sensation or functional impairment.
- Patient's history:
  - Trauma or surgical procedure associated with injury.
  - The date of the incident.
  - The progress of symptoms or functional complaints.
  - Progress of recovery—return of sensation within the first 4 weeks—excellent prognosis and indicates Neuropraxia. Later onset of sensation (1–3 months) is usually associated with axonotmesis. Total lack of recovery for 12 weeks or longer indicates neurotmesis and a poor prognosis for significant spontaneous recovery.
- Clinical neurosensory examination of the trigeminal nerve consists of four tests **(Figs 45.5 and 45.6)**
  - Static light touch
  - Brush directional discrimination
  - Two-point discrimination
  - Pin pressure nociceptive discrimination.

The first step is to map the area of sensory disturbance **(Fig. 45.5)**. This is done by brushing the skin with a camel hair brush from an unaffected region of the face toward the affected area. The patient is instructed to raise his or her hand, when the brush can no longer be detected or the sensation of the brush changes significantly. The area of transition is marked on the skin using an eyebrow pencil and divided into grids to allow topographic recording of the test results. Next, a dot is marked in the center of each grid to aid in the assessment of localization of stimuli.

- **Static light touch detection**: The test is performed using the Semmes-Weinstein filaments, which are nylon filaments of identical lengths, but variable diameter mounted in plastic handles.



Figs 45.5A and B: Mapping of the areas of sensory disturbance: (A) Area of total anesthesia in a patient one week after bilateral sagittal split ramus osteotomy; (B) Same patient after 8 weeks. Note the decrease in the area of altered sensation



Figs 45.6A to E: Devices for neurosensory testing: (A) Von Frey monofilaments for testing static light touch, which begins with the 1.65 monofilament; (B) Ultra soft brush for light touch testing brush directional stroke; (C) Two-point discriminator—the instrument is the two-point anesthesiometer. It is capable of applying a standardized amount of pressure at bending of approximately 3.6 g. This device consists of two parallel von Frey monofilaments attached to an acrylic bar at specific millimeter distances from each other 8 mm, 10 mm, 12 mm anesthesiometer can be selected, which is applied perpendicular to the skin surface, with both the filaments touching simultaneously until they bend. A normal response is considered 2 of 3 correct responses of feeling two points; (D) Thermal discrimination—the device selected is a cotton-tipped applicator saturated with ethyl chloride. The applicator applied rapidly, lightly to each facial zone. This is randomly repeated 3 times using ethyl chloride or placebo. A normal response is considered 2 of the 3 correct answers of a cool/normal/or not cold feeling; (E) Anesthesiometer

The stiffness of each filament is calculated and calibrated by the manufacturer, so a known force can be applied to the skin.

The patient is instructed to close the eyes and to say "touch", whenever a light touch on the face is felt and asked to point the exact spot where the touch was felt. The filament is vertically oriented and placed on the skin and in 1–1.5 seconds continues the descent until the filament is bowed but the side is not in contact with the skin. Continue pressure without movement for 1 second and in

1–1.5 seconds slowly raise the filament. The patient should be questioned as to perception of the stimulus relative to the unaffected side.

- **Brush directional discrimination**: With the patients eyes closed, a (00) camel hair brush is gently stroked over a 1 cm. area of skin at a constant rate. The patient is asked if any sensation is detected and which direction the brush moved. The correct number of responses for total number of trends is recorded.
- **Two-point discrimination**: It is measured with any instrument which allows the distance between the points to be altered. Two-point anesthesiometer is used. A sharp and blunt point is used.
- **Pin pressure nociception**: A pressure algesimeter is used, made from a number 4 Tailor's needle and an orthodontic strain gauge (15–150 g). The force is gradually increased on the affected area, until the sharpness of pain is identical to that of unaffected area is tested. If there is no response at 100 g of pin pressure, then the area is considered as anesthesia.

Thermal discrimination is assessed with a cotton swab saturated with ethyl chloride spray and immediately applied to the skin.

Photographs or diagrams of the affected area while testing are helpful in documentation and for comparison with results of subsequent testing. Local anesthetic nerve blocks are indicated in evaluating painful nerve injuries. Failure to relieve pain in the presence of effective nerve block suggests a central sympathetic or psychological rather than peripheral cause of dysesthesia.

MANAGEMENT

Nerve regeneration in bony canals frequently occurs without surgical aid because the canal acts as a guide to growth and union.

But, if the bony canal is obstructed by displaced bone or a fragment of a tooth or soft tissue/muscle interposition, then the nerve regeneration is not possible without surgical intervention.

- Neurorrhaphy should not be performed until infection has subsided.
- All pathologic conditions of the nerve ends must be resected (neuromas)
- The nerve must be properly coapted.

Indications for microneurosurgery:

- Observed nerve severance
- Total anesthesia beyond 3 months
- Dysesthesia beyond 4 months
- Severe hypoesthesia without improvement beyond 4 months.

Contraindications for microneurosurgery:

- Central neuropathic pain
- Dysesthesia not abolished by local anaesthesia (LA) nerve block
- Improving sensation
- Sensory deficit acceptable to the patient
- Metabolic neuropathy
- Medially compromised patient
- Excessive delay after injury.

Principles of repair of injuries of the peripheral branches of the trigeminal nerve (microneurosurgery):

- Controlled general anesthesia
- Visualization
- Magnification of the surgical field
- Good hemostasis
- Removal of pathologic tissue or foreign material
- Proper alignment
- Coaptation of proximal and distal nerve stumps
- Suturing without tension.

Surgical Approach

- The inferior alveolar nerve is exposed by either a transoral or a submandibular approach depending on the location and circumstances (intentional or unintentional) of the injury and the preference of the surgeon.
- The mental nerve is approached by a buccal sulcus incision.
- The lingual nerve is operated through an incision around the lingual aspects of the premolar and molars that extends posteriorly along the superior border of the ascending mandibular ramus.
- The infraorbital nerve is visualized through intraoral maxillary labio-buccal vestibular approach or extraoral subciliary, transconjunctival incisions.
- Magnification of the nerve is provided by surgical loops and operating microscope.
- The nerve is exposed, impinging scar tissue, bone or foreign material is removed, (external decompression).
- The epineurium may be opened and interfascicular scarring relieved (internal neurolysis).
- Internal inspection of the nerve is also necessary to detect neuromas or discontinuity of individual fascicles **(Fig. 45.7).**
- When neuromas are excised, the existing pathology or its removal may create a discontinuity defect.

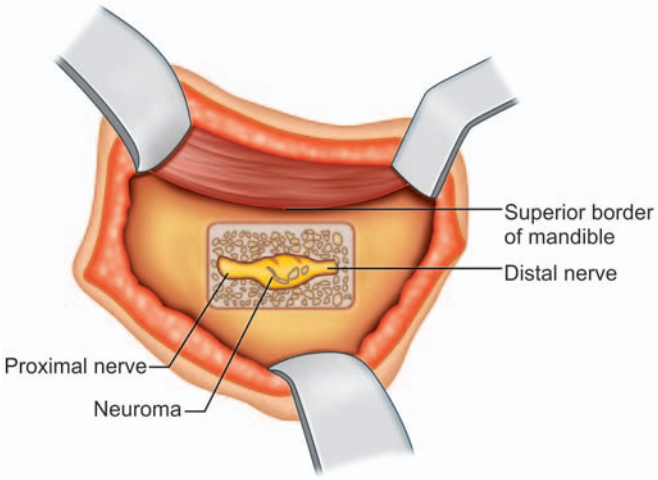


Fig. 45.7: Extraoral Risdon's incision to expose the inferior alveolar nerve. Window is created by removing the buccal cortical bony plate. Inspection of the nerve to detect neuroma is done

- The proximal and distal nerve ends are assessed and serial 1 mm sections are removed if indicated until viable fascicles are visualized or identified on frozen sections.
- The nerve stumps are then fully mobilized and advanced to close the gap (preexisting gaps of 1 to 1.5 cm can be closed in the lingual nerve, but not possible in the infraorbital, mental or inferior alveolar nerves) **(Fig. 45.8)**.
- The coapted nerve ends are secured with tension free sutures (neurorrhaphy) of fine 10-0 nonreactive material.
- The sutures are generally placed through the epineurium only. In pure sensory nerves polyfascicular, perineural suturing provides no special advantage.
- In case of wider gap, an autogenous nerve graft is interposed between the nerve stumps to eliminate tension and facilitate healing potential and regeneration equal to that of a tension free neurorrhaphy **(Fig. 45.9)**.
- The great auricular (neck) and sural (lower extremity) nerves are common donors. The medial antebrachial cutaneous nerve (forearm) is also advocated.

Planned repositioning of the inferior alveolar or mental nerves is helpful in preventing injury, when surgeries like dental implant placement, screw fixation, alloplastic augmentations are to be carried out.

Short span (1–3 cm) nerve gaps may be repaired without autogenous nerve grafting by the technique called "guided nerve regeneration". Axonal growth is directed across the discontinuity by a tube made of alloplastic materials (polytetrafluoroethylene, polyglycolic acid, collagen with laminin gel) or autogenous tissue like vein graft which prevents ingrowth of the scar tissue **(Figs 45.10 and 45.11)**.

Nerve Regeneration: New Concept (Fig. 45.12)

If a traumatic injury takes place causing a loss of nerve tissue, the clinician has the option of taking nerve from another portion of the patient's body to replace the "more important" nerve deficit. While up to 80% successful, autologous nerve grafts create further trauma to the patient. Tissue engineers have recognized the need for an artificial means to facilitate nerve regeneration and have pursued bioabsorbable nerve guidance conduits as a solution. "Bioabsorbable nerve conduits" are designed to facilitate nerve regeneration by optimizing growth conditions at the wound site in a number of ways. When a

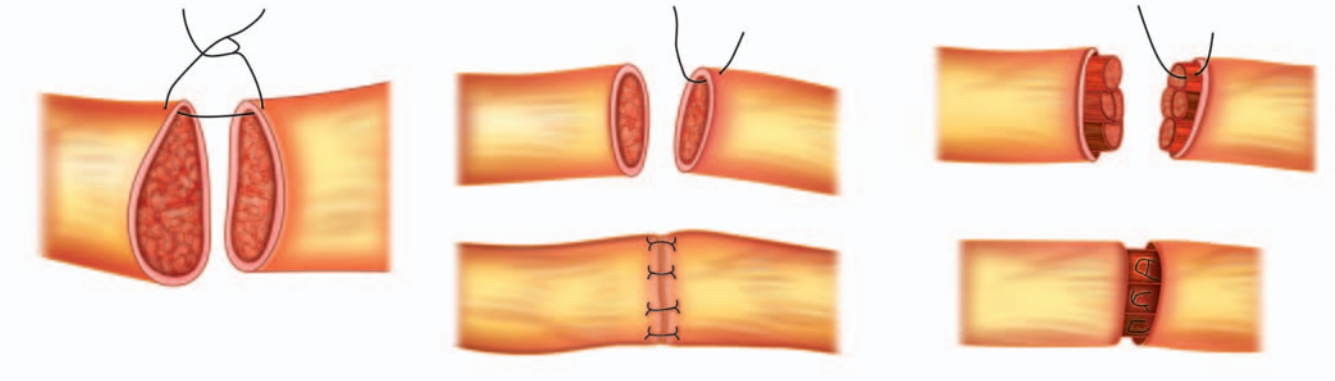


Fig. 45.8: Approximation of the nerve stumps and suturing

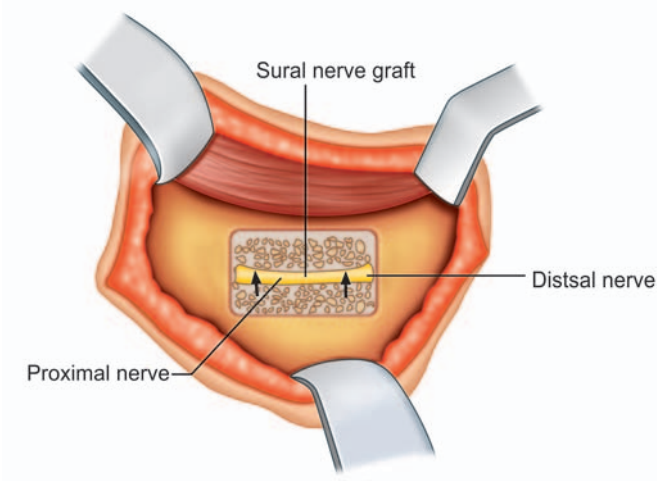
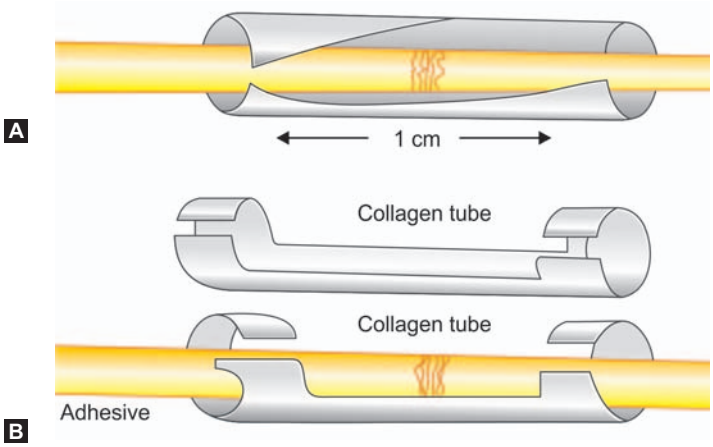


Fig. 45.9: Neurorrhaphy



Figs 45.10A and B: (A) Silastic sleeve wrapped around the severed nerve for guided nerve regeneration; (B) Collagen tube or sheath is used along with collagen adhesive for guided nerve regeneration

peripheral nerve guidance conduit is surgically implanted, the proximal and distal nerve stumps are sutured into the conduit. This creates a physical guiding pathway for nerve growth, as well as a reservoir that sequesters important growth factors that further guide the sprouting daughter axons in the proximal nerve stump. Finally, by building the conduit with development of a tissue engineered device to aid nerve tissue regeneration involves synthesis of novel biodegradable polymers, controlled release of pharmaceutical agents from biodegradable polymers, and micropatterning polymer surfaces with extracellular matrix proteins or peptides, hence defining cell adhesion, spreading and axonal outgrowth.

Postoperative Management

The patient must be mentally prepared for anesthesia in the nerve distribution to be operated on:

- Standard protocols are followed regarding antibiotics, analgesics, fluids and discharge.
- The neck sutures are removed at 5–7 days postsurgery. Leg sutures are removed at 10 days postsurgery.

Long-Term Prognosis

Best prognosis for an anesthetic nerve operated on within 3 months. About 75–80% of patients show significant subjective and objective return by 4 months and about 10%

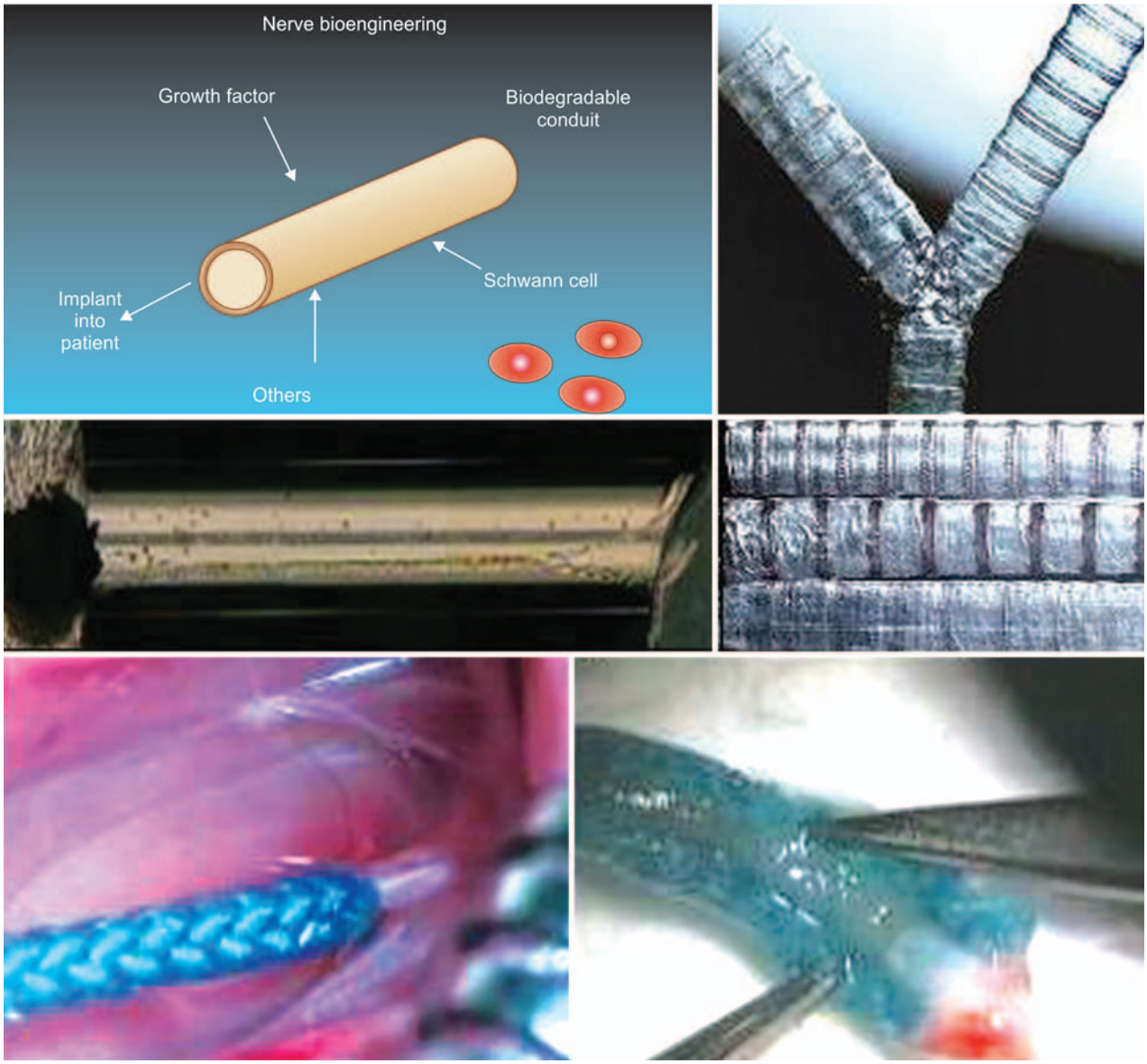


Fig. 45.11: Nerve guidance conduits (NGC) with jetted reinforcing rings

more by 6 months. The usual waiting period is of 6 months. Return of sensation in large defects may take 1 year.

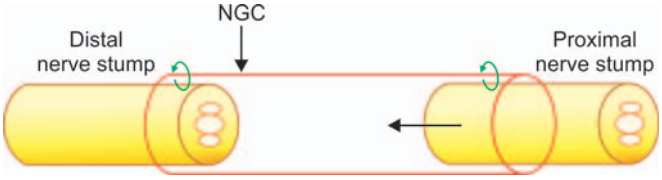


Fig. 45.12: Nerve regeneration—new concept

Points to Remember

- Impaired Sensation in the jaws and facial region
- Etiology of sensory disturbance in maxillofacial region
- Incidence of injuries of inferior alveolar nerve
- Classification of Mechanical Nerve Injuries
- Evaluation of neurosensory problems of trigeminal nerve
- Management of the same.

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CHAPTER 46 Facial Nerve and Motor Disturbances of Face and Jaws

FACIAL NERVE

- It is the seventh cranial nerve.
- It is the nerve of second branchial arch.
- Facial nerve possesses a motor and a sensory root.
- The sensory root is called the nerves intermedius.
- It supplies the motor innervation to muscles of facial expressions and also for elevation of the hyoid bone [special visceral (branchial) efferent].
- The motor root supplies to the muscles of the face, scalp, and auricle, the buccinator, platysma, stapedius, stylohyoid and posterior belly of diagastric muscle.
- **General visceral efferent (parasympathetic) fibers**: It is believed to transmit the preganglionic parasympathetic (secretomotor) fibers to the submandibular and sublingual salivary glands, the lacrimal gland and glands of the nose, the palate and the pharynx.

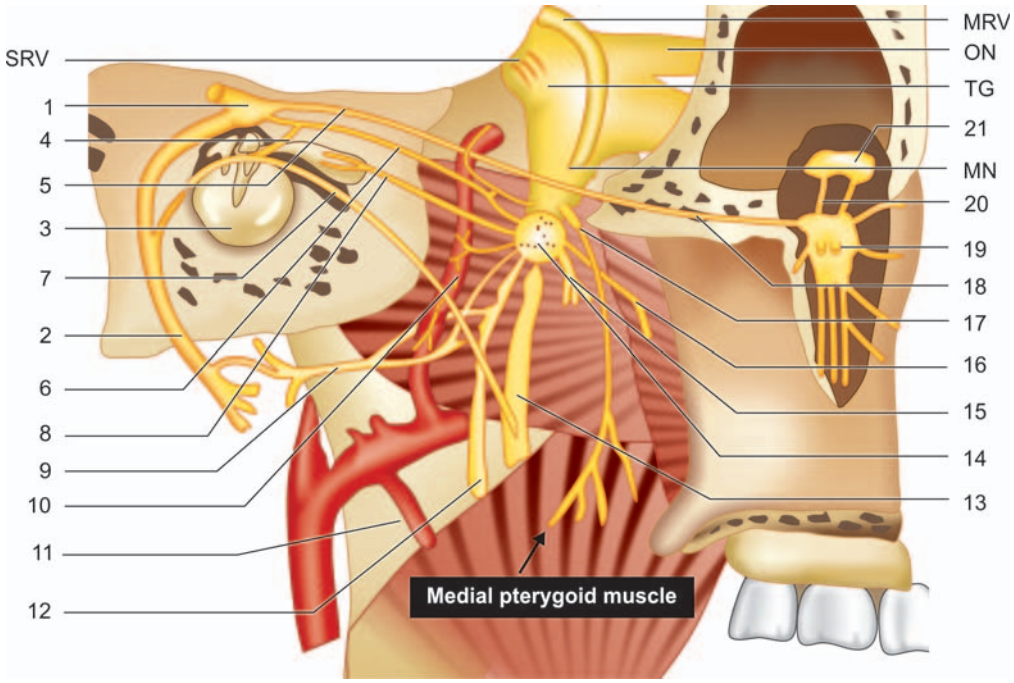


Fig. 46.1: (1) Geniculate ganglion of facial nerve; (2) Facial nerve; (3) Tympanic membrane; (4) Tympanic branch of IX; (5) Greater (major) petrosal nerve; (6) Lesser (minor) petrosal nerve; (7) Chorda tympani; (8) N of tensor tympani; (9) Auriculotemporal nerve; (10) Sympathetic plexus; (11) Inferior alveolar artery; (12) Inferior alveolar nerve; (13) Lingual nerve; (14) Otic ganglion; (15) Anterior division of mandibular nerve; (16) Nerve to tensor veli palatini; (17) Nerve to medial pterygoid muscle; (18) Nerve of pterygoid canal; (19) Pterygopalatine ganglion; (20) Ganglionic branches; (21) Maxillary nerve

Abbreviations: SRV, sensory root of V nerve; MRV, motor root of V nerve; TG, trigeminal ganglion; ON, ophthalmic nerve; MN, mandibular nerve

- The sensory root conveys from the chorda tympani nerve, the fibers of taste for the anterior two-thirds of the tongue and from the palatine and greater petrosal nerves, the fibers of taste from the soft palate **(Fig. 46.1)**.

Anatomical Course and Relationship (Fig. 46.2)

- The two roots of the facial nerve, i.e. a motor and a sensory root, both appear at the lateral part of the lower border of the pons, just medial to the eighth cranial (auditory) nerve. The motor part lies more medial and sensory root laterally, just adjacent to auditory nerve. From their attachment to the brain, the two roots of the facial nerve pass laterally and forward with the eighth cranial nerve to the opening of the internal auditory meatus.
- In the internal auditory meatus, the motor root lies in a groove on the upper and anterior surface of the auditory nerve, the sensory root being placed between them (there seventh and eighth nerves are accompanied by the labyrinthine vessels).
- At the bottom of the meatus, the two roots (sensory and motor) fuse to form a single trunk, which lies in the petrous temporal bone—the facial nerve enters the facial canal.
- Within the canal, the course of the nerve is divided into three parts by two bends **(Fig. 46.3)**:
  - The first part is directed laterally above the vestibule.
  - The second part runs backwards in relation to the medial wall of the middle ear, just above the promontory. The first bend is sharp at the junction of the first and second part and is called the genu. It presents a reddish gangliform swelling—named *the ganglion of the facial nerve or geniculate ganglion.*
  - The third part is directed vertically downwards behind the promontory. This second bend is gradual and lies between the promontory and the aditus to the mastoid antrum.
- The facial nerve leaves the skull by passing through the stylomastoid foramen.
- As it emerges from the stylomastoid foramen, the facial nerve lies about 2 cm deep to the middle of the anterior border of the mastoid process.
- **The extracranial course of the facial nerve**: It crosses the lateral side of the base of the styloid process. It enters the posteromedial surface of the parotid gland, runs forward through the gland crossing the retromandibular vein and the external carotid artery. Behind the neck of the mandible, it divides into its five terminal branches, which emerge along the anterior border of the parotid gland **(Fig. 46.4)**.

Branches of Distribution of the Facial Nerve

A.	Within the facial canal:	1. Greater petrosal nerve 2. The nerves to the stapedius 3. The chorda tympani
B.	As it exits from:	1. Posterior auricular The stylomastoid 2. Digastric, posterior belly Foramen 3. Stylohyoid

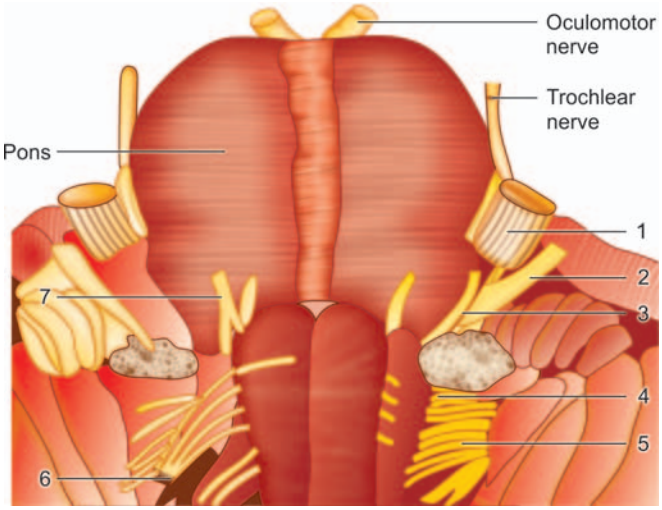


Fig. 46.2: The ventral aspect of the brainstem. (1) Roots of trigeminal nerve; (2) Auditory nerve; (3) Roots of facial nerve; (4) Glossopharyngeal nerve; (5) Rootlets of vagus nerve; (6) Hypoglossal nerve roots; (7) Abducens nerve

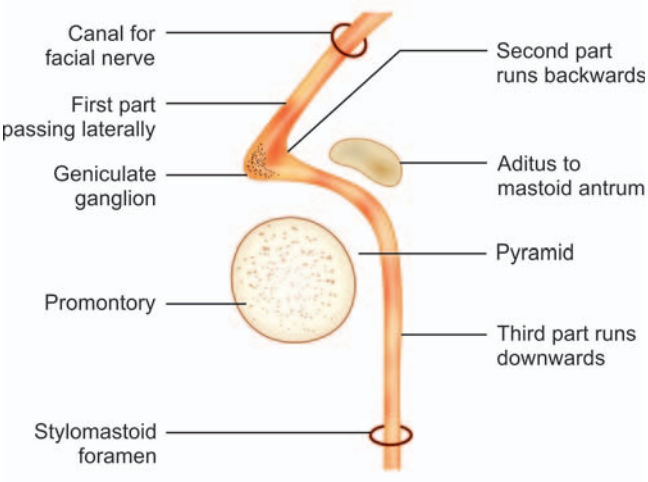


Fig. 46.3: Diagram to show intrapetrous part of the facial nerve

C. Terminal: branches within the parotid gland- on the face **(Fig. 46.5)**
   1. Temporal
   2. Zygomatic
   3. Buccal
   4. Mandibular
   5. Cervical

D. Communicating branches with the adjacent cranial and spinal nerves—the motor nerves of first, second and third branchial arches communicate with each other. The facial nerve also communicates with the sensory nerves distributed over its motor territory.

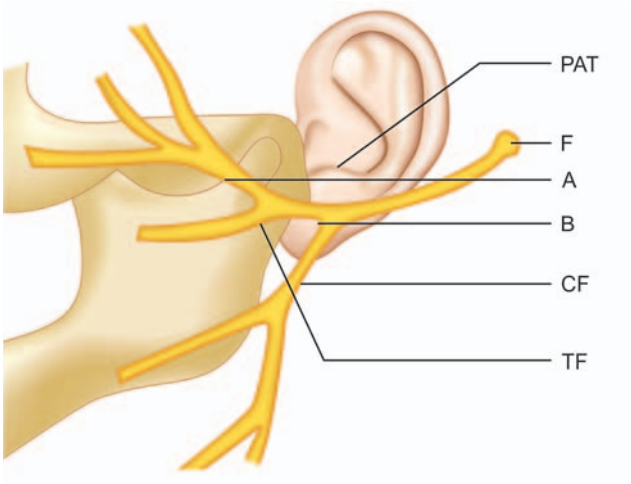


Fig. 46.4: Extracranial course of facial nerve

Abbreviations: TF, Temporofacial division; CF, Cervicofacial division; PAT, Post-aspect of tragus of the ear; A to PAT = 22.5 mm; B to PAT = 23 mm

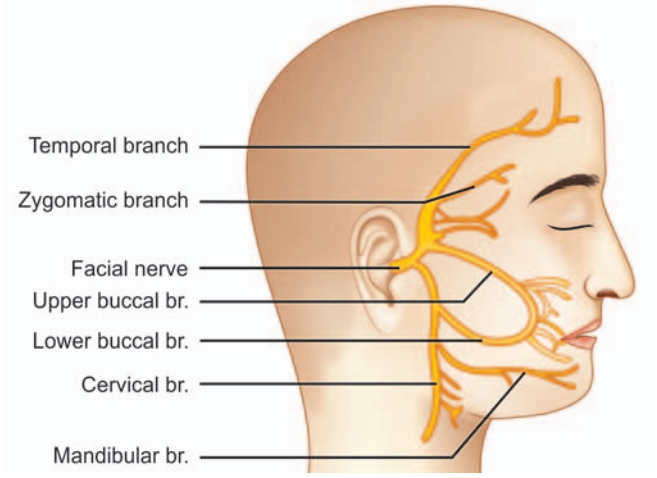


Fig. 46.5: Terminal branches of facial nerve within the parotid gland (on the face)

Ganglia

There are three ganglia associated with the facial nerve:

1. **The geniculate ganglion**: It is a sensory ganglion and is located on the first bend of the facial nerve, in relation to the medial wall of the middle ear. The taste fibers present in the nerve are peripheral processes of pseudounipolar neurons present in the geniculate ganglion.
2. **Submandibular ganglion (Fig. 46.6)**: It is a parasympathetic peripheral ganglion. It relays secretomotor fibers to the submandibular and sublingual glands. Functionally, it is connected to the facial nerve (chorda tympani), but topographically, it is related to the lingual nerve. The fusiform ganglion lies on the hyoglossus muscle just above the deep part of the submandibular salivary gland, suspended from the lingual nerve by two roots.
3. **The pterygopalatine ganglion (sphenopalatine ganglion)**: It is the largest parasympathetic peripheral ganglion. It serves as a relay station for secretomotor fibers to the lacrimal gland and to the mucous glands of the nose, the paranasal sinuses, the palate and the pharynx. Topographically, it is related to the maxillary nerve, but functionally, it is connected to the facial nerve through its greater petrosal branch.

The flattened ganglion lies just below the maxillary nerve, in the pterygopalatine fossa, close to the sphenopalatine foramen and in front of the pterygoid canal. The branches, which appear to arise from the sphenopalatine ganglion, include:

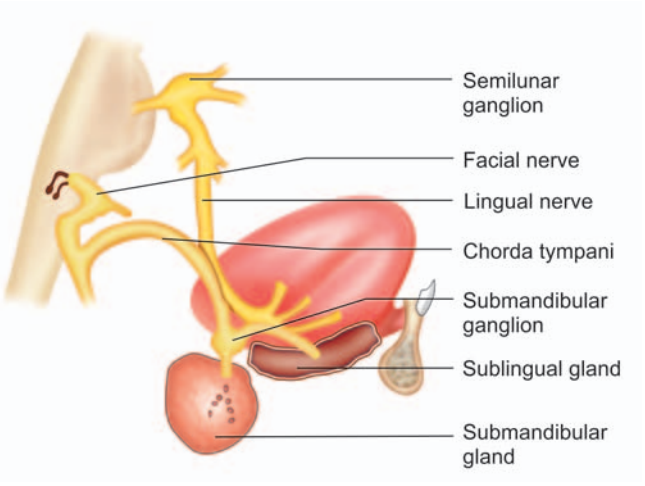


Fig. 46.6: Diagram—Anatomical relations of submandibular ganglion

- Orbital branches
- The palatine branches: The greater palatine and lesser palatine nerves
- Nasal branches: Long and short sphenopalatine nerves
- Pharyngeal branches.

Applied Anatomy

Facial palsy is commonly unilateral. It may be either:

1. Peripheral—from lesion of the facial nerve
2. Nuclear—from destruction of the facial nucleus
3. Central or cerebral or supranuclear—from injury to the brain to the fibers passing from the cortex through the internal capsule to the facial nucleus or from the injury to the face area of the motor cortex itself.

Motor Control

The motor centers controlling the muscles of the face are situated in the lowest portion of the motor area, whereas centers affecting the foot muscles are situated high on the brain. The control of skeletal muscles of the maxillofacial region originates in cerebral cortex. These nerve tracts controlling the extraocular, masticatory, lingual, palatal, pharyngeal and facial group of muscles are labeled as upper motor neurons. From the cerebral cortex, these neurons travel both in crossed and uncrossed tracts to terminate at various levels of the brainstem. From there, the lower motor neurons send cranial nerves to the skeletal muscles. It is because of these tracts and their crossed and uncrossed courses that the various types of palsies are seen.

It is important to know that the lower motor neurons of all cranial nerves, except trochlear nerve, do not cross the midline. Therefore, the lesions of the facial nerve lower motor neurons cause paralysis of all facial muscles on the same side, whereas the lesions of the upper motor neurons of the facial nerve cause palsy of the lower facial muscles only.

Supranuclear Facial Paralysis

Supranuclear facial paralysis, which is usually a part of hemiplegia, is the lower part of the face that is chiefly affected, while the upper part remains unaffected, i.e. the frontalis and orbicularis oculi muscles escape.

Nuclear Paralysis

Nuclear lesions may vary in extent. Several types may be distinguished according to the point in its course at which the facial nerve is injured.

- A lesion in the pons may involve the motor nucleus of the facial nerve along with the abducens nerve, as the fibers of the facial nerve loop around its nucleus in the pons.
- When the nerve is paralyzed in the petrous temporal in addition to the paralysis of the motor nucleus, there is loss of taste in the anterior part of the tongue. The sense of hearing is affected from paralysis of the stapedius.
- When the cause of the paralysis is fracture of the base of the skull, the auditory and petrosal nerves are usually involved.
- The most common cause of facial palsy is injury at or after facial nerves exit from the stylomastoid foramen (Bell's palsy).

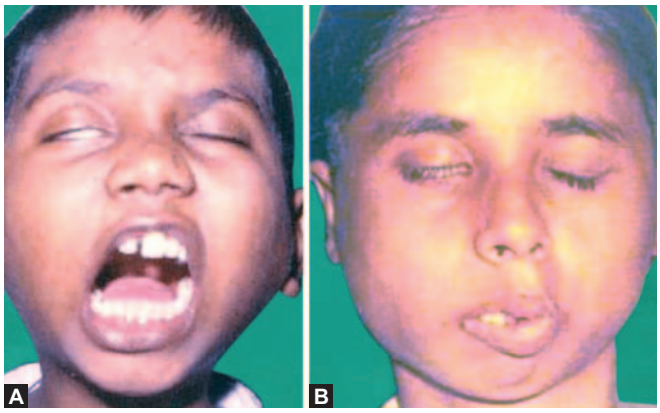
  In these cases:
  - The face looks asymmetrical even at rest and more so in the old patient than in the young.
  - The affected side of the face and the forehead remains motionless, when voluntary or emotional movement is attempted **(Fig. 46.7)**.
  - The creases of the forehead are smoothened out.
  - The eyes can be shut only by hand. Efforts to close the eye merely cause the eyeball to roll upwards until the cornea lies under the upper lid **(Figs 46.8 and 46.9)**.
  - The tip of the nose is drawn over towards the unaffected side.
  - The nasolabial fold is partially obliterated on the affected side.
  - The ala nasi does not move properly on respiration.
  - The lips remain in contact on the paralyzed side but cannot be pursed for whistling **(Fig. 46.10)**.



Fig. 46.7: Note that the left side of the face is motionless



Fig. 46.8: Bell's palsy. Patient is making efforts to close the eyes. Note that on the left side, the eyeball is rolled up and there is inability to close the left eye



Figs 46.9A and B: Bell's palsy on the right side of the face



Fig. 46.10: Bell's palsy. Lips cannot be pursed to whistle



Fig. 46.11: Bell's palsy. Patient is attempting to smile. Note the drooping of the L side of lower lip

- When a smile is attempted, the angle of the mouth is drawn up on the unaffected side; but on the affected side, the lips remain nearly closed and the mouth assumes a characteristic triangular form **(Fig. 46.11)**.
- During mastication, food accumulates in the cheek, from paralysis of the buccinator, and dribbles or is pushed out from in between the paralyzed lips.
- On protrusion, the tongue is thrust over towards the paralyzed side.

In *histrionic spasm* because of the dysfunction of the facial nerve, there is almost constant and uncontrollable twitching of some or all of the muscles of the face. This twitching is sometimes so severe as to cause great discomfort, annoyance and embarrassment to the patient, and it may also interfere with sleep. Many a times, tonic contractions of orbicularis oculi muscles only will be seen, and there will be constant blinking of the eye.

Melkersson-Rosenthal Syndrome (Orofacial Granulomatosis)

In this syndrome, there is a presence of nontender persistent swelling, which may involve one or both lips. Sometimes, amber vesicles resembling lymphangiomas are found. In addition to this, there is facial paralysis and presence of fissured tongue.

Crocodile Tear Syndrome

Due to the injury to the facial nerve proximal to the geniculate ganglion, there may be a misdirection of the nerve fibers to

the lacrimal gland instead of going to submandibular gland, through the greater petrosal nerve. As a result, the patient lacrimates while eating. This paroxysmal lacrimation is termed as "crocodile tear syndrome" and can be treated by dividing the greater petrosal nerve.

MOTOR DISTURBANCES OF THE FACE AND JAWS

Weakness of facial muscles to perform motor functions is called *paresis* (partial dysfunction).

Total flaccidity of facial muscles to perform motor functions is called *facial paralysis.*

- Paresis or paralysis of the facial muscles is a dreaded functional and esthetic complication.
- Altered motor function of the lips, cheeks, forehead and eyelids produces significant problems in the affected individual.
  - Loss of motor control of the lips and cheeks makes the drinking of fluids and mastication of food difficult or clumsy.
  - There can be drooling of saliva outside the mouth.
  - Loss of protection for cornea of the eye can lead to pain, infection and reduced visual acuity (corneal ulceration).
  - Facial expression becomes asymmetric and is socially embarrassing—serious disturbance in social life.

Etiological Classification

The various etiological factors for facial paralysis may be broadly classified into three major groups:

- **Intracranial (central cause)**
  - Vascular abnormalities
  - Central nervous system degenerative diseases
  - Tumors of the intracranial cavity
  - Trauma to the brain
  - Congenital abnormalities and agenesis.
- **Intratemporal**
  - Bacterial and viral infection
  - Cholesteatoma
  - Trauma:
    - Blunt temporal bone trauma
    - Longitudinal and horizontal fractures of the temporal bone
    - Gunshot wounds
  - Tumors invading the middle ear, mastoid and facial nerve
  - Iatrogenic causes.
- *Extracranial*
  - Malignant tumors of the parotid gland
  - Trauma—lacerations, gunshot wounds
  - Iatrogenic causes
  - Primary tumors of the facial nerve
  - Malignant tumors of the ascending ramus of the mandible, pterygoid region and skin.

Extracranial iatrogenic causes, in which facial nerve is at risk in oral and maxillofacial surgical procedures:

- Facial trauma—lacerations, fractures
- Orthognathic surgery
- Temporomandibular joint (TMJ) arthrotomy, arthroscopy
- Parotid gland surgery
- Facial esthetic surgery.

Such injuries report range from 1% to 55% in TMJ surgeries. Most of the injuries, however, produce only temporary motor dysfunction that resolves within 6 months. The overall risk of permanent motor deficit from facial nerve injuries during surgical procedures is much less than 1% excluding those in which the nerve must be intentionally sacrificed as in malignancies.

The facial paralysis following injection of local anesthetic agent is occasionally seen after pterygomandibular block technique. If the needle is inserted too far backwards, causing deposition of local anesthetic solution in the parotid gland, disturbs the function of the peripheral branches of the facial nerve. In other instance, it is the result of a vascular reflex caused by the vasoconstrictor, which produces an ischemic paralysis in the region of the stylomastoid foramen. In the first instance, the duration of the paralysis equals to that of the duration of the anesthesia, whereas in the latter, it may be much longer, depending on the degree of damage to the nerve.

Management

- Reassure the patient—explain that it resolves without residual effect.
- Eye patch to prevent corneal ulceration—topical ointment and eye closure with the cotton pad is used.
- Instruct to avoid wearing of contact lenses till the effect is worn off.
- Record the incidence on the patient's chart.
- Further care in future.

Causes of Facial Nerve Palsy

Rainer Schmelzeisen et al. reported the following causes of facial nerve palsy in 1999:

- **Congenital**:
  - Rare—due to congenital nuclear aplasia-Moebius' syndrome
  - Myotonic dystrophy
  - Melkersson-Rosenthal syndrome plus lingua plicata
  - Congenital cholesteatoma/congenital facial nerve palsy.
- **Neurologic**:
  - Myasthenia gravis
  - Multiple sclerosis
  - Guillain-Barré syndrome.
- **Neoplastic**:
  - Facial nerve tumors—Schwannoma, neurofibroma, neurogenic sarcoma
  - Glomustumors
  - Meningiomas, acoustic neuroma
  - Parotid tumors
  - Temporal bone/external auditory canal tumors (carcinomas).
- **Infectious**:
  - Otitis media, mastoiditis
  - Bacterial causes (diphtheria, tuberculosis)
  - Viral causes (herpes zoster oticus, Lyme disease, cat scratch disease, mumps, infectious mononucleosis).
- **Other causes**:
  - Toxic
  - Metabolic
  - Idiopathic—Bell's palsy brainstem infarction.
- **Iatrogenic**:
  - Parotidectomy
  - Rhytidectomy
  - Lateral skull base surgery.
- **Traumatic**:
  - Temporal bone fractures
  - Penetrating trauma (gunshot)
  - Facial lacerations
  - High altitude palsy.

Goals in the Treatment

- To achieve normal appearance at rest
- Symmetry with voluntary motion
- Control of the ocular, oral and nasal sphincters
- Symmetry with involuntary emotion and controlled balance when expressing emotion
- No significant functional deficit secondary to the reconstructive surgery.

The fact remains that the totally paralyzed face can never be made normal, as some of the treatment methods for facial paralysis are controversial and still under the evolution. The facial rehabilitation requires expertise of many disciplines—neurosurgeon, neurologist, ophthalmologist, otolaryngologist, plastic surgeon, oral and maxillofacial surgeon, physiotherapist, etc.

Evaluation of Facial Nerve Functions

The patient who exhibits facial nerve dysfunction requires prompt evaluation.

- A careful history for the onset characteristics is important, and duration of the condition and the degree of recovery.
  - An acute onset on awakening in the morning is typical of Bell's palsy. Sudden onset may be also of infectious or inflammatory etiology (herpes zoster oticus, multiple sclerosis). Patients with neoplasm usually demonstrate progressive paresis over long period with initial mild symptoms. In trauma, there is definite history given by the patient. Delayed onset of facial palsy has better prognosis. Temporal bone neoplasms may show involvement of other cranial nerves—9th, 10th, 11th nerve, etc.
  - A history of trauma, surgery or infection or rashes should be investigated and a full otologic history is obtained.
- Examination of face at rest and in motion, noting muscular tone and symmetry and analyzing the various mimetic muscles. It is important to differentiate weakness (paresis) from total flaccidity (paralysis).
  - The symmetry of the forehead wrinkling—patient is asked to raise the brows.
  - A functioning orbicularis oculi muscle allows for a complete closure of the eyelid and absence of visible upward rotation and exposure of sclera.
  - A forced smile allows the detection of asymmetries of the perioral muscles depending on the buccal and marginal mandibular branches. Patient is also asked to blow.
  - The side comparisons of the depth of the nasolabial fold and the symmetric contraction of the platysma muscle are important.

- Pure taste sensation is carried out using samples of sweat, bitter, acid and salty substances on the anterior tongue.
- CT scan for skull base fracture, if history is obtained.
- MRI to detect intracranial lesions, if suspected.
- Electromyography (EMG), evoked EMG as well as electroneurography are employed.
- In case of acute injury, nerve excitability tests are used.
- Magnetic transcranial and electrical stylomastoidal stimulation allows the differentiation of lesions and enables distinction to be made between central and peripheral facial nerve palsy.

Prognosis

Facial nerve injuries are also classified according to Seddon or Sunderland. *Neuropraxia* resolves promptly with return of facial mobility within few weeks. *Axonotmesis* exhibits prolonged weakness with gradual return of function after several months. Total and prolonged paralysis of affected facial musculature with little or no return of function is the usual fate of untreated *neurotmesis.*

House-Brackmann (1985) Classification

The House-Brackmann (1985) classification is used for the classification of facial palsy:

Grade I: Normal function without weakness.

Grade II: Mild dysfunction with slight facial asymmetry with a minor degree of synkinesis.

Grade III: Moderate dysfunctions—obvious, but not disfiguring, asymmetry with contracture and/or hemifacial spasm, but residual forehead movement.

Grade IV: Moderately severe dysfunction—obvious, disfiguring asymmetry with lack of forehead motion and incomplete eye closure.

Grade V: Severe dysfunction—asymmetry at rest and only slight facial movement.

Grade VI: Total paralysis—complete absence of tone or motion.

Prognosis is dependent on grade of severity.

Treatment

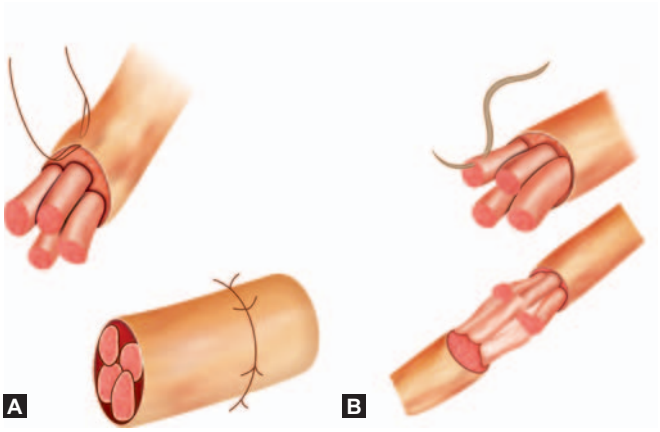
Open injuries of the facial nerve should be repaired surgically as soon as possible. Immediate primary repair at the time of intentional or unintentional transection (neurotmesis) gives the best result.

Delayed primary repair or early secondary repair is acceptable, when delay is necessary for certain reasons like contaminated wound, compromised medical status, extensive tissue destruction, etc.

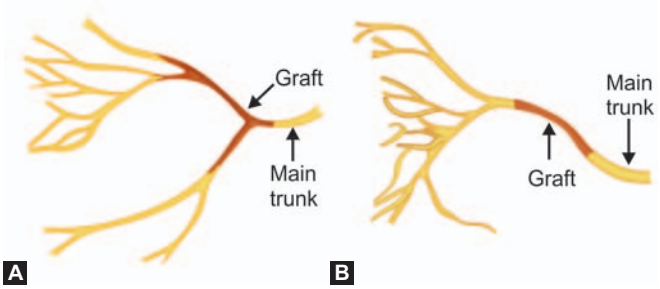
Because of progressive distal nerve degeneration and muscle atrophy, 12 months is often considered as the limit for successful facial nerve repair.

Neurorrhaphy Procedures

- Surgical repair of the transected facial nerve is done with direct end-to-end approximation and suturing (lacerations, iatrogenic injuries, benign conditions) **(Figs 46.12A and B)**.
- If there is a gap between the proximal and distal part of the nerve with some part of the nerve loss then autogenous nerve grafting is done **(Figs 46.13A and B)**.
  - The hypoglossal nerve has been a very effective autogenous graft for facial nerve reconstruction.



Figs 46.12A and B: Neurorrhaphy. (A) Epineural suture. Only the outer connective tissue sheath, the epineurium is sutured together with interrupted sutures; (B) Perineurium is sutured individually



Figs 46.13A and B: Variations in nerve grafting. (A) Main trunk and three peripheral branches; (B) Single graft is interposed between the main trunk and the dominant peripheral division

- The sural nerve is an alternative donor **(Fig. 46.14)**.
- Branches from the cervical plexus, from the ipsilateral or contralateral side are also most frequently used for facial nerve autografting **(Fig. 46.15)**.
- A great auricular nerve can be used.

Factors Influencing the Results of Extracranial Facial Nerve Repair

- Level of the injury
- The prevailing biologic condition of the wound

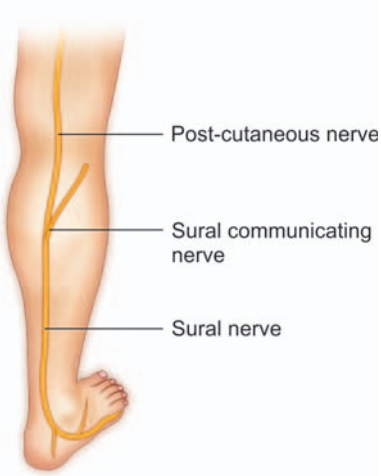


Fig. 46.14: For cross-face nerve grafting, a sural nerve graft of 30–40 cm length can be obtained

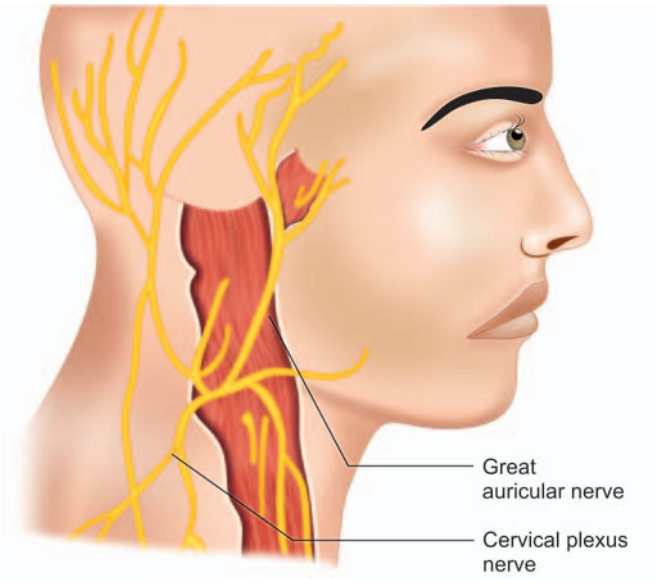


Fig. 46.15: A cervical plexus nerve graft from the ipsilateral side of the face can be obtained. Usually, a 9–12 cm graft with a main trunk and 4–5 branches can be obtained with good physical match

- The technique of repair
- The amount of tissue damage or loss, scar formation, vascular supply in the area of repair, patient's age and general health also have direct effect on the healing.
  - The graft must lie in a healthy, well-vascularized area, free of scar tissue.
  - There should be no tension on the neurorrhaphies.
  - Because of slight shrinkage of a graft, about 20% longer nerve than the actual defect is used.
  - When treating long-standing facial paralysis, it is important to resect fibrotic tissue in addition to any neuroma of the proximal stump.
  - Placement of a minimum number of small diameter sutures is critical.

Technique of Nerve Grafting

Microsurgical techniques:

- In primary or early secondary nerve reconstruction following injury, direct identification and preparation of the nerve stump is possible.
- In secondary microsurgical nerve repair, exploration of the site of the lesion and the stumps of the facial nerve are done. The identification of the nerve at the stylomastoid foramen is the best choice.

At least 2 mm thick facial nerve stump is identified with the help of a nerve stimulator.

The main facial nerve and small distal branches are repaired by epineural sutures, which are technically easier and provide less surgical trauma to the inner nerve structures. Depending on the nerve diameter, two, four or six 10.0 nylon sutures are given.

End-to-end anastomosis can only be performed immediately following sharp injury of the facial nerve.

Reanimation technique: Using hypoglossal and/or contralateral facial nerve anastomosis or surgical redirection of the accessory nerve into the degenerate 7th nerve tissues has been effective in restoring some facial muscle function **(Fig. 46.16)**.

Masking procedures (repair of facial drooping due to facial paralysis): In long-standing facial nerve palsy, the results of micronerve reconstruction are unfavorable due to the atrophy of the facial muscles.

In these patients, regional muscle transpositions with temporal, masseter or platysma muscles may be considered **(Figs 46.17 and 46.18)**.

These muscles are transposed and passed through the incisions in the lip/cheek groove and then sutured to the dermis. Alternately, the strips of fascia lata may be looped

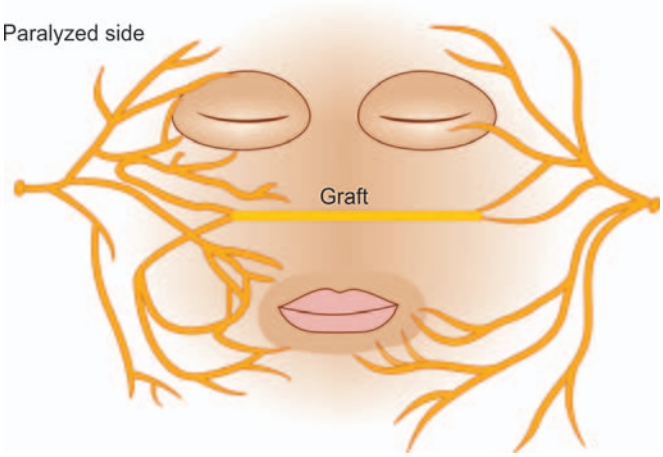


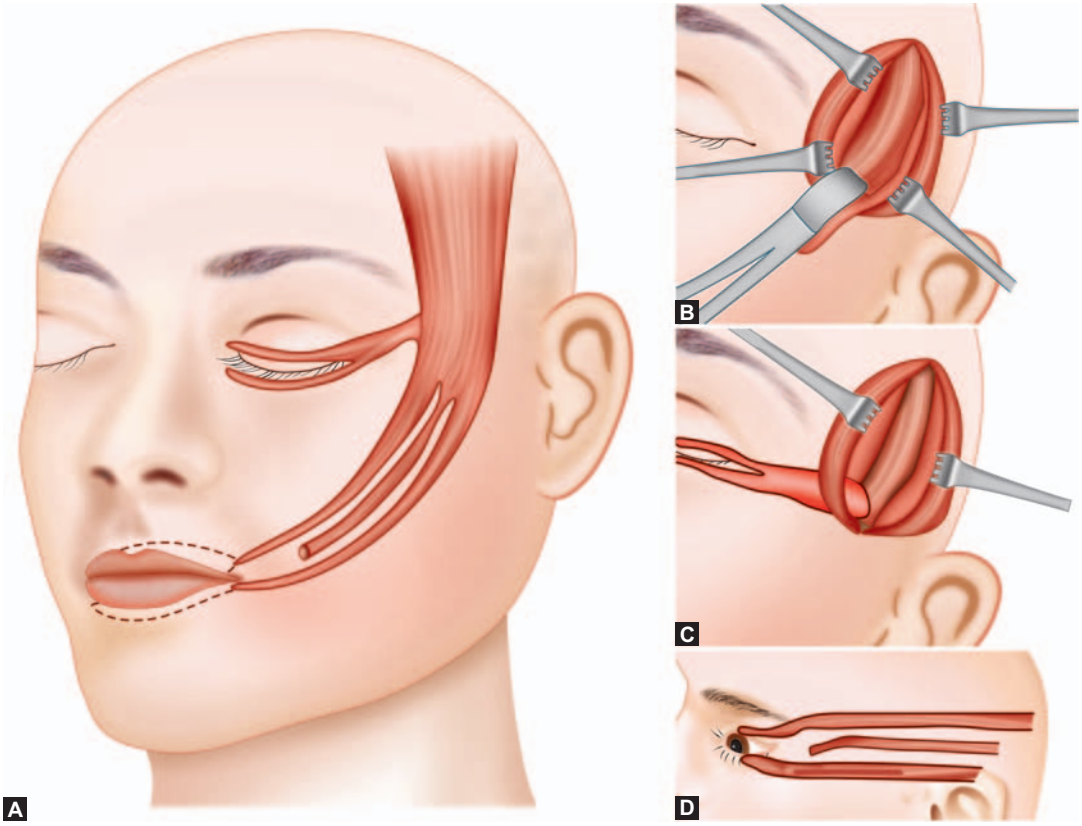
Fig. 46.16: Reanimation or cross-face nerve grafting technique—Fisch technique: On the nonparalyzed side intact buccal branch can be connected to the paralyzed stem of the facial nerve with a sural nerve graft. The graft is passed over the upper lip

through the cheek and anchored to the temporal and parotid fascia at one end and to the angle of the mouth and lips at the other end.

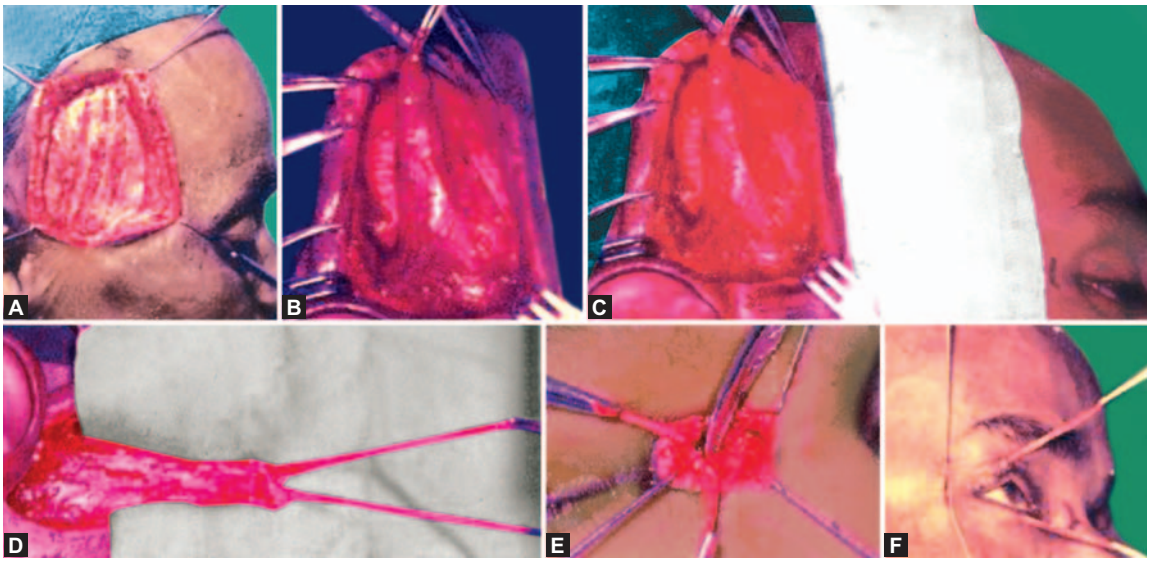
Blair's four strips of fascia lata procedure—one strip to engage the upper lip, another the lower, a third is attached just external to the angle of the mouth and a fourth grips the tissue in the region of the nasolabial fold.

Surgical correction of the eyelids (Figs 46.19A to D): Medical treatment for protection of the cornea (ointment, taping) often fails and surgical procedures such as tarsorrhaphy, magnetic implants and springs may be associated with infections. Insertion of gold weight implants has been also tried.

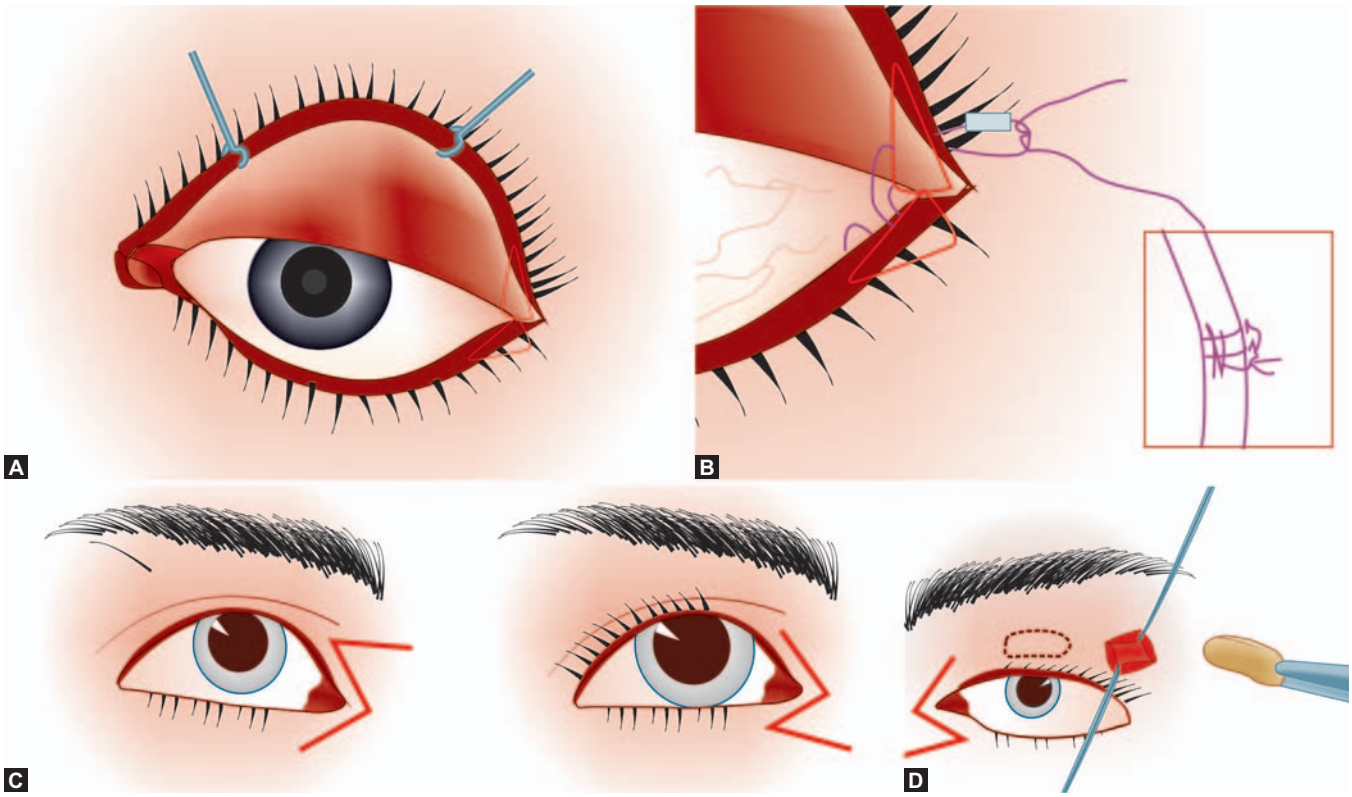
Use of prosthesis to give support to the buccal sulcus is also tried. The rim of the prosthesis distends the lateral part of vestibule of mouth, chiefly in front of the zygomatic process. This bulk is attached to a denture. Such buccal support does a great deal to improve the appearance of the patient.



Figs 46.17A to D: Temporalis transposition—muscle slings are transposed to the upper and lower eyelids, upper and lower lips, nasolabial fold and commissure. Undermined tunneling is done to transfer the slings to the desired destination. The ends of the slings are then sutured



Figs 46.18A to F: Temporalis muscle transposition—intraoperative photographs. (A) Exposure of temporalis muscle through extended preauricular incision; (B and C) Elevation of temporalis muscle slings; (D) Temporalis muscle slings brought forwards through the tunnel to the commissure; (E) Tunneling near the outer canthus of the eye; (F) The slings are transposed to the upper and lower eyelids



Figs 46.19A to D: Surgical corrections of the eyelids which are affected due to palsy. (A and B) Mc Laughlin's tarsorrhaphy; (C) Other tarsorrhaphy incisions; (D) Insertion of gold weight implant in the upper eyelid

Postoperative care: Prevention of disturbance of the nerve repair area during recovery from anesthesia and in the first few postoperative days is important for successful nerve regeneration.

Avoidance of talking and intake of solid food in the first 48 hours followed by minimal facial movement for the next 5 days is emphasized.

Supportive care: A tarsorrhaphy or eye patch and methylcellulose drops are provided, when eyelid closure is inadequate to protect the cornea from injury. Application of heat to the face, massage to facial muscles and attempted facial exercises are helpful to maintain the muscle tone and to prevent muscle atrophy.

Electrodiagnostic studies are carried out serially, until there is evidence of reinnervation. Once this has occurred, intensive physical therapy is begun to stimulate and facilitate coordinated movements of the facial muscles. Patient should be followed up for minimum 3 years.

Bell's Palsy

Definition: It is defined as an idiopathic paresis or paralysis of the facial nerve of sudden onset (unilateral lower motor neuron paralysis of sudden onset, not related to any other disease elsewhere in the body). The name was ascribed to Sir Charles Bell, who in 1821, demonstrated the separation of the motor and sensory innervation of the face.

Incidence: 15–40 cases per 1 lac cases.

Sex predilection: Women are more affected than men. The disease is 3.3 times more common in pregnant women and is especially prevalent in the third trimester or within the first week of postpartum.

Age: It can occur at any age but more seen in the middle-aged people. Thirty-one percent of patients with recurrent Bell's palsy are diabetics.

Side involvement: It can be equally seen involving the right or left nerves. It is unilateral but in 1% of cases, bilateral involvement can be seen. Positive family history is reported in about 8% of patients.

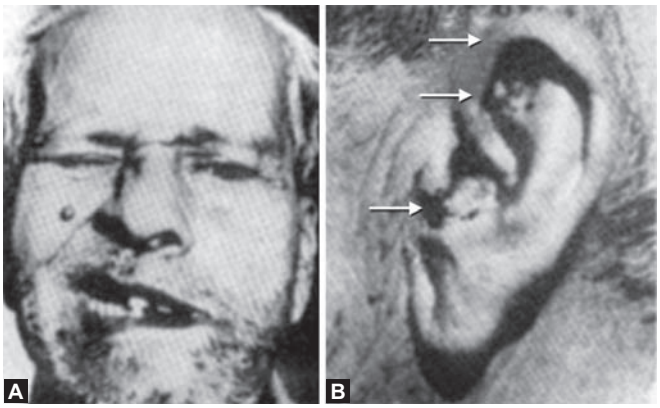
Etiology

Although Bell's palsy, by definition, is an idiopathic condition, there are abundant etiological theories put forward from abnormal immune response to reactivated herpes simplex virus in the geniculate ganglion.

Five hypotheses have been proposed regarding etiology, but many times, a combination of factors may be in the play.

1. **Rheumatic hypothesis**: Berard (1936) proposed that rheumatic swelling might press the nerve against the walls of the fallopian canal (obsolete theory).
2. **Cold hypothesis (proposed by Charles Bell):** Exposure to extreme cold or cold draught can bring about the disorder.
3. **Ischemic hypothesis**: The ischemia from disturbed circulation in the vasoneurosis causes facial paralysis.

   Factors producing vasospasm: (i) cold; (ii) anoxia; (iii) CO_2 excess; (iv) vasomotor instability; (v) injury; (vi) toxic, allergic, hormonal influence.
4. **Immunological hypothesis**: This theory has gained acceptance in recent years. There is similarity between Bell's palsy and Guillain-Barre syndrome, which is more widespread, but also a neurological condition. It is postulated that in vivo sensitization of lymphocytes to peripheral nerve myelin gives rise to a cell-mediated autoimmune response in both the conditions.
5. **Viral hypothesis**: The proponents believe that Bell's palsy is caused by subclinical herpes zoster or herpes simplex infection. Herpes simplex virus hypothesis has gained much attention, because of the high frequency of elevated viral antibody titers, as well as elevated levels of interferon in these patients. The combination of facial paralysis and herpes is known as the *Ramsay-Hunt syndrome*. Herpetic eruptions may occur on the skin, ear, tympanic membrane, palate, fauces, soft palate and tongue. The eighth nerve involvement will have vertigo, deafness, vomiting and tinnitus **(Figs 46.20A and B)**.



Figs 46.20A and B: Ramsay-Hunt syndrome. Ramsay-Hunt in 1907 described a clinical syndrome comprising herpes zoster oticus, lower motor facial nerve paralysis with or without deafness, tinnitus and vertigo due to geniculate ganglionitis. (A) Patient with lower motor neuron facial palsy; (B) Vesicular eruptions over concha and external auditory meatus

Histologically, patients with Bell's palsy have a thickened, edematous perineurium and associated normal blood vessels. There is a diffuse infiltrate of small round inflammatory cells between nerve bundles. Myelin sheaths undergo degeneration. These changes are seen throughout the bony course of the facial nerve.

Clinical Features

- There is sudden onset; usually, patient gives history of occurrence after awakening early in the morning.
- Unilateral involvement of the entire side of the face is seen.
- Abrupt loss of muscular control on one side of the face.
- Inability to smile, close the eye, or wink or raise the eyebrow on the affected side.
- Whistling is impossible.
- The corner of the mouth droops, causing drooling of saliva.
- In an attempt to close the eyelid, the eyeball rolls upward, so that the pupil is covered and only the white sclera is visible (*Bell's sign*).
- Inability to wrinkle the forehead or elevate the upper or lower lip.
- The eye waters due to inability to close.
- There is widening of the palpebral fissure, loss of blinking reflex.
- There is obliteration of the nasolabial fold.
- The face appears distorted and mask-like appearance to the facial features.
- Speech becomes slurred.
- Occasionally, there is loss or alteration of taste.

Prognosis

Initially, unilateral facial weakness affecting all parts of the facial musculature is noticed. This gradually worsens over 2–3 days, reaching a maximum in about 2 weeks. Remission begins within 3 weeks of onset in 85% of cases with remainder taking as long as 6 months. Spontaneous recovery is known to occur in Bell's palsy.

Differential diagnosis should be made in the facial paralysis due to other etiological factors and idiopathic Bell's palsy.

Management

Physiotherapy: The effect of facial paralysis or Bell's palsy is wasting or muscle atrophy. Physiotherapy is, therefore, indicated to maintain the muscle tone and should be instituted as early as possible. It consists of electrical stimuli by galvanism, gentle massage and facial exercises.

Medication

- If the patient is seen within 2–3 weeks of onset of symptoms: Tab prednisolone in doses of 1 mg/kg/d for 10–14 days has been recommended with a gradual tapering.
  Example: Dosage for a 60 kg person: Prednisolone 10 mg tablets—3 tablets twice daily for 4 days, then 2 tablets twice daily for 4 days, then 1 tablet twice daily for 4 days, then 1 tablet daily for 4 days and stop.
- Vitamins B_1, B_6, B_{12} may be administered.
- If the patient is seen after 3–4 weeks, then steroid therapy is of no use.
- An audiogram should be performed; a CT or MRI and an EMG should be considered.
- If incomplete eye closure is present, artificial lubrication, taping the eye or perhaps the placement of a spring, gold weight or tarsorrhaphy might prevent visual loss from exposure keratitis.
- A baseline ophthalmologic examination is often helpful to determine further therapy.
- *Chronic sequelae*—may be in the form of hyperkinesia or hypokinesia.
  - *In hyperkinesia*—offending muscle groups are denervated or botulinum toxin can be used.
  - *Clostridium botulinum* toxin (Botox) is a neurotoxin, that temporarily interferes with acetylcholine release from motor nerve end-plates, causing skeletal muscle paralysis. The effect lasts 4–6 months. Botulinum toxin has been useful in the treatment of facial paralysis by weakening the contralateral side to allow centering of the mouth, more symmetry on smiling and treatment of hypertrophic platysmal bands.
  - Hypokinesia may require nerve transfers, muscle transfer or static slings.
- If electroneurography reveals a greater than 90% loss of compound action potential within first 2 weeks following onset of paralysis, facial nerve decompression is recommended. After this period, surgery is not beneficial.
  - *Nerve decompression*—can be carried out internally or externally.
  - **Internal decompression:** The nerve is exposed in the fallopian canal; pressure in the canal is relieved by exposing the nerve and the epineural sheath is opened to visualize the nerve fibers and release adhesions or re-establish continuity.
  - *External decompression*—is done by releasing of epineural sheath from surrounding scar tissue, bone or a foreign body.
  - *Nerve anastomosis—reanimation*: Anastomosis of the central end of hypoglossal or spinal

accessory nerve with the distal end of the facial nerve is done.

- **Nerve grafting**: Whenever there is evidence of neuroma or loss of portion of a nerve, nerve grafting can be considered.

Points to Remember

- Facial nerve applied anatomy
- Motor disturbances of face and jaws
- Causes of facial nerve palsy, evaluation, classification, and treatment.

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Section 15

Oral Malignancies

47. Premalignant Lesions and Conditions of the Oral and Maxillofacial Region
48. Oral Cancer

CHAPTER 47 Premalignant Lesions and Conditions of the Oral and Maxillofacial Region

INTRODUCTION

Oral cancer (predominantly squamous cell carcinoma) accounts for approximately 3% of all malignancies and is a significant healthcare problem in India and worldwide. Certain oral mucosal lesions, particularly white lesions (leukoplakias) and some red lesions (erythroplakias) have a potential for malignant transformation. These changes of oral mucosa which increases the risk of oral malignancy are called premalignant lesions/conditions. Beside leukoplakia and erythroplakia various other conditions implicated in the development of oral cancer include, palatal lesion of reverse smoking, oral lichen planus, oral submucous fibrosis (OSMF), discoid lupus erythematosus (DLE), and hereditary disorders such as dyskeratosis congenital and epidermolysis bullosa. It is important to identify these lesions/conditions as the carcinogenesis process can be persevered at this stage, thus avoiding the morbidity and mortality associated with oral cancers.

DEFINITION AND CLASSIFICATION

The World Health Organization (WHO) classified oral precancerous or potentially malignant disorders into two groups in 1972 **(Table 47.1)**:

- A premalignant lesion is "a morphologically altered tissue in which oral cancer is more likely to occur than its apparently normal counterpart".

A premalignant condition is "a generalized state associated with significantly increased risk of cancer".

INCIDENCE

The overall incidence of progression of premalignant lesion of the oral cavity, to invasive squamous cell carcinoma has been quoted in range of 2.7–17.5%.

Table 47.1: List of premalignant lesions and conditions

Precancerous lesion	*Precancerous condition*
• Leukoplakia • Erythroplakia • Palatal lesions of reverse smokers	• Oral submucous fibrosis • Lichen planus • Epidermolysis bullosa • Discoid lupus erythematosus Sideropenic dysphagia, (mucosal atrophy associated with chronic iron deficiency anemia).

Premalignant lesions are those lesions in which carcinoma may develop. Premalignant conditions are associated with a risk of carcinoma at some site within the mouth, not necessarily marked by a pre-existing lesion.

Erythroplakia are more ominous than leukoplakia and have higher risk of malignant transformation which may be as high as 50%. Also important is the site of involvement within the oral cavity. High-risk sites for change into dysplasia and carcinoma (Ca) in situ as identified by Waldron and colleagues are floor of mouth, tongue and lip.

LEUKOPLAKIA

Definition

The term leukoplakia literally means a "white patch". It is widely regarded as one of the most common precancerous lesion of oral cavity, which cannot be rubbed or dislodged or scraped off easily. WHO defines leukoplakia as a "white patch or plaque that cannot be characterized clinically or pathologically as any other disease, and which is not associated with any physical or chemical agent except the use of tobacco".

Etiology

Tobacco abuse is the most common etiological factor for leukoplakia. Tobacco smoking causes more number of

leukoplakias than tobacco chewing. However, malignant transformation is more frequently seen in leukoplakias caused by the intake of chewing forms of tobacco. Rate of malignant transformation is reported to vary between 3–6%. Other predisposing factors contributing to leukoplakia include:

- **Local factors:** Chronic trauma, alcohol, candidiasis, syphilis, human papilloma and Epstein-Bar virus infection, electrogalvanism (reaction between unlike restorative metals), ultraviolet radiation, xerostomia, etc.
- **Systemic factors:** Nutritional deficiency, anemia and endocrine dysfunction.

Prevalence and Clinical Manifestations

Leukoplakia is more prevalent in South-East Asia (prevalence in India is 0.2–4.9%). Majority of the lesions are seen in the age group of 35–45 years, with males more frequently affected than females. Buccal and vestibular mucosa is most frequently affected (habit related), whereas floor of the mouth least affected. Clinically most of the lesions are asymptomatic and are discovered on routine examination. Sometimes patients may be aware of a white lesion or roughness or thickening of oral mucosa **(Fig. 47.1)**. Burning sensation is a presenting feature in speckled leukoplakia. Based on its presentation clinical subtypes of leukoplakia are described, which includes: preleukoplakia, homogenous (most common form), verrucous (least common), nodular or speckled and proliferative verrucous leukoplakia (rare form), erosive leukoplakia **(Fig. 47.2 and Table 47.2)**.

Progression of Disease

Long-term behavior and natural history of the disease process may lead to:

- Persistence of the lesion without any change.
- Spontaneously regression of the lesion, especially when habit is discontinued.
- Recurrence
- **Malignant transformation:** It involves development of oral cancer in pre-existing leukoplakia. Overall rate of malignant transformation of leukoplakia is 3–6%. The rate is 20% in nodular/speckled lesions. Nodular area, ulceration, rolled margins, induration, and growth are the signs of malignant transformation. Therefore, long-term follow-up is essential for these lesions.

Differential Diagnosis

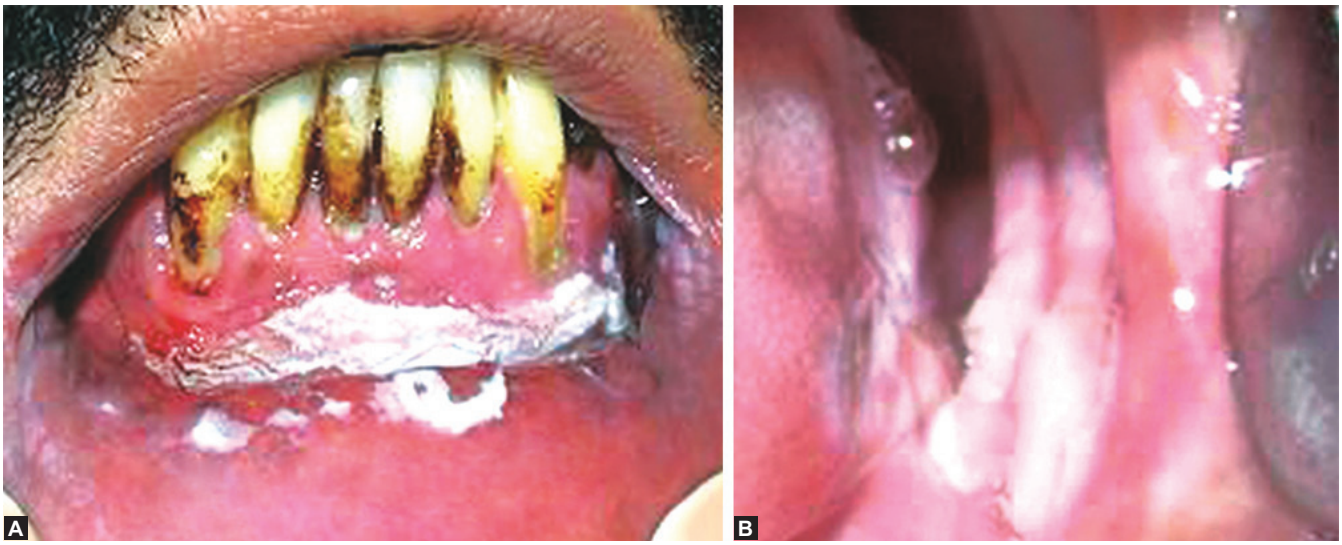
Clinical differential diagnosis for leukoplakia includes—white sponge nevus, hyperplastic candidiasis, lichen planus, leukoedema and traumatic keratosis.

Investigations

Investigations for diagnosis of leukoplakia includes—exfoliative cytology, brush biopsy, incisional biopsy, and excisional biopsy.

Histopathological Features

Leukoplakia may show different histological features, which can be graded as (1) Hyperkeratosis; (2) Epithelial dysplasia; and (3) carcinoma in situ **(Box 47.1)**.



Courtesy: Prof Anil D`cruz

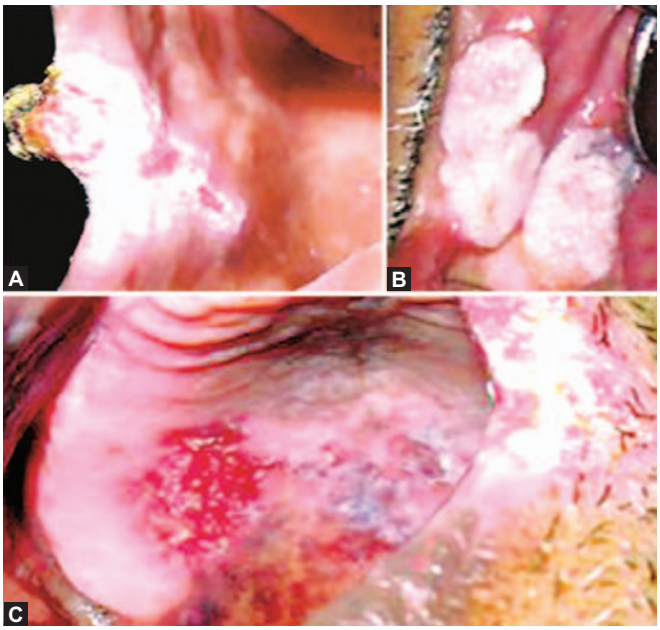
Figs 47.1A and B: Leukoplakia of gingivobuccal sulcus presenting as white non-scrapable patch

Table 47.2: Clinical features for subtypes of leukoplakia (Figs 47.2A to C)

Preleukoplakia	***Homogenous leukoplakia***
• Precursor of leukoplakia • Prevalence: 0.5–4.1% • Low malignant potential • Appears as a gray or grayish-white, flat or sometimes fissured lesion with indistinct borders • *Erosive leukoplakia*—erosion of the superficial layer is obvious	• Presents as white, brownish-white plaque with more or less uniform appearance. They are non-scrapable with distinct borders, showing typical "cracked-mud or corrugated appearance" • Present at a site that comes in contact with tobacco • Size varies from few millimeters to extensive lesions • There is loss of elasticity/pliability of affected mucosa. Loss of papillae, if present on dorsum of tongue
Verrucous leukoplakia	***Nodular (or speckled) leukoplakia***
• Present at a site that comes in contact with tobacco • Appears as a white plaque with multiple finger-like projections from surface *(wrinkled surface)* • Has distinct borders • Are non-scrapable	• Present at a site that comes in contact with tobacco • Appears as a mixed red and white lesion, i.e. small multiple keratotic (white) nodules scattered over an atrophic (red) patch of mucosa • *Size:* Varies from about 10 mm to extensive lesions • Has relatively less distinct borders • Are non-scrapable • Has higher rate of malignant transformation
Proliferative verrucous leukoplakia	
• This is special, high risk form of leukoplakia • It presents as white plaque with nodular or verrucous projections • Can be differentiated from verrucous leukoplakia by its: – Rapid multisite involvement of oral mucosa – Female predilection – Minimal association with tobacco and strong association with human papillomavirus (HPV) and *Candida* – Higher rate of malignant transformation.	

Box 47.1: Histopathological features of leukoplakia

Hyperkeratosis	Characterized by increase keratinization (ortho or para) of the upper epithelial layer
Epithelial dysplasia	Epithelium shows abnormal stratification, drop shaped rete pegs, mitotic figures, altered nuclear-cytoplasmic ratio, pleomorphism and nuclear hyperchromatism
Carcinoma in situ	Malignant transformation is seen in the epithelial layer. However, the basement membrane is intact without any connective tissue invasion of the neoplastic cells



Courtesy: Prof Anil D`cruz

Figs 47.2A to C: Various clinical variants of leukoplakia (A) Nodular leukoplakia; (B) Verrucous leukoplakia; (C) Erosive leukoplakia

Although the clinical appearance of leukoplakia is not always an indicator of histological variant it shows. Homogeneous lesions usually show keratosis. Mild dysplasia may be seen in some cases of homogeneous leukoplakia. Nodular/speckled lesions usually show varying degrees of dysplasia; however, frank malignancy may also be evident in some cases. Histological features are important as it influence treatment decisions.

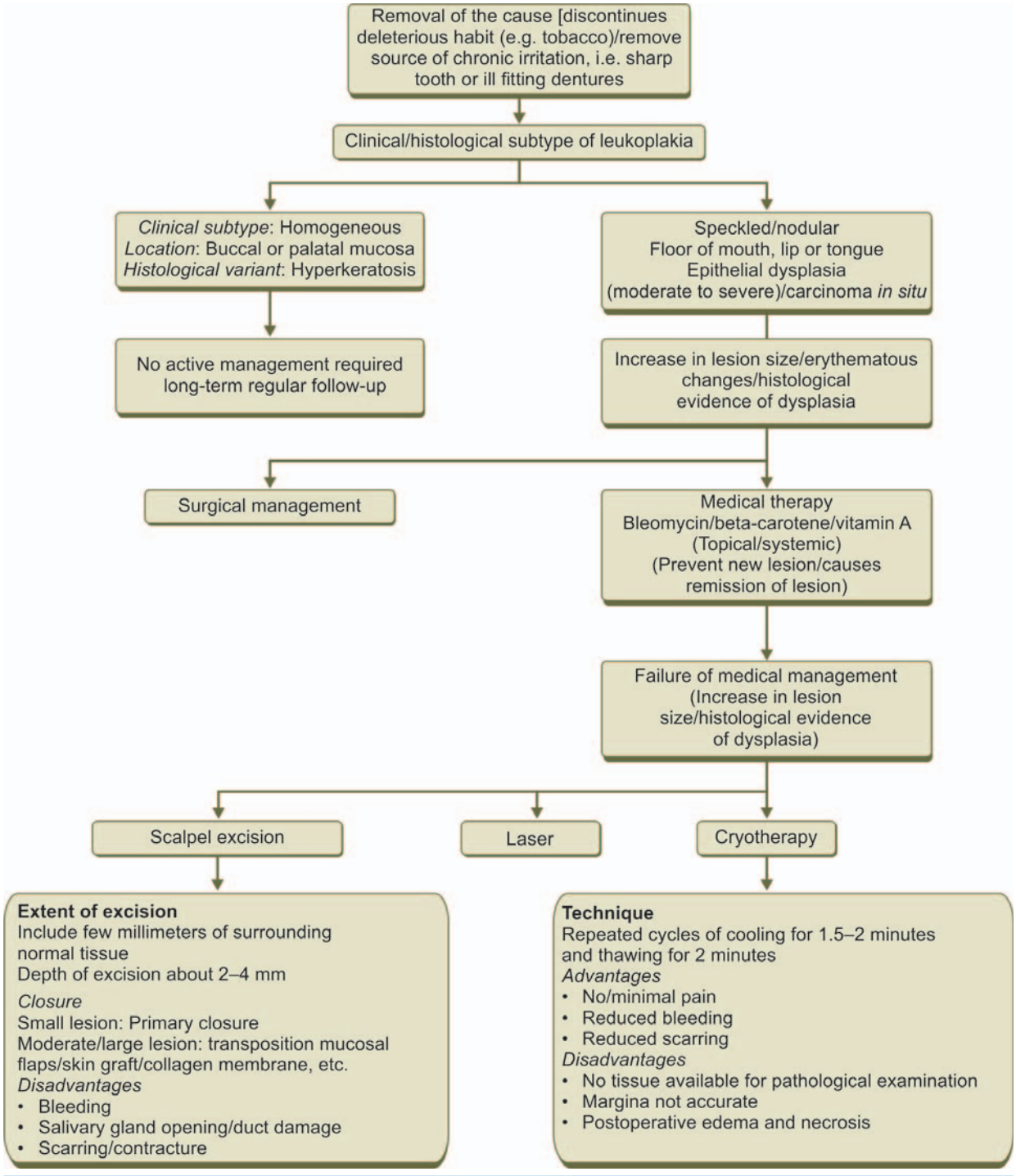
Treatment (Flowchart 47.1)

The treatment of oral leukoplakia is dictated by its risk to progress to malignancy (dictated by the clinical subtype of the lesion and site of occurrence).

Homogeneous leukoplakia, at sites other than the high risk sites, may be conservatively managed, by habit counseling and close observation. Heterogeneous variants and leukoplakia at high risk sites needs to be treated. Various management options of leukoplakia include:

- Patient education and motivation to discontinue tobacco habit.
- Identification and removal of any predisposing factors.
- Anti-fungal agents for 2 weeks may reduce lesion size.
- Periodic observation.
- Increase in lesion size or change in appearance indicates need for biopsy and histological examination.
- Dysplastic changes indicate surgical removal (excision) and long-term follow-up.

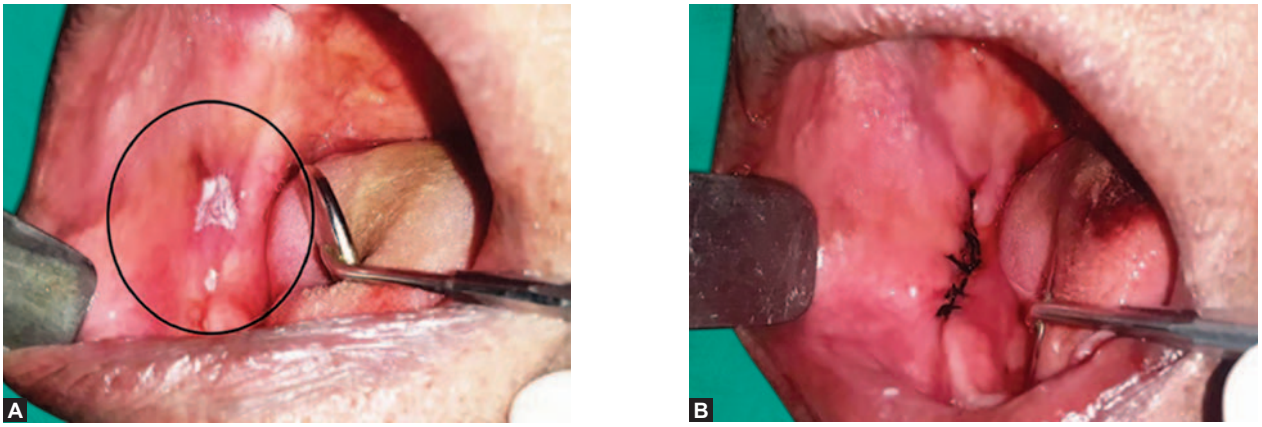
Flowchart 47.1: Algorithm for management of leukoplakia



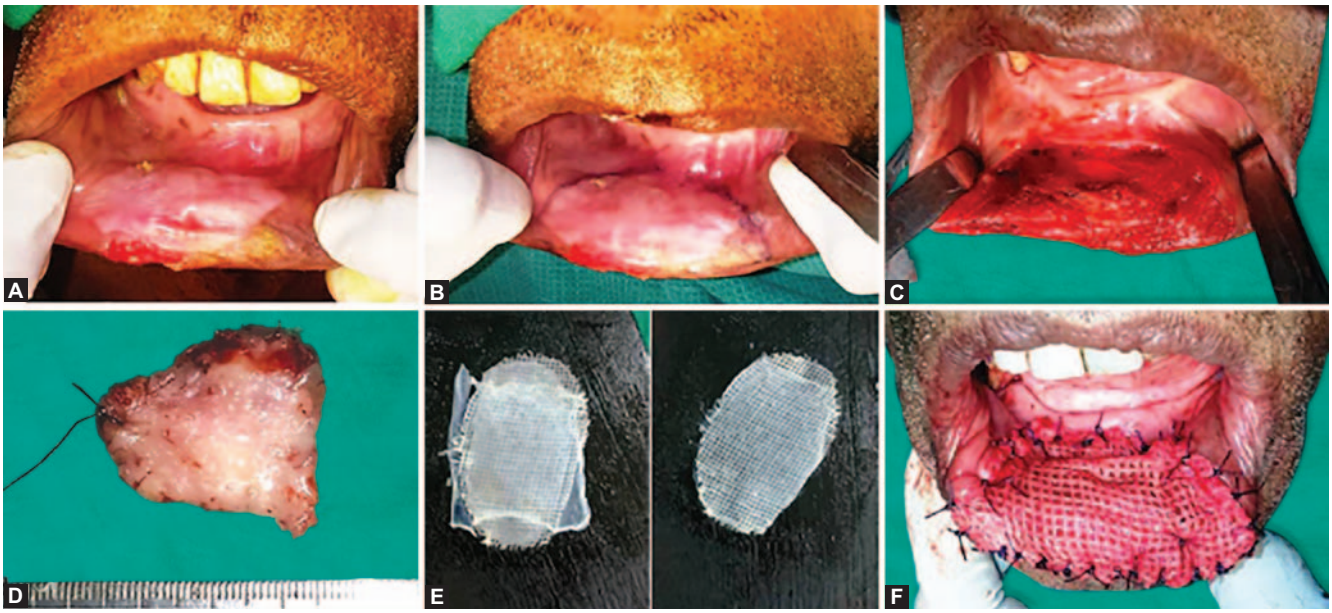
- Cryosurgery, laser therapy has been used for the removal of the lesion.
- **Antioxidant supplements:** Vitamin A and its analogues like tretinoin, isotretinoin, etretinate, beta carotene, vitamin E, and lycopene have been tried successfully.
- Vitamin A and its analogues have shown variable results in obtaining clinical remission of leukoplakia. However, they do not prevent dysplasia or malignant transformation.
- Anticancer chemotherapeutic agents, e.g. bleomycin, human fibroblast interferon and fluorouracil have also been used for management of leukoplakia.

Surgical Management of Leukoplakia

Surgical removal of the lesion is indicated for heterogeneous leukoplakias **(Figs 47.3 and 47.4)**, leukoplakia at high risk sites, e.g. floor of mouth, tongue and lip, and those showing dysplastic features on histopathological evaluation.



Figs 47.3A and B: Leukoplakia (A) Involving the right buccal mucosa and retromolar triangle; (B) Small size lesion can be excised and primarily closed



Figs 47.4A to F: Surgical excision of leukoplakia (A) A large white patch involving the lower labial mucosa. Area of ulceration and crusting at the vermilion border of the lip can also be appreciated. Such changes are clinical indicators of dysplastic/malignant changes and warrants biopsy for evaluation of the lesion; (B) Borders of excision marked using methylene blue ink; (C) Surgical bed after removal of the lesion. The depth of excision is above the plane of orbicularis oris muscle; (D) Excised lesion; (E) Collagen membrane adapted over vaseline impregnated gauze and cut to the shape of the mucosal defect; (F) Collagen membrane-dressing sutured over the defect

Such lesions are excised surgically in view of their high propensity for malignant transformation. Surgical removal can be accomplished either with conventional surgical methods (knife or electrocautery) or with use of laser. If laser is used, every effort should be made to excise rather than fulgurate the lesion as this provides tissue for histopathological examination, which may occasionally reveal foci of invasive carcinoma.

ERYTHROPLAKIA

Erythroplakia literally means a red patch. It is defined as "bright red velvety plaque or patch that cannot be characterized clinically or pathologically as any other disease".

Etiology

Tobacco abuse is the single most common causative factor implicated for erythroplakia **(Box 47.2)**.

Clinical Features

It is a rare lesion, with reported incidence of about 0.02% **(Figs 47.5A to C)**. Majority of cases are found in the 6th and 7th decade of life. Though it can occur at any part of oral mucosa, floor of the mouth, ventral tongue, soft palate and tonsillar fauces are most frequently affected. It is usually asymptomatic and gets discovered on routine examination. Sometimes patients may complaint of burning sensation with the lesion. Two clinical form of erythroplakia is described; homogeneous, having velvety surface and speckled with white keratotic nodules.

Histological Features

Microscopic features may vary from severe degree of dysplasia to carcinoma in situ. Frank malignancy may also be evident in advanced cases.

Differential Diagnosis

Differential diagnosis of erythroplakia should include atrophic candidiasis and erosive lichen planus.

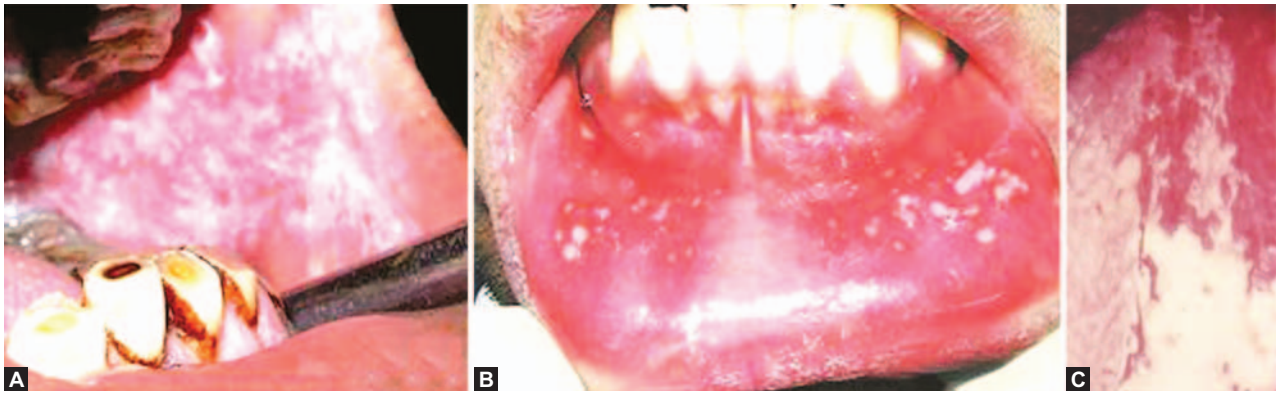
Treatment

Management of erythroplakia includes patient education and motivation to discontinue tobacco habit. Any local irritants associated with the lesion should be identified and removed. However, if the lesion is persistent, histological examination must be carried out. Dysplastic changes on histopathological examination are an indication for surgical removal of the lesion and long-term follow-up.

ORAL SUBMUCOUS FIBROSIS (OSMF)

Introduction and Definition

Oral submucous fibrosis is the most common premalignant condition affecting the oral cavity. It is a chronic debilitating condition, characterized by generalized submucosal inflammation and fibrosis, resulting in progressive inability to open the mouth. The condition was first described by Joshi et al., in 1950, in a woman of Indian origin, from Africa. It is defined as:



Courtesy: Prof Anil D`cruz

Figs 47.5A to C: Erythroplakia (A) On the cheek mucosa; (B) On the lip mucosa; (C) On the tongue

Box 47.2: The various factors implicated to cause the disorder includes:

- Areca nut chewing, e.g. "mawa", "paan masala" (most probable causative factor)
- Tobacco abuse
- Chilly consumption
- Autoimmune disease
- Genetic predisposition
- Nutritional deficiency
- Oral component of scleroderma
- Idiopathic

"An insidious, chronic mucosal condition affecting any part of oral cavity and sometimes pharynx, associated with fibroelastic transformation of juxtaepithelial connective tissue layer and epithelial atrophy leading to progressive stiffness of the oral mucosa causing trismus and inability to eat."

Etiopathogenesis

Oral submucous fibrosis is commonly associated with the habit of consumption of areca nut, "paan" and related products. It often gets aggravated by spicy foods, chilies and nutritional deficiency **(Box 47.2)**.

The pathogenesis of OSMF has been attributed primarily to the use of areca nut, the risk increasing with the duration and amount of its use. Arecholines, tannins, catechins and high copper content of areca nut is believed to initiate and propagate the subepithelial fibrosis, characteristic of the disease **(Flowchart 47.2)**.

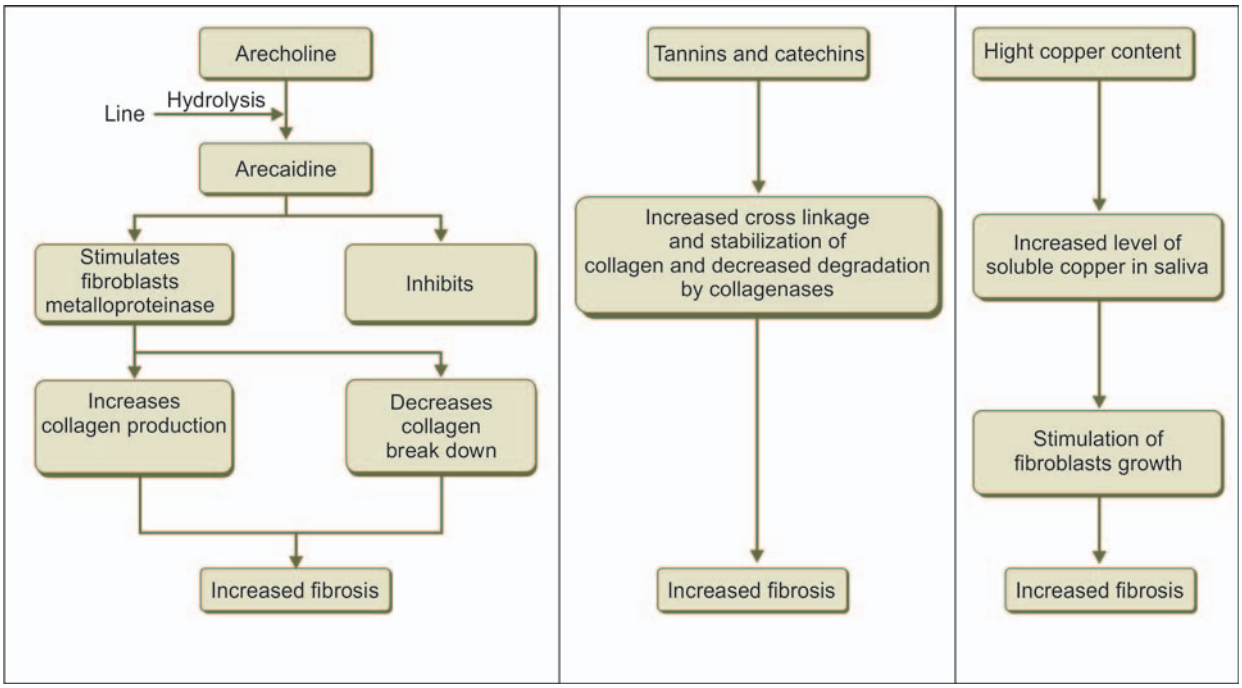
Epidemiology

Oral submucous fibrosis is common in Indian subcontinent. It affects up to 0.4% of Indian population. Incidence of the disease has been on the rise, especially amongst younger population, due to easy availability and aggressive marketing of fancy areca nut products in India.

Clinical Features

It can occur at any age, however majority of the cases are seen in the 3rd and 4th decades of life. It is reported to occur in both sexes with equal predilection. Patient invariably reports long-term use of areca nut, "paan, gutka" or related products. The oral submucous fibrosis (OSMF) process involves large area of oral mucosa. It usually starts with involvement of bilateral buccal mucosa, followed by labial, lingual and palatal mucosa.

Flowchart 47.2: Pathogenesis of oral submucous fibrosis



Box. 47.3: Signs and symptoms of oral submucous fibrosis

- Symptoms
  - Progressive reduction in mouth opening
  - Burning sensation of oral mucosa, intolerance to spicy food
  - Hypersalivation or dryness of mouth
  - Difficulty in speech, swallowing and mastication
  - Hearing disturbances (due to fibrosis around the opening of eustachian tube)
  - Dysphagia (due to fibrosis of posterior part of oral cavity, soft palate, uvula, tongue, floor of mouth and in advanced cases pharyngeal involvement)
- Signs
  - Reduced inter-incisal distance
  - Blanching of mucosa—"marble-like appearance" **(Figs 47.6A and B)**
  - On palpation, leathery consistency of mucosa and fibrous bands particularly in posterior parts of buccal mucosa and labial mucosa ("elliptical rima oris") are the characteristic features.
  - Shrunken uvula when soft palate mucosa is involved. Soft palate loses its mobility.
  - Tongue involvement causes loss of papillae **(Figs 47.7A and B)**.
  - Involvement of floor of mouth causes loss of tongue movements.
  - Sometimes vesicle formation, erosions, ulcerations and hyper or depigmentation of oral mucosa is seen.

Gingiva is less commonly involved. In advanced cases soft palate, uvula and faucial pillars are also affected. The symptoms and signs of OSMF includes in **Box 47.3**.

Investigations and Histological Features

Clinical features are characteristics of OSMF and often do not require any further investigations for diagnosis. Histological examination is indicated if dysplastic changes are suspected **(Box 47.4)**.

Staging

Oral submucous fibrosis has been classified based on its clinical and histological features, by various researchers.

Box 47.4: Histopathological features of oral submucous fibrosis

- Atrophic epithelium
- Loss of rete pegs
- Submucosal inflammatory infiltration
- Hyalization of collagen bundles
- Fibroblast proliferation and collagen hyperplasia

A. Classifications based on clinical features of OSMF are as follows:

Desa JV (1957), *divided OSF into three stages:*
Stage I: Stomatitis and vesiculation
Stage II: Fibrosis
Stage III: As its sequelae

Pindborg JJ (1989), *divided OSMF into three stages:*

Stage I: Stomatitis including erythematous mucosa, vesicles, mucosal ulcers, melanotic mucosal pigmentation and mucosal petechia.

Stage II: Fibrosis occurs in healing vesicles and ulcers, which is hallmark of this stage. Early lesions show blanching of the oral mucosa. Older lesions include vertical and circular palpable fibrous bands in the buccal mucosa and around the mouth opening or lips. This results in a mottled marble like appearance of the mucosa, because of the vertical thick, fibrous bands in association with a blanched mucosa. Specific findings include reduction of mouth opening, stiff and small tongue, blanched and leathery floor of the mouth, fibrotic and depigmented gingiva, and rubbery soft palate with decreased mobility, blanched and atrophic tonsils, shrunken bud-like uvula and sunken cheeks, not commensurate with age or nutritional status.

Stage III: Sequelae of OSMF are as follows–Leukoplakia is found in more than 25% of individuals with OSMF. Speech and hearing deficit may occur because of involvement of tongue and the eustachian tube.

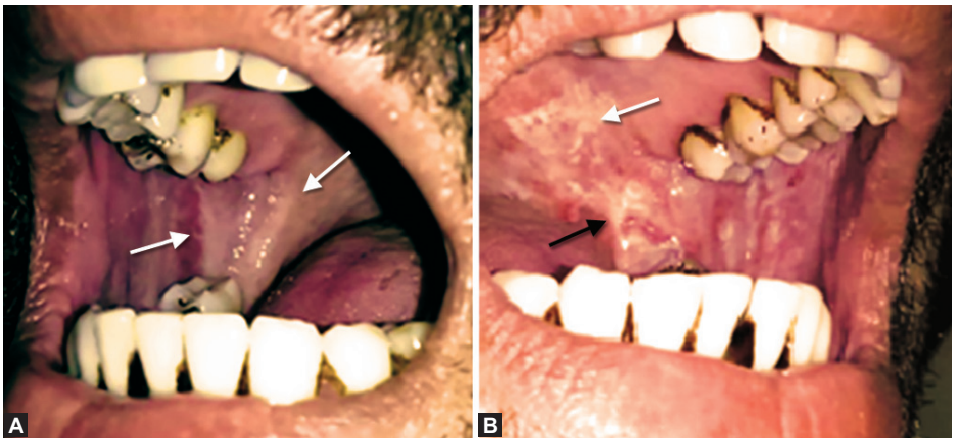
B. Classifications based on histopathological features of OSMF:

Pindborg JJ and Sirsat SM (1966), divided OSMF depending only on histopathological features as:

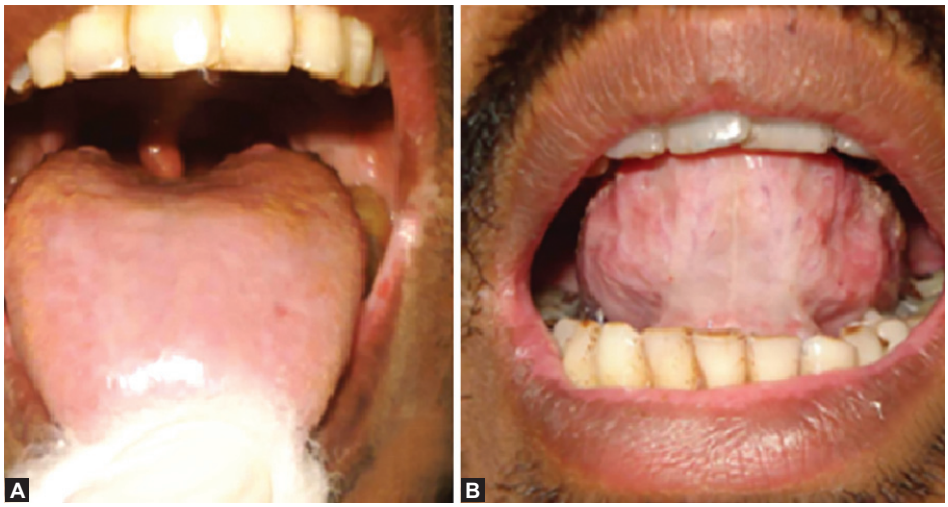
Very early stage: Finely fibrillar collagen dispersed with marked edema. Plump young fibroblast containing abundant cytoplasm is seen. Blood vessels are dilated and congested. Inflammatory cells, mainly polymorphonuclear leukocytes with occasional eosinophils are found.

Early stage: Juxtaepithelial area shows early hyalinization. Collagens are still in separate thick bundles. Moderate number of plump young fibroblasts are present. Dilated and congested blood vessels are seen. Inflammatory cells are primarily lymphocytes, eosinophils and occasional plasma cells.

Moderately advanced stage: Collagen is moderately hyalinized. Thickened collagen bundles are separated



Figs 47.6A and B: Oral submucous fibrosis showing (A) Blanching over right buccal mucosa extending to the faucial pillar; (B) Contralateral side of same patient shows leukoplakia patches over palate (white arrow) and erythroleukoplakia patches over buccal mucosa and faucial pillars (black arrow). Such changes are often clinical indicators of dysplastic and malignant changes



Figs 47.7A and B: Oral submucous fibrosis showing (A) Oral submucous fibrosis of tongue with loss of papillae; (B) Restricted tongue movement

by slight residual edema. Fibroblastic response is less marked. Blood vessels are either normal or compressed. Inflammatory exudate consists of lymphocytes and plasma cells.

Advanced stage: Collagen is completely hyalinized. Smooth sheets with no separate bundles of collagen are seen. Edema is absent. Hyalinized area is devoid of fibroblasts. Blood vessels are completely obliterated or narrowed. Inflammatory cells are lymphocytes and plasma cells.

C. Classifications based on clinical and histopathological features:

Khanna JN and Andrade NN (1995), developed classification system based on both clinical presentation and histological features for the surgical management of OSMF.

Group I (very early cases): Common symptoms are burning sensation in the mouth, acute ulceration, recurrent stomatitis, and is not associated with mouth opening limitation.

Histology: Fine fibrillar collagen network interspersed with marked edema, dilated blood vessels and congested large aggregate of plump young fibroblasts is present with abundant cytoplasm. Inflammatory cells mainly consist of polymorphonuclear leukocytes with few eosinophils. The epithelium appears normal.

Group II (early cases): Buccal mucosa appears mottled and marble like. Widespread sheets of fibrous

bands are palpable. Interincisal distance is reduced to 26–35 mm.

Histology: Juxtaepithelial hyalinization is present. Collagen present as thickened but separate bundles. Blood vessels are dilated and congested. Young fibroblasts are seen in moderate number. Inflammatory cells mainly consist of polymorphonuclear leukocytes with few eosinophils and occasional plasma cells. Flattening or shortening of epithelial rete pegs is evident with varying degree of keratinization.

Group III (moderately advanced cases): It is characterized by trismus, interincisal distance of 15–25 mm, buccal mucosa appears pale firmly attached to underlying tissues, atrophy of vermilion border, vertical fibrous bands palpable at the soft palate, pterygomandibular raphe and anterior faucial pillars.

Histology: Juxtaepithelial hyalinization is present, with thickened collagen bundles, residual edema, constricted blood vessels, mature fibroblasts with scanty cytoplasm and spindle-shaped nuclei. Inflammatory cells consist of lymphocytes and plasma cells. Epithelium is markedly atrophic with loss of rete pegs.

Group IVA (advanced cases): It is characterized by severe trismus, interincisal distance of less than 15 mm, thickened faucial pillars, shrunken uvula, restricted tongue movement, and presence of circular band around entire lip and mouth.

Group IVB (advanced cases): It is most advanced stage of OSMF and shows presence of hyperkeratotic leukoplakia and/or squamous cell carcinoma.

Histology: Shows hyalinized collagen, extensive fibrosis, obliterated mucosal blood vessels. There is total loss of epithelial rete pegs, presence of mild to moderate atypia and extensive degeneration of muscle fibers.

Differential Diagnosis

Differential diagnosis of OSMF includes scleroderma and siderophenic dysphagia.

Management

Management of OSMF depends on severity of the disease. Early cases can be managed by conservative and medical therapy. However, advanced disease requires surgical intervention with long-term postoperative physiotherapy and follow-up. Conservative and medical management of OSMF include:

- Patient education and motivation to discontinue areca nut and tobacco habit.
- Nutritional support.
- **Drug therapy:**
  - Short-term improvement in mouth opening and relief from burning sensation can be obtained from intralesional injections of steroids, placental extract, hyaluronidase, or use of gamma-interferon, pentoxyphylline, chymotrypsin, collagenase, and antioxidants. However, none of these provide long lasting relief.
  - Topical applications of anesthetics and steroids may be useful.
  - Long-term use of antioxidants may improve the condition.

Excision of fibrous bands remains the mainstay of surgical management of OSMF. Various surgical options for management includes:

- Simple excision of fibrous bands
- Excision of fibrous bands along the interposition in the defect created with:
  - Split thickness skin grafting
  - Nasolabial flap
  - Buccal fat pad **(Fig. 47.9)**
  - Collagen membrane **(Fig. 47.8)**
  - Tongue flaps
  - Palatal island flap
  - Temporalis fascial flap
  - Free flap (radial forearm flap).

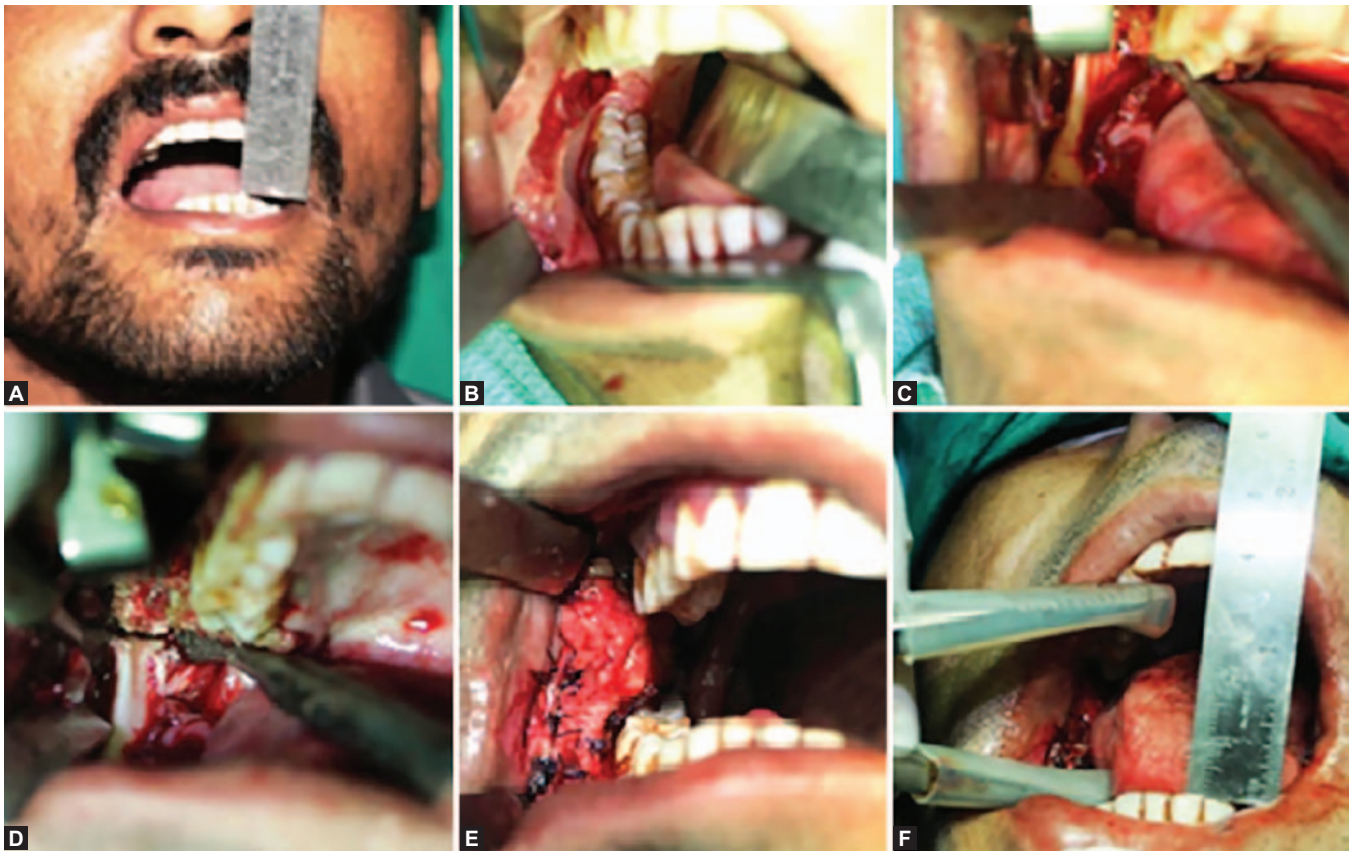
The above procedure can be combined with temporalis myotomy, coronoidectomy and removal of third molar teeth to further improve mouth opening. Rigorous postoperative physiotherapy is essential to eliminate surgery induced fibrosis and relapse of the condition. Long-term follow-up is a must for every patient to detect dysplastic changes and malignant transformation.

Prognosis and Malignant Transformation Rate of OSMF

It is a progressive disease and worsens over the time, if habit is not discontinued. Rate of malignant transformation is approximately 7–13%.



Figs 47.8A to C: Management of oral submucous fibrosis (OSMF) by (A) excision of fibrous band; (B) Coronoidectomy; and (C) Collagen membrane lining over the surgical defect



Figs 47.9A to F: Steps in surgical management of oral submucous fibrosis (OSMF) by excision of fibrous band and buccal fat pad grafting (A) Reduced mouth opening preoperatively; (B) Horizontal incision placed over buccal mucosa, extending from corner of mouth to the retromolar region. The incision is deepened to the underlying connecting tissue (keeping it superior to the plane of buccinators muscle) cutting the fibrous bands; (C) The incision extended posteriorly along the anterior border of ramus of mandible and a forked ramus retractor assists in complete exposure of the coronoid process; (D) Temporalis myotomy performed and osteotomy cut placed for coronoidectomy; (E) The surgical defect lined with buccal fat pad; (F) Postoperative mouth opening attained in operating room

ORAL LICHEN PLANUS

Introduction

Lichen planus (LP) is a chronic immunologic inflammatory disease affecting skin and mucous membrane. Lichen planus is so-called because of similarity of its clinical appearance to lichen. Lichen is a naturally occurring saprophyte (fungus and algae), that produces white linear patterns on the rocks and plant wood.

It involves approximately 1% of the population. 40–50% of patients with oral lesions also have skin lesions. The oral lesions may precede or appear after skin lesions.

Etiology

Etiology of LP is not definitely known. Probable etiology reported to cause LP include:

- Autoimmune response to basement membrane antigen.
- Prolonged emotional stress, diabetes and trauma can act as risk factors in susceptible patients.
- Lichen planus is also believed to show hereditary tendency.

Clinical Features (Figs 47.10 and 47.11, Box 47.5)

Majority of cases are seen in the 4h–6th decades of life. Females are more frequently affected than males. Bilateral buccal mucosa is most commonly involved, followed by labial, lingual and palatal mucosa. Gingiva is less commonly involved. Patients with LP may present with complaint of (symptoms) roughness or thickening of mucosa**,** burning sensation with intolerance to spicy food. In some patients, intense pain causing difficulty in speech, swallowing and mastication have been reported.

Skin lesions of LP are flat polygonal macules and papules. They are commonly seen on forearm, anterior leg and genitalia. The lesion is covered with fine scaling, white striations (slightly elevated, fine, whitish lines) arranged in different patterns called "*Wickham striae*". They are extremely pruritic, leading to erosions and ulcerations. Trauma can lead to formation of fresh lesions *(Koebner phenomenon)*.

Oral lesions of LP can be of three types—hypertrophic, atrophic/erosive and bullous. Features of all the three forms are summarized in the **Table 47.3**.

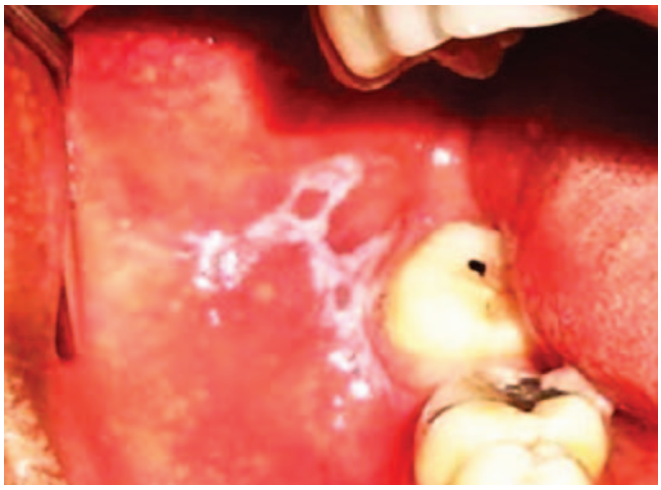


Fig. 47.10: Clinical presentation of lichen planus

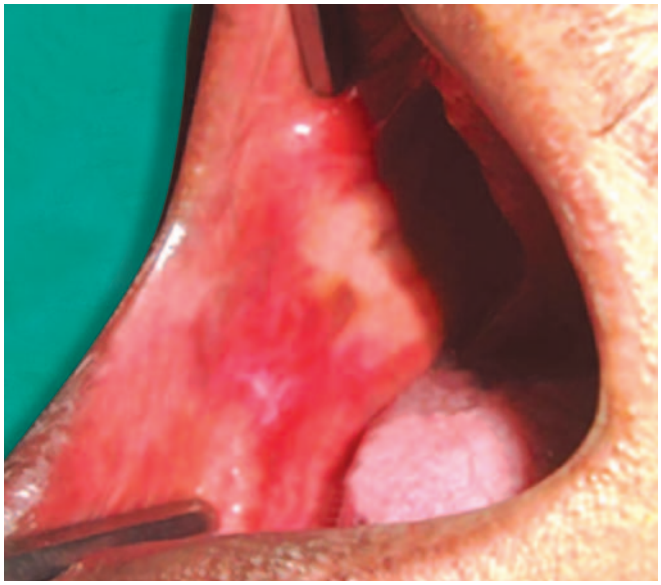


Fig. 47.11: Lichenoid reaction over right buccal mucosa in a diabetic patient on long-term oral hypoglycemic drugs

Grinspan's Syndrome

It is a syndrome characterized by presence of the triad: *Essential hypertension*, *diabetes mellitus* and *oral LP*. It was first reported by Grinspan in 1966. The exact nature of the correlation between the elements of this symptomatic triad is unclear.

Investigations

Clinical features are characteristic enough to diagnose hypertrophic forms. Histological examination may be

Table 47.3: Different forms of oral lichen planus

Hypertrophic	*Atrophic/erosive*	*Bullous*
• Hypertrophic form manifests as different arrangement of white striae (reticular, linear, annular or lace-like). • Sometimes a plaque-like white lesions with very few striae is seen • All forms are non-scrapable • The pliability of mucosa is not lost • Papillae on the tongue may not be lost • Sometimes associated with melanosis	• Atrophic form is less common • Atrophy may vary from erosions to deep ulcerations • Usually associated with some hypertrophic (striae) form • Tender to palpation and may bleed • May be associated with desquamative gingivitis • More prone to malignant transformation	• Least common • Appears as a bulla surrounded by some striations • Ruptures easily to form ulceration • Tender to palpation and may bleed

required to diagnose atrophic/erosive and bullous forms. Immunofluorescence studies are useful to differentiate LP from other ulcerative or bullous conditions.

Differential Diagnosis

Differential diagnosis of LP must include leukoplakia, candidiasis, pemphigus, pemphigoid, DLE, and erythema multiforme.

Management

Management objectives of LP are symptomatic relief, general support and an attempt to cure the lesion. Stress reduction protocols must be followed. Asymptomatic lesions should be periodically observed for any changes.

Conservative/Medical Management

Medical therapy for LP depends on the clinical form and presentation of the disease.

- Hypertrophic form without symptoms requires patient counseling and periodic observation.
- Hypertrophic form with mild symptoms is treated by patient counseling, topical anesthetics application over lesion [5% lignocaine, 0.15% benzydamine (*Tantum oral rinse*)] and periodic observation.
- Plaque-like lesions may benefit from a course of antifungal therapy.
- Atrophic form with mild to moderate symptoms is best treated by patient counseling, topical anesthetics, topical steroids [0.1% triamcinolone acetonide/0.05% fluocinonide/0.05% clobetasol in orabase to be applied after every meal and at bed time], antianxiety medication [5 mg diazepam at bed time for 1–2 weeks] and periodic observation.
- Management of bullous and atrophic form with severe symptoms is similar to atrophic form with mild to moderate symptoms Additionally, systemic steroids may be prescribed [prednisolone 20 mg tablet, twice a day for 5 days or betamethasone 0.5 mg tablet thrice daily for 5 days]. Systemic steroid therapy should not be withdrawn abruptly and dose must be tapered. Intralesional injection of steroid (betamethasone, 4 mg/mL solution, has been reportedly used successfully for stubborn lesions.

Surgical Management

It involves surgical removal of the lesion using scalpel, Cryo-Probes™ or laser. Surgical excision may help in management of stubborn lesions, not amenable to medical treatment. However, recurrence after excision may still occur.

Clinical Course and Prognosis

Clinical progression of LP is unpredictable. Hypertrophic forms may remain asymptomatic and unchanged for years. Spontaneous regression may occur in some patients. Rarely, hypertrophic form may change to atrophic or ulcerative form and become symptomatic. Atrophic forms are always symptomatic and rarely regress spontaneously, hence need treatment. All forms of LP may recur after regression or successful treatment. Malignant transformation is rare (about 0.4%) and usually takes place in atrophic forms **(Fig. 47.11 and Box 47.5)**.

Box 47.5: Lichenoid reaction

Lichenoid reaction is oral mucosal lesion that has the clinical and histopathologic characteristics of lichen planus. Lichenoid reaction can be differentiated from lichen planus based on:

- ❑ Association of lichenoid reaction with the administration of drug, contact with a metal or use of food flavoring agents.
- ❑ Lichenoid reaction resolves when the drug or other causative factor is eliminated.
- ❑ Drug-induced lichenoid eruptions are the most common. Drugs which are known to cause lichenoid reaction are nonsteroidal anti-inflammatory drugs (NSAIDs), diuretics, antihypertensive, oral hypoglycemic and penicillamine.

Points to Remember

- Definition & classification of premalignant lesion and condition.
- Risk of malignant transformation of oral premalignant lesions.
- Description of individual lesions (leukoplakia, erythroplakia, oral submucous fibrosis, lichen planus)
- Treatment of premalignant lesions and conditions.

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CHAPTER 48 Oral Cancer

The oral cavity is the most predominant location in the head and neck region for primary malignant tumors. The oral cancers are the leading cause of morbidity and mortality amongst all cancers in India. The higher rates in India are attributed to the differences in lifestyle, habits, poverty, lack of education and less access to medical care. The malignant tumors of the oral cavity can arise from either mesenchymal or epithelial tissues.

Squamous cell carcinoma can arise from oral epithelium itself and from the terminal portions of the ducts of the salivary glands, minor and major. Salivary tumors arise from the minor salivary glands. Malignant melanoma arises from the melanocytes distributed in the basal layer of the oral epithelium. Sarcoma can arise from cartilage, bone, muscle, fibrous tissue and fat (osteosarcoma, chondroma, chondrosarcoma). Lymphoma also occurs in and around the mouth.

The term "Oral Cancer" is nearly synonymous with squamous cell carcinoma, because of its predominance seen in the oral cavity. In all primary oral malignant tumors, 92 percent are the squamous cell carcinomas.

INCIDENCE

Cancer of the oral cavity is a major public health problem with approximately 300,000 new cases reported annually worldwide. Two-thirds of these occur in developing countries, the majority within the Indian subcontinent, where these account for up to 20 percent of all cancers. The majority present with locally advanced disease (stage III and IV) with dismal 5-year survival rates of 20–50%. There are 145,000 deaths worldwide and 45,000 deaths in India per year. The oral cavity includes various subsites namely, the lip, buccal mucosa, alveolar bone (including upper and lower gums), hard palate, retromolar trigone, anterior two-thirds of the tongue and floor of the mouth. The involvement of each of these cancers has a different and distinct global incidence, patterns of spread and prognosis. However, they are broadly clubbed into two groups—tongue and floor of the mouth cancers and buccal mucosa, alveolus cancers. In the west, due to the high consumption of smoked tobacco and alcohol, tongue and floor of the mouth are the predominant oral cancers. In contrast, buccal mucosa, lower alveolus and retromolar trigone are the predominant sites in India, owing to the high consumption of chewed tobacco and areca nut chewing habit. (In South Asia, tobacco and areca nut chewing habit results in chronic lesions and the majority of the oral cancers arise from such lesions). These cancers are together called 'Gingivo-Buccal cancers' and have aptly been defined as the 'Indian oral cancer'. Discussion of the details of each individual oral cavity subsite is beyond the scope of this chapter. However, the broad principles governing the diagnosis and management of these patients are discussed below.

ANATOMICAL SUBSITES OF CANCER IN THE ORAL CAVITY

The oral cavity consists of the following subsites **(Fig. 48.1)**:

- Lip mucosa
- Buccal mucosa
- Lower alveolar ridge
- Upper alveolar ridge
- Retromolar gingiva (trigone)
- Floor of the mouth
- Hard palate
- Anterior two-thirds of the tongue (oral tongue).

Lip Mucosa

It begins at the vermilion border of the lip and includes only that surface which comes in contact with the opposing lip.

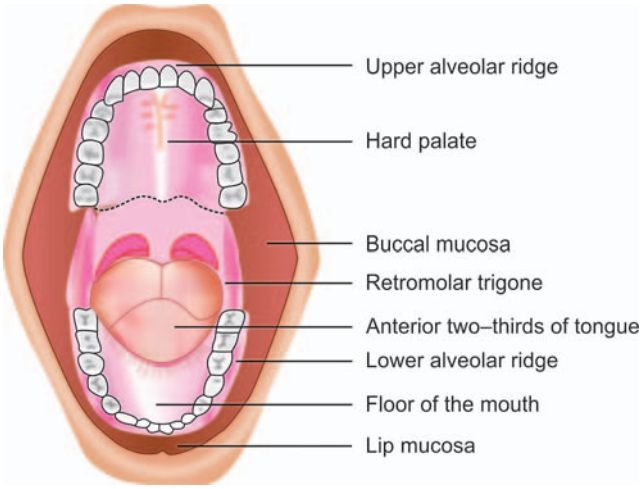


Fig. 48.1: Anatomical subsites of cancer in the oral cavity

Buccal Mucosa

This includes all the lining of the inner surface of the cheeks and the lips from the line of contact of the opposing lip to the line of attachment of the mucosa of the alveolar ridge (upper and lower) and pterygomandibular raphe.

Lower Alveolar Ridge

This refers to the mucosa overlying the alveolar process of the mandible, which extends from the line of attachment of the mucosa in the buccal gutter to the line of free mucosa of the floor of the mouth. Posteriorly, it extends to the ascending ramus of the mandible.

Upper Alveolar Ridge

This refers to the mucosa overlying the alveolar process of the maxilla, which extends from the line of attachment of the mucosa in the upper gingival gutter to the junction of the hard palate.

Retromolar Gingiva (Retromolar Trigone)

This is the attached mucosa overlying the ascending ramus of the mandible from the level of the posterior surface of the last molar tooth to the apex superiorly, adjacent to the tuberosity of the maxilla.

Floor of the Mouth

This is a semilunar space over the mylohyoid and hyoglossus muscles, extending from the inner surface of the lower alveolar ridge to the undersurface of the tongue. Its posterior boundary is the base of the anterior pillar of the tonsil.

Hard Palate

This is the semilunar area between the upper alveolar ridge and the mucous membrane covering the palatine process of the maxillary palatine bones.

Anterior Two-thirds of the Tongue

This is the freely mobile portion of the tongue that extends anteriorly from the line of the circumvallate papillae to the undersurface of the tongue at the junction with the floor of the mouth.

ETIOLOGY

Various etiological factors have been implicated in the causation of oral cancer. Case control and cohort studies have revealed that the ***consumption of tobacco*** and ***alcohol*** are the two most important of these risk factors.

Tobacco

Nitrosamines derived from nicotine are the main carcinogens implicated. It has been shown that those smoking 40 or more cigarettes/day are 5–7 times more at risk of developing cancer than nonsmokers.

The type of tobacco, curing methods (e.g. bidi) and method of smoking (e.g. reverse smoking) may influence risk of oral cancer. Paan chewing (betel quid) is an important factor in our nation. It consists of betel nut and lime wrapped in a betel leaf, tobacco, catechu and spices. This induces leukoplakia, which can undergo malignant transformation. Use of areca nut has been implicated in the causation of oral submucous fibrosis of the oral cavity. **(Fig. 48.2)**.



Fig. 48.2: Malignant lesion in retromolar region in OSMF patient

Alcohol

This possibly acts as irritant or solvent which facilitates penetration of mucosa by other carcinogens. It may also suppress efficiency of DNA repair after exposure to nitrosamines.

Tobacco and Alcohol Synergism

The harmful effects of the two etiological agents are enhanced when they are used in combination.

Viruses

Oral human papilloma virus (HPV) infection has now been recognized to play a role in the pathogenesis of head and neck squamous cell carcinomas. The high risk prototypes HPV-16 and HPV-18 are found to be capable of transforming epithelial cells into cancer in the upper respiratory tract. Although HPV infection is a predominant factor in causation of cancers of the oropharynx, it has also been implicated as a cause of cancer in the oral cavity.

Poor Dental Hygiene, Constant Chronic Trauma to Mucosa Due to Dental Cause

Poor oral and dental hygiene, sharp teeth, ill-fitting dentures, sharp crown and bridges, etc. are factors which may contribute to oral cancer.

The above mentioned factors probably result in cancer due to altered cell growth control processes, together with changes in interaction between the cell and it is surrounding, which give rise to invasion and metastasis. A well-described tumor progression cycle has been described for oral cancers implicating various genetic changes. However, in brief, the genes involved in carcinogenic process are oncogenes, tumor suppressor genes, DNA repair genes and those controlling apoptosis (programmed cell death). Imbalance in the interaction between these, can cause increased cell proliferation or reduced apoptosis. If DNA repair does not occur, cells accumulate abnormalities and cancer develops.

SPREAD OF SQUAMOUS CELL CARCINOMAS OF THE ORAL CAVITY

The major mechanisms of squamous cell carcinoma spread are by:

- **Local infiltration.**
  - Invasion of local soft tissues.
  - Invasion of perineural spaces.
  - Invasion of vessels—(The internal jugular vein is often involved by direct spread from adjacent nodal metastasis).
  - Invasion of bone.
- **Lymphatic spread**—metastasis in regional lymph nodes **(Fig. 48.3)**. Lindberg in 1972, described spread of tumor in lymphatics by tumor emboli from primary passing into deep lymphatics and then to regional nodes.
- **Blood-borne metastasis.** (Distant spread)
  - Cancers of the tongue, floor of the mouth and alveolar ridges metastasize primarily to the ipsilateral submandibular, jugulodigastric and middle deep cervical groups—the 'submaxillary,' 'subdigastric and midjugular' groups of Lindberg.
  - Retromolar trigone lesions metastasize into submandibular, jugulodigastric and upper and middle deep cervical nodes.
  - Lip and tongue lesions metastasize to submental and submandibular nodes.
  - Lesions of tongue, lip, floor of the mouth, close to the midline metastasize to nodes bilaterally.
  - Once in deep jugular chain, tumor spreads from node to node in downward direction towards mediastinal nodes.

Clinical Features

Cancer of the oral cavity can present in a variety of ways depending on the subsite involved **(Figs 48.4A and B)**. Classically they present either as a nonhealing ulcer,

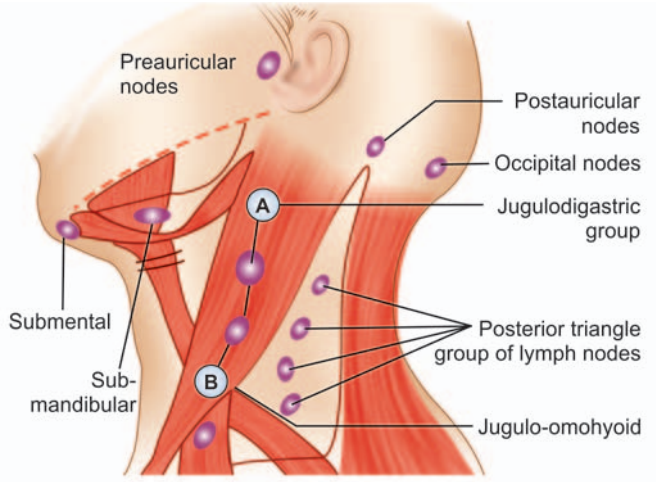
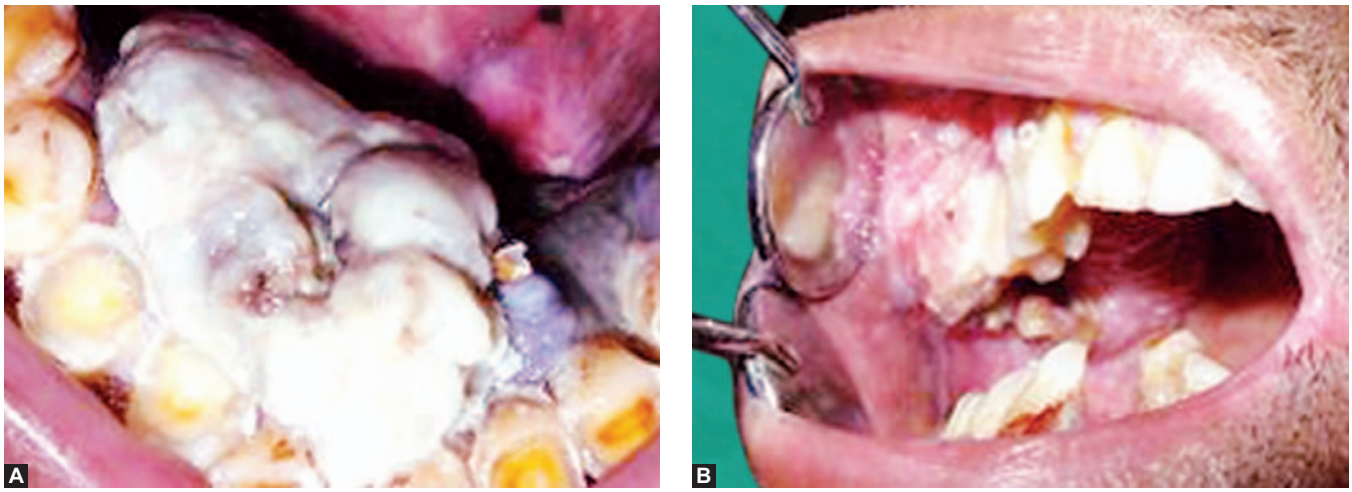


Fig. 48.3: Cervical lymphatic system. A to B level deep to sterno-cleidomastoid—deep jugular chain of nodes



Figs 48.4A and B: Clinical intraoral pictures of oral cancer

with varying degrees of pain and occasional episodes of bleeding from the lesion or an exophytic growth of duration may be several weeks to a few months before patient seeks treatment. Ulcerative lesions usually have an irregular edge and induration of the underlying soft tissues. Exophytic growth may present as a cauliflower like irregular growth or may be flat. Occasionally they may also present as a submucosal growth with surrounding induration. More advanced lesions can present with pain, bleeding or fixity to surrounding structures. Buccal mucosa cancers that involve the infratemporal fossa present with recent onset of trismus. This must be distinguished from long standing trismus, which is a sign of oral submucous fibrosis. Advanced tongue cancers present with hypoglossal palsy and restriction of mobility of tongue, progressive difficulty in mastication and speech, pooling of saliva, friability and surface bleeding. Lesions can also present with metastatic disease to the regional draining cervical nodes. It is important to remember that occasionally lesions of the alveolus in and around the nonhealing tooth extraction sockets can manifest with unexplained loosening of the involved teeth.

The cancer may affect the nutritional status by preventing the alimentation. Functional impairment may be caused by the obstruction from a large mass or from other associated condition like trismus. Malnutrition results in impaired wound healing, reduced immunocompetence and decreased tolerance to chemotherapy, radiotherapy and surgery.

Biopsy

A biopsy is the minimum investigation required for diagnosis. Biopsy of the lesion should be in the form of a punch biopsy or an incisional biopsy, if the lesion is largely submucosal. The biopsy should not be taken from the edge of the lesion as this may be very painful. Avoid taking biopsy from obviously necrotic areas in the lesion. There is no role for scrape cytology in the diagnosis of squamous cell cancer of the oral cavity.

Imaging for Oral Cavity Cancers

Clinical examination is fairly accurate for evaluation of early oral cancers. However, with larger tumors, clinical examination alone is inadequate. Accurate assessment of the extent of these cancers requires proper imaging studies. Important treatment decisions are based upon the exact extent of spread of disease to areas such as the mandible, the floor of mouth, the infratemporal region, base of tongue, soft tissue, etc. When choosing the ideal imaging modality, our decision is guided by the clinical findings.

Imaging for Assessing Mandibular Involvement

The orthopantomogram can be used to identify gross involvement of bone; however it has its limitations. It cannot identify subtle erosions of mandible and is not reliable for midline lesions of the oral cavity **(Table 48.1)**. A comparison of the sensitivity and specificity of all other investigations, for imaging of the mandible, is outlined in the **Table 48.2**.

As can be seen SPECT has the highest sensitivity in identifying bone involvement. However, this is an expensive investigation and is not readily available. A contrast enhanced CT scan using the puffed cheek technique, is the recommended investigation for identifying early mandibular invasion and involvement of bones of the paranasal sinuses.

Table 48.1: Guidelines for the selection of imaging modality

a.	Imaging to assess mandibular involvement—orthopantogram or CT scan
b.	Imaging to assess extent of soft tissue spread and recurrent tumors—MRI scan
c.	Imaging for involvement of infratemporal fossa—CT scan
d.	Imaging for tongue lesions—MRI scan

Table 48.2: Summary and comparison of the imaging techniques and clinical examination

Imaging technique	*Number of reports*	*Specificity (mean)*	*Sensitivity (mean)*
1. Clinical examination	9	61	82
2. Plain radiography	18	81	76
3. Bone scintigraphy	15	74	93
4. SPECT*	3	76	97
5. Computerized tomography	7	86	75
6. Dentascan	3	–	–
7. Magnetic resonance imaging	4	72	85

*Single photon emission computed tomography

Imaging to Assess the Extent of Soft Tissue Spread

A CT scan is the imaging modality of choice. Involvement of the infratemporal fossa must be closely evaluated, particularly, if the patient gives a history of recent onset of trismus. Involvement of the infratemporal fossa is a sign of relative inoperability as lesion clearance in this area is difficult **(Fig. 48.5)**.

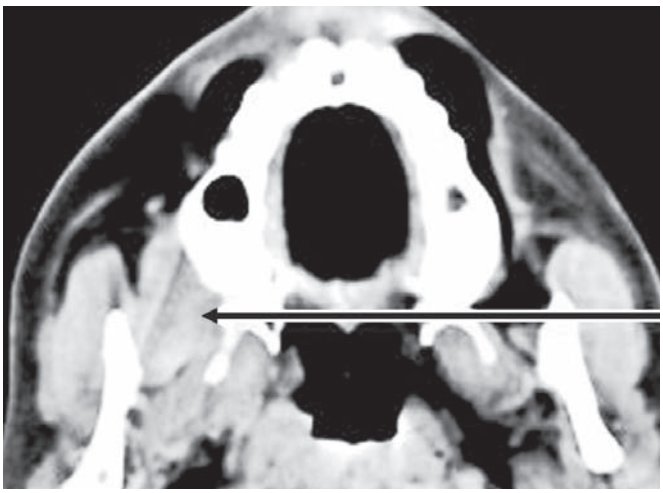


Fig. 48.5: CT scan showing involvement of the infratemporal fossa

FNAC of Neck Nodes

Fine needle aspiration cytology (FNAC) can be used to diagnose metastatic neck nodes to help in treatment planning. Open biopsies should never be performed as it violates the field and can cause seeding of cancer.

TNM Staging (Table 48.3)

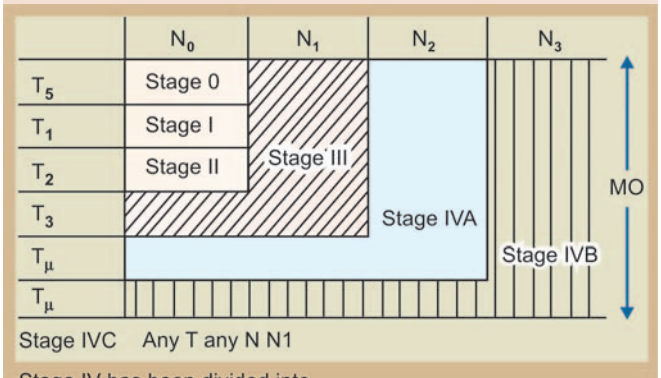
T staging

- T_x Primary lesion cannot be assessed
- T_0 No evidence of primary lesion
- Tis Carcinoma *in situ*
- T_1 Lesion 2 cm or less in the greatest diameter
- T_2 Lesion >2 cm but <4 cm in the greatest diameter
- T_3 Lesion >4 cm in the greatest diameter
- T_4 T4 lesions have been divided into
  T4A—Lesion invades through cortical bone, into deep/extrinsic muscles of the tongue (genioglossus, hypoglossus, palatoglossus and styloglossus), maxillary sinus or skin of face
  T4B—Lesion invades masticatory space, pterygoid plates, or skull base and/or encases internal carotid artery.

N Staging

- N_x Regional LN cannot be assessed
- N_0 No regional LN metastasis
- N_1 Metastasis to a single ipsilateral lymph node <3 cm in greatest dimension
- N_2A Metastasis to a single ipsilateral node, >3 cm but not more than 6 cm in greatest dimension.

Table 48.3: Staging of oral cavity cancer



Stage IV has been divided into
Stage IVA operable cancer
Stage IVB inoperable cancer
Stage IVC metastatic cancer

- N_2B Metastasis in multiple ipsilateral nodes none more than 6 cm in greatest dimension
- N_2C Metastasis in bilateral or contralateral nodes, none more than 6 cm in greatest dimension
- N_3 Metastasis in a lymph node more than 6 cm in greatest dimension.

M stage

- M_x Distant metastasis cannot be assessed
- M_0 No distant metastasis
- M_1 Distant metastasis present.

MANAGEMENT

Management of oral cavity cancers presents unique problems to clinicians as treatment has a bearing on esthetics as well as it affects critical functions like mastication, swallowing and speech. Treatment of oral cancer requires a multimodal approach with a team comprising of oncosurgeons, radiotherapists, and medical oncologists. In addition to these, supportive specialities such as radiology, pathology, speech therapy, dental and physiotherapy play an equally important and critical role.

Treatment of oral cancer depends upon the stage of cancer at diagnosis. The broad guidelines are as follows:

Early stage oral cancer (Stage I and II) can be treated with single modality treatment. Locally advanced and operable cancers (Stage III and IVA) need to be treated with combined modality treatment.

Locally advanced, inoperable cancers or metastatic cancers (Stage IVB and IVC) are treated with palliative intent (Radiotherapy-RT or Chemotherapy-CT) or only symptomatic treatment if the patient's performance status is low.

Principles of Management of Early Stage Cancer

Oral cancer and its treatment often expose the patient to considerable physiologic and psychologic strain.

Early oral cavity cancer can be treated with surgery or radiotherapy or a combination of both. There is no difference in survival with either modality of treatment. However, even within early oral cancers, both modalities have their specific indications.

Advantages of Surgery

- Simple.
- Fast.
- No significant cosmetic and functional defects.
- Repeated procedures possible.
- Cost effective.

Disadvantages of Radiotherapy

- Prolonged treatment.
- Significant side effects like xerostomia, dental caries, osteoradionecrosis.
- Can usually be given only once
- Not suitable for treatment, if lesion involves or is close to the bone.

Keeping the above in mind, for early oral cavity lesions, surgery is the treatment of choice. Radiotherapy is reserved for patients who are not willing for surgery or when surgery will cause significant cosmetic or functional defects or if patients are unfit for anesthesia.

Radiotherapy in Early Oral Cavity Cancer

Radiotherapy can be given either as brachytherapy (see below) or as external beam radiotherapy. External beam radiotherapy is given with radiation sources external to the patient. Telecobalt machines emitting gamma rays or linear accelerators producing photons are commonly used.

Brachytherapy

In this form of radiotherapy, radiation is administered interstitially through catheters surgically placed across the lesion. Brachytherapy spares normal tissues such as bone, salivary glands and spinal cord. Lymph nodes are under dosed with brachytherapy alone and hence external beam radiotherapy is also used in addition in such cases. The ideal lesions suitable for brachytherapy should be less than 3 cm, superficially invasive and not close to the bone.

For interstitial implants alone or as a part of treatment, median local control rates for T1, T2 lesions of 86 and 80%, respectively, have been reported. These control rates are comparable to surgery for early oral cavity cancers.

Postoperative Radiation Therapy to the Neck is Indicated

- Multiple positive lymph nodes in the neck.
- Extracapsular extension by metastatic disease.
- Perivascular or perineural invasion.
- Gross residual disease following surgery.
- Cranial nerve involvement or extension to the base of skull, tumor emboli in lymphatics, etc.

Surgical Technique for Resection of Early Oral Cancers

- **Margins:** All lesions should be excised with a margin of at least 1 cm in all dimensions (mucosa and soft tissue) when feasible. Any margin less than 0.5 cm is a compromised margin.
- **Modality used:** Excisions can be done using the cautery, laser (CO_2) or knife. The results are the same with any of the modality as far as cancer control is concerned. There have been some reports of better healing using lasers, but this has not been very well documented **(Figs 48.6A and B)**.
- Resection of the part of the jaw-maxilla/mandible, along with neck dissection **(Figs 48.7 and 48.8)**.

Approaches to Oral Cavity

- Peroral—restricted to small anteriorly placed lesions.
- Lip split—to raise a cheek flap for posteriorly based gingivobuccal complex lesions and for performing marginal mandibulectomy.
- Pull through approach—this approach is used for tongue and floor mouth lesions particularly when the posterior margin is an issue with peroral excision **(Fig. 48.9)**.
- Mandibulotomy (median or paramedian)—for tongue and floor of mouth lesions close to the mandible to help achieve a lateral margin of clearance **(Figs 48.10A and B)**.

Marginal Mandibulectomy

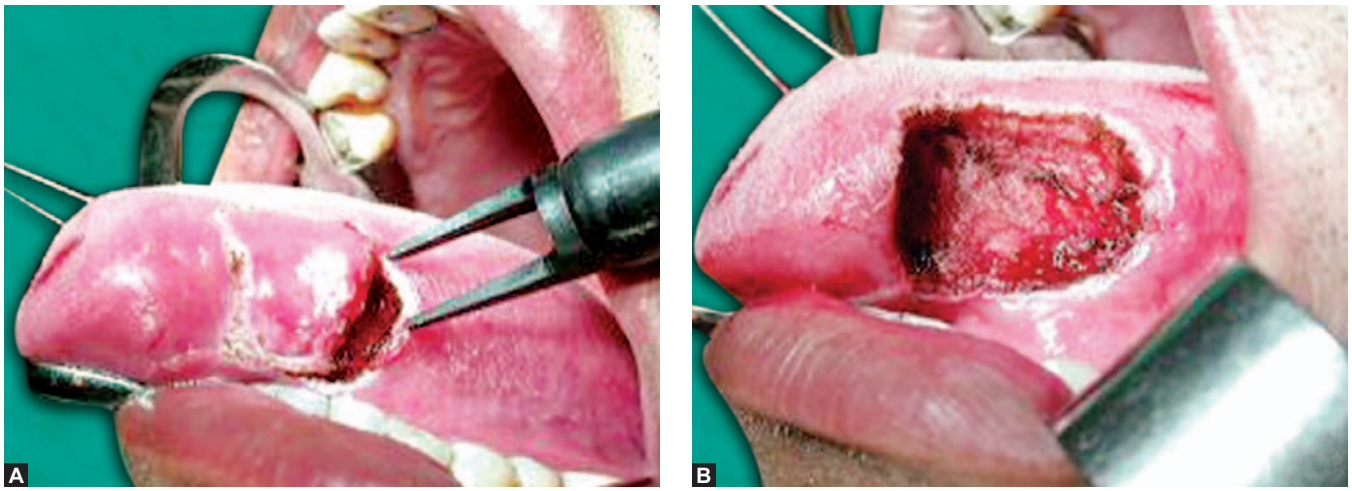
Marginal mandibulectomy involves the removal of the rim of the mandible and is done for lesions reaching close to the mandible, but not grossly involving it. It can be done for lesions superficially eroding the bone, but this should be done judiciously and in selected cases only. A margin of 0.5–1 cm should be achieved on the bone and a minimum of 1 cm of the mandible should be preserved to prevent postoperative fractures **(Table 48.4)**.

Types and Indications for Marginal Mandibulectomy

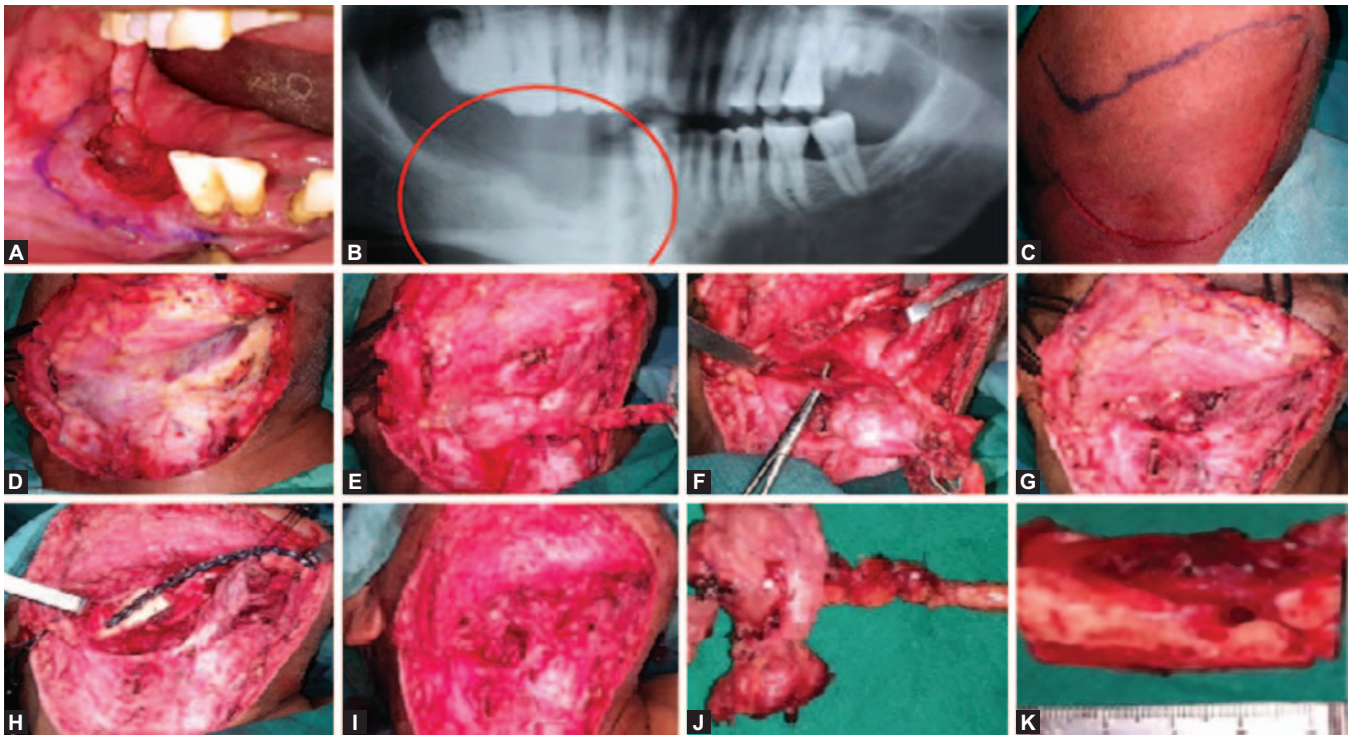
- **Horizontal mandibulectomy/alveolectomy:** Patients with gingivobuccal cancer reaching close to the mandible, but not grossly involving the mandible.
- **Lingual plate excision:** For lesions of the floor of mouth or tongue.
- **Buccal plate excision:** For lesions of the gingivobuccal complex with minimal paramandibular spread.

Table 48.4: Contraindications for marginal mandibulectomy

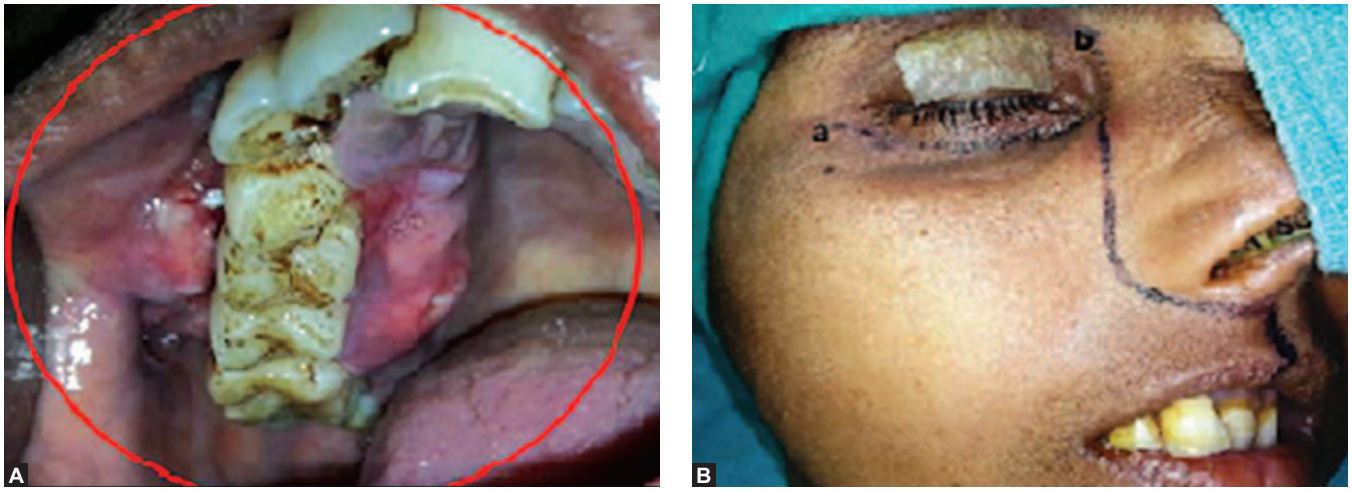
• Edentulous mandible (as the height of an edentulous mandible is reduced)
• Postradiotherapy setting
• Gross paramandibular spread



Figs 48.6A and B: (A) Lesion suited for laser excision; (B) Post-laser excision minimal charring



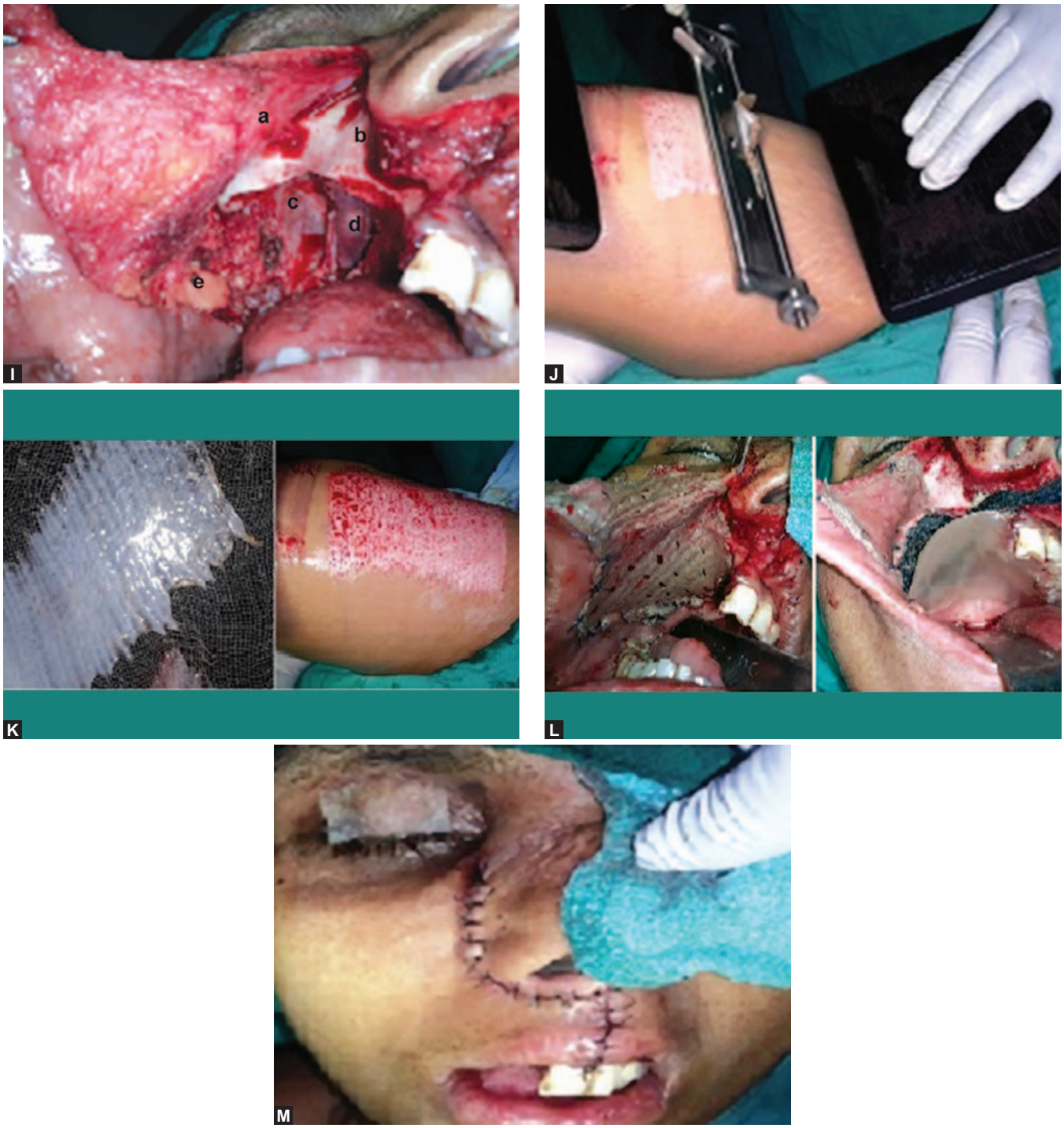
Figs 48.7A to K: (A) Primary ulcerative CA lesion in right mandibular area; (B) OPG showing bony involvement; (C) Incision for neck dissection and resection of the involved portion of the mandible; (D) Flap raised; (E) Fibrofatty tissue removed from submental triangle; (F) Fibrofatty tissue removed from submandibular triangle; (G) Lymph nodes cleared from level I and II; (H) Segmental mandibulectomy, followed by fixation of reconstruction plate; (I) Plate covered with muscles closure; (J) Excised neck dissection specimen; (K) Segmentally resected mandible



Figs 48.8A and B



Figs 48.8C to H



Figs 48.8I to M

Figs 48.8A to M: A case of squamous cell carcinoma of right hemimaxilla: (A) Intraoral picture of the lesion; (B) Weber-Furguson incision marked along with (a) subcilliary extension and (b) Lynch modification; (C to F) Infiltration of LA with adrenaline solution in subcutaneous plane for hemostasis and clean dissection; (G) Exposure of the lesion; (H) Osteotomy cuts; (I) Surgical defect after hemi-maxillectomy, (a) infraorbital nerve, (b) piriform aperture, (c) roof of antrum, (d) mucosa of floor of the nose, (e) buccal fat pad; (J) Split thickness skin graft harvesting from right thigh; (K) Skin graft lining the hemimaxillectomy defect; (L) Defect packed with BIP ribbon gauze and secured in place with obturator; (M) Final layered suturing

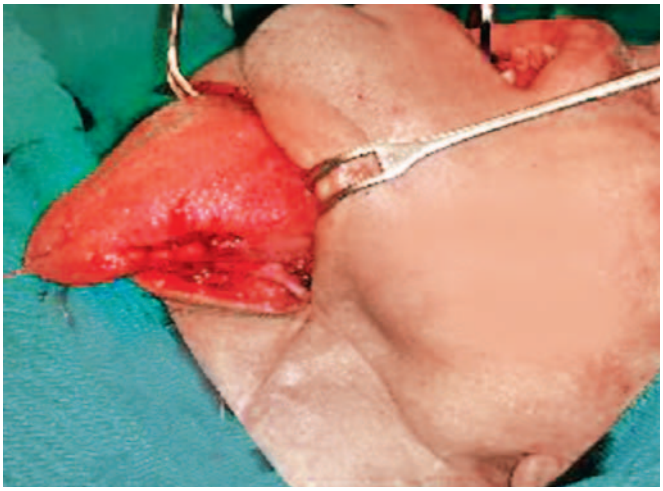


Fig. 48.9: Approach for tongue cancer via a pull through method

Principles of Management of Locally Advanced Oral Cavity Cancers

Locally advanced cancers (Stage III and Stage IV) require multimodality treatment. A flow chart showing the principles of management of these cancers is given in **Flowchart 48.1 and Table 48.5**.

Surgery for Locally Advanced Cancer

Composite resections are the surgical procedures performed for most patients with locally advanced oral cavity cancers. As in early oral cancers, all lesions should be excised with a margin of at least 1 cm in all dimensions. Adequate margin should be achieved on mucosa, soft tissue and bone. Any margin less than 0.5 cm is a compromised margin **(Figs 48.11A to D)**.

Composite resections involve removal of:

- The entire lesion with involved areas like the mucosa, skin, and mandible.

Flowchart 48.1: Principles of management of locally advanced oral cancer

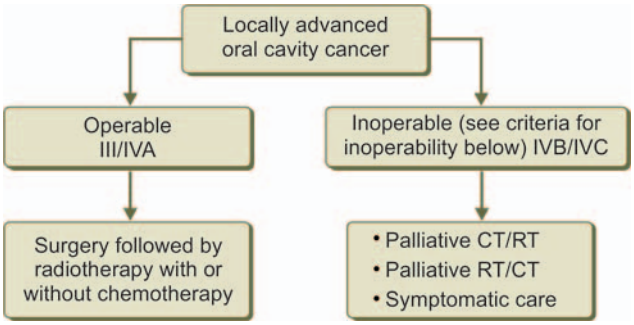
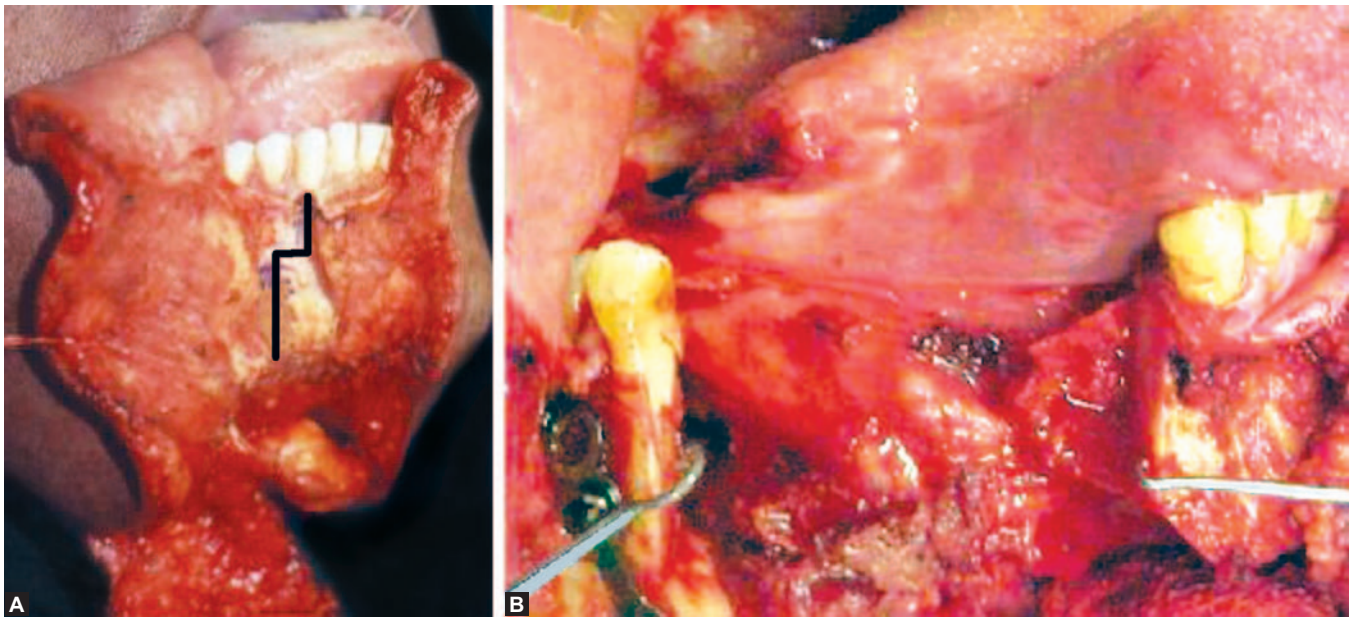
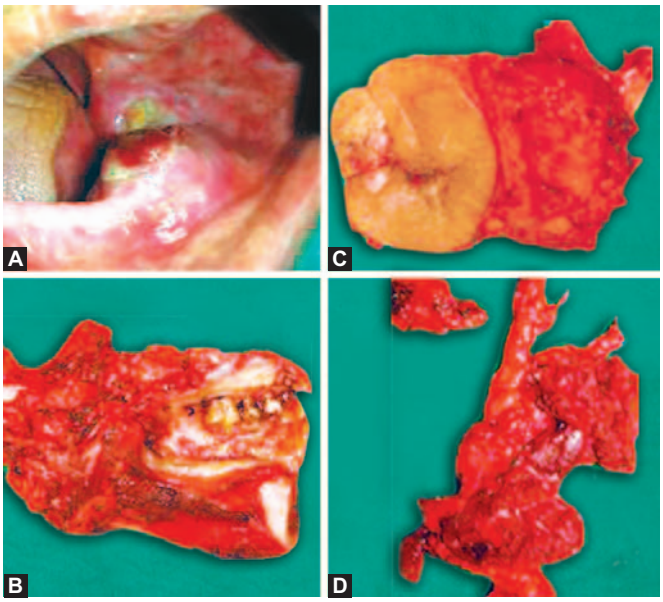


Table 48.5: Criteria suggesting inoperability

• Fixed neck nodal adenopathy
• Recent onset of trismus (gross infratemporal fossa invasion)
• Base skull involvement
• Extensive soft tissue involvement
• Distant metastasis



Figs 48.10A and B: (A) Paramedian mandibulotomy osteotomy cuts; (B) Approach via paramedian mandibulotomy demonstrating exposure



Figs 48.11A to D: Composite resection for oral cancer

- Removal of neck nodes
  These are usually done in continuity.

Types of Segmental Resections of the Mandible

- Hemimandibulectomy
- Segmental mandibulectomy.
  - Posterior segmental mandibulectomy
  - Middle-third mandibulectomy.

Principles of Reconstruction

An attempt should be made to reconstruct all excised tissues with similar tissues. Mucosa, skin, soft tissue and bone should be reconstructed in all patients after composite resections. This will help to restore good function and cosmesis of the patient **(Table 48.6)**.

Mucosal Defects can be Delt with Following Modalities

- Leave raw areas, allow it to granulate on its own
- Primary closure

Table 48.6: Reconstruction after surgery for oral cavity cancers

Objectives
• Achieve primary healing
• Maintain oral competence
• Facilitate swallowing
• Prevent aspiration
• Preserve speech

- Cover with split thickness skin graft (STSG)
- Microvascular reconstruction **(Figs 48.12A to C)**.

Reconstruction of Mandibular Defects

Mandibular defects can be reconstructed using external material (plates, silastic implants, etc.), allografts (cadaveric bone) or autografts. Of these, the autografts are the preferred form of reconstruction using the microvascular free tissue transfer method.

Anterior mandibular defects should be reconstructed by free osteocutaneous flaps using microvascular anastomosis. The bone can be harvested from any one of the following areas of the body:

- Fibular osteocutaneous flap (preferred, because of long bone length, easy contouring and dual blood supply), **(Figs 48.13A and B)**
- Radial osteocutaneous flap
- Scapular osteocutaneous flap
- Iliac osteocutaneous flap.

Of these flaps, **the fibular** osteocutaneous flap is the workhorse and the most preferred flap (>90% cases). This is because it has the advantages of being reliable, gives a long bone length (up to 25 cm), has minimal or no donor site morbidity and provides for easy contouring due to its segmental blood supply.

Lateral mandibular defects usually do not require bone replacement and may be adequately reconstructed with soft tissue replacement using myocutaneous flaps, e.g. pectoralis major myocutaneous flap. This should be complemented by proper use of guide bite prosthesis and appropriate postoperative isometric exercises.

MANAGEMENT OF THE NECK LYMPH NODES

Clinical Examination of Neck Lymph Nodes

In a comprehensive examination, the patient should be seated with the head and shoulders in the position of anatomical rest. This gives a relaxed and balanced posture for the patient. Palpation of the neck is best conducted from the rear of the patient. The palpation should begin at the base of the posterior cervical triangles and then moves upwards within the anatomical confines of this triangle to the apex at the superior nuchal line. Anterior triangles are next palpated, with their apex below the sternoclavicular joint and suprasternal notch up to the base located at the inferior border of mandible.

Then, the simultaneous bilateral manual palpation is interrupted to displace the sternocleidomastoid muscle posteriorly and laterally. This displacement is done by



Figs 48.12A to C: Reconstruction of mucosa and skin after excision of a buccal mucosa cancer



Figs 48.13A and B: Reconstruction using a free fibular osteocutaneous flap

having the nonexploring hand flex and laterally rotate the cervical spine, so that the palpating hand can feel the area under sternocleidomastoid muscle. The accessory group of lymph nodes is deep to the middle third of this muscle. Order of palpating the lymph nodes should be supraclavicular group, posterior triangle group, jugulo-omohyoid group, jugulodigastric group, submandibular, submental, preauricular, postauricular and occipital group of nodes.

The location, size, consistency and number of palpable lymph nodes should be noted.

Clinical Signs of Extracapsular Spread

- Invasion of the overlying skin
- Fixation to deeper soft tissues
- Paralysis of cranial nerves.

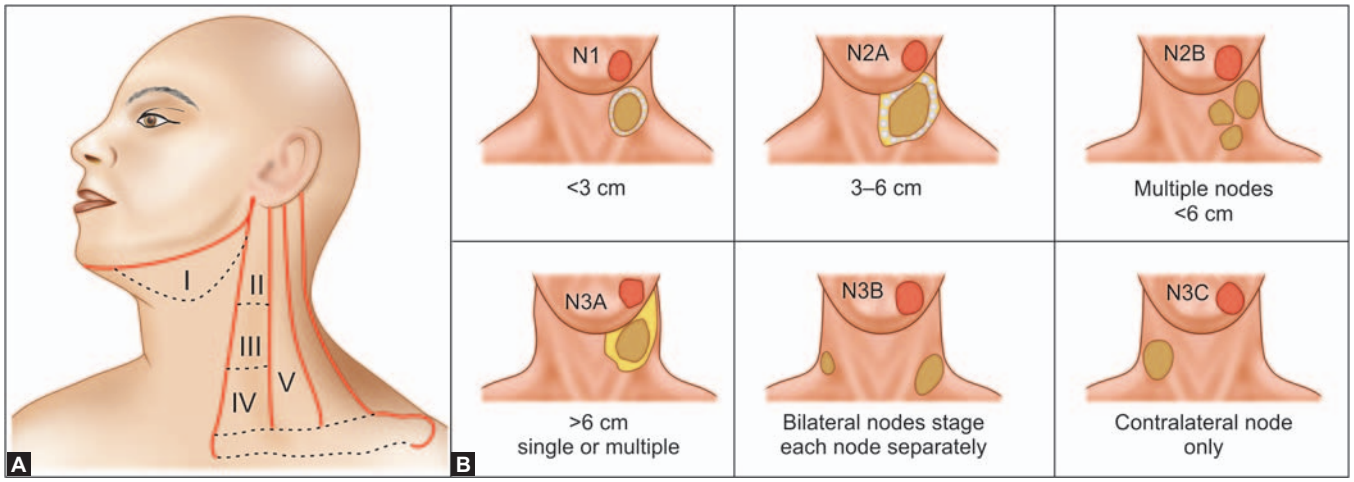
Assessment of the Extend of Involvement of Clinically Negative Lymph Nodes

- USG guided fine needle aspiration biopsy for histological diagnosis of metastasis
- CT scan with intravenous contrast
- MRI with gadolinium contrast.

LYMPH NODE LEVELS (FIGS 48.14A AND B)

As per American Joint Committee Staging Manual, 1998

- Level IA—nodes in submental triangle (Submental group).
- Level IB—nodes in submandibular triangle (Submandibular group).
- Level II—upper deep jugular nodes (skull base to carotid bifurcation).
  - These are subdivided by spinal accessory nerve into IIA lying posterosuperior and IIB, lying anteroinferior to the nerve.
- Level III—mid jugular group of nodes (carotid bifurcation to omohyoid)
- Level IV—lower jugular group of nodes (omohyoid to clavicle)
- Level V—nodes in posterior triangle
- Level VI—nodes in anterior triangle (Central compartment group)



Figs 48.14A and B: (A) Lymph node levels; (B) Lymph nodes-N staging

- Level VII—upper mediastinal group of nodes.

For primary lesions in the oral cavity, the regional lymph nodes at highest risk of early dissemination by metastatic cancer are limited to levels I, II and III. Therefore, if the neck is clinically negative, levels IV and V lymph nodes are generally not considered for micrometastasis from primary oral cancers.

Nodal Metastasis

Involvement of regional lymph nodes by oral cancer is dependent on following factors:

- Site and location of primary lesion
- Size
- T stage
- Histomorphologic feature.

Tongue and floor of the mouth lesions show more increased risk of nodal metastasis than hard palate lesion. Increasing T stage will increase the risk of nodal metastasis, irrespective to site. Endophytic lesions are more prone than exophytic lesions, similarly poorly differentiated carcinoma have increased risk of metastasis than well differentiated carcinoma.

The management of neck nodes depends upon:

- Staging of the neck
- T size of the oral cancer
- Type of treatment for the primary (surgery, radiotherapy).

Minimal gross metastasis or micrometastasis may be controlled by radiotherapy alone.

Surgical treatment: Comprehensive surgical clearance of all grossly enlarged lymph nodes offers accurate histological information for micrometastasis in the clinically negative neck. Whenever a significant risk of micrometastasis to regional lymph node is anticipated, based on the features of the primary lesion of the oral cancer, an elective dissection of regional lymph nodes is undertaken.

The principles for management of the neck are shown in **Flowchart 48.2 and 48.3**.

CLASSIFICATION OF NECK DISSECTION

The current classification of neck dissections is as follows **(Figs 48.15A to C)**:

Radical Neck Dissection (RND)

Removal of all cervical lymphatics and lymph nodes from level I-V, with sacrifice of the spinal accessory nerve, the sternocleidomastoid muscle and the internal jugular vein.

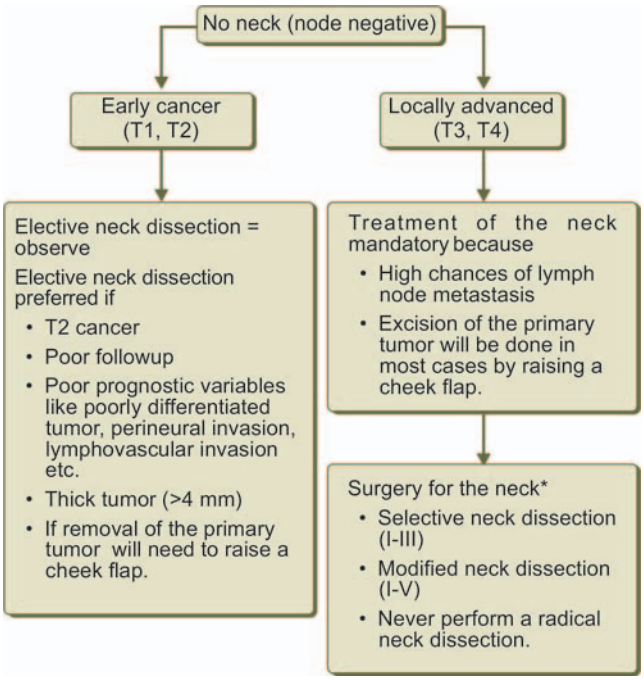
Modified Radical Neck Dissection (MRND)

Involves the removal of cervical lymphatics and lymph nodes from levels I-V along with one or more of the non lymphatic structures mentioned below:

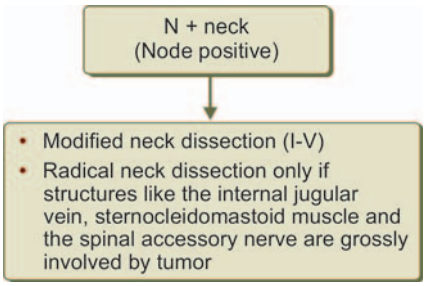
- The spinal accessory nerve (SAN)
- The internal jugular vein (IJV)
- The sternocleidomastoid muscle (SCM)

Nomenclature of MRNDs: The structures preserved should be specifically named along with the MRND, e.g. when the internal jugular vein and the spinal accessory nerve are preserved the denotation will be "***MRND (preserving the IJV and the SAN)***".

Flowchart 48.2: Principles for management of the neck



Flowchart 48.3: Principles for management of neck



The earlier nomenclature of MND Type I, II III is no longer to be used.

Selective Neck Dissection (SND)

This refers to a cervical lymphadenectomy in which there is preservation of one or more lymph node groups that are routinely removed in a MRND along with preservation of the SAN, IJV and the SCM. The lymph node groups removed depend upon the patterns of metastasis relative to the primary site of the tumor. This procedure is generally performed for staging of the neck and is rarely used as a therapeutic procedure.

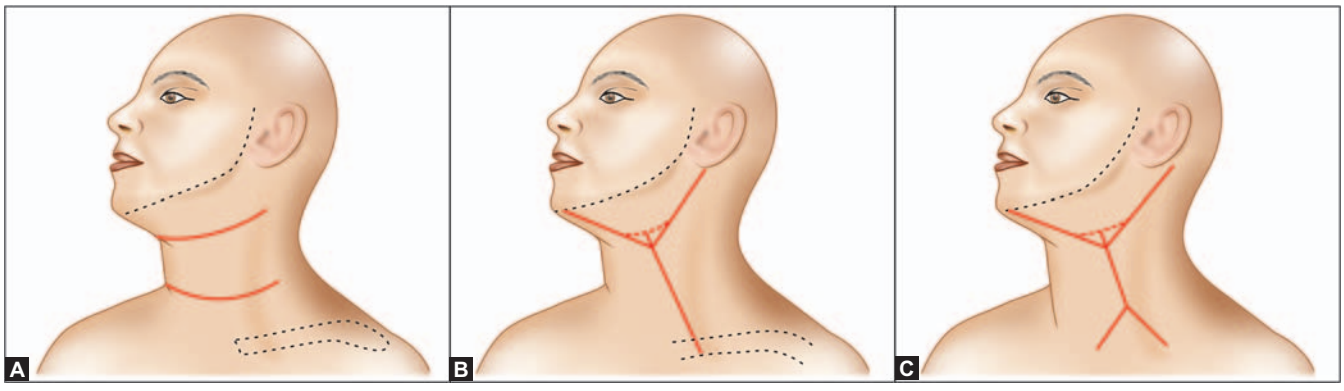
Nomenclature of SNDs: Each variation of SND is denoted by "SND (denote levels and sublevels), e.g. for oral cavity cancers, lymph node levels I-III are at highest risk for metastasis, therefore "***SND (I-III)***" will be performed as a staging procedure.

Extended Neck Dissection

When lymph node groups or nonlymphatic structures other than the ones removed in a RND need to be removed, e.g. external carotid artery, level VI lymph nodes, etc. it is called an extended neck dissection.

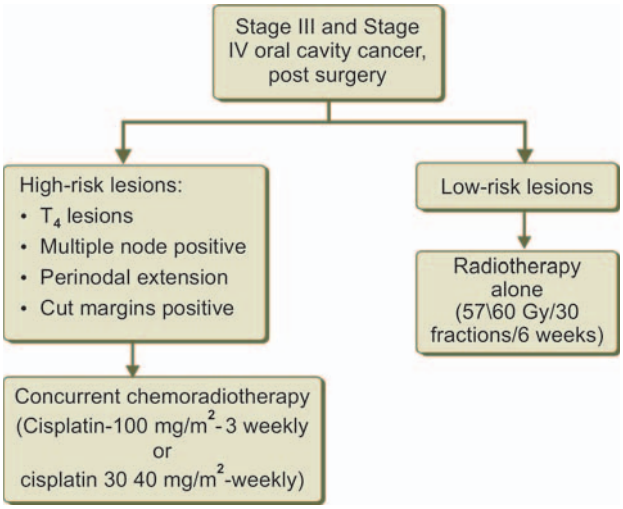
Adjuvant Treatment

As outlined above, patients with Stage III and Stage IV cancers need adjuvant treatment with radiotherapy. Current standards of care dictate, that patients with high risk tumors (see below) within stage III and IV need to be treated with radiotherapy and chemotherapy **(Flowchart 48.4)**.



Figs 48.15A to C: Different skin incisions used in neck dissection, carried out in association with the surgery for the management of oral cancer: (A) MacFee's incision; (B) Triradiate incision; (C) Hayes Martin's incision

Flowchart 48.4: Adjuvant therapies for stage III and stage IV oral cancer



SURVIVAL AND PROGNOSIS

The stage of disease at presentation is the most important factor. Stage I and II disease has better prognosis (5 years survival 31–100%) whereas advanced stages III, IV have poor prognosis (5 years survival 7–41%) depending upon site.

ROLE OF DENTAL PRACTITIONER IN ORAL CANCER MANAGEMENT

This traditionally neglected area is assuming an increasing importance with the modern multidisciplinary management concept. Dental oncology is the discipline within dentistry that combines general dentistry, oral and maxillofacial surgery, maxillofacial prosthetics, oral medicine and oral pathology.

- Prevention and early detection—dentists are often likely to be consulted for premalignant or early malignant lesions. Here they can encourage patients to quit tobacco and refer suspicious lesions to specialist. It is important for practicing dentists to examine the entire oral cavity when performing routine dental care to pick up suspicious lesions.
- Dental care prior to commencing radiation—this is very important and involves oral prophylaxis, fluoride application, extract hopeless teeth and restore carious teeth.
- Patient education post radiotherapy to maintain good oral health.
- Maxillofacial prosthesis fabrication—both intra and extra-oral prosthesis can be fabricated to replace teeth, nose, ear and eye, etc. This has become possible due to the advent of osseointegrated implants.

Preoperative Dental Work-up

- Many patients with primary cancer of oral cavity have extremely poor oral hygiene.
- Optimum status of oral hygiene should be achieved prior to surgery.
- All grossly septic teeth should be extracted except teeth involved within the lesion or its near vicinity.
- Oral prophylaxis should be carried out.
- All dental restoration work can be postponed until adequate surgical treatment.
- Planning dental impression taking for the fabrication of mandibular splint or obturator should be done prior to surgery.

Points to Remember

- Incidence
- Anatomical subsites of cancer in the oral cavity
- Etiology
- Spread of squamous cell carcinomas of the oral cavity
- Diagnosis and staging of oral cavity cancer
- Management
- Management of the neck lymph nodes
- Classification of neck dissection
- Survival and prognosis
- Role of dental practitioner in oral cancer management.

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Section 16

Implantology in Oral and Maxillofacial Surgery

49. Dental Implants: An Overview

CHAPTER 49

Dental Implants: An Overview

HISTORY

Implants for rehabilitation and retention of dental and facial prostheses have graduated from a phase of wishful thinking to one of the most gratifying experiences for patients and treating fraternity alike.

This magnificent journey began about 3000 years ago, when a copper stud was nailed into an Egyptian's mouth. This was documented by Dr and Mrs Popenoe, after their excavations in 1931, in Honduras. They found a mandible of Mayan skull with tooth-shaped pieces of shells in the sockets of missing teeth. In the recent history, Magiolo (1809), Edmunds (1886) and Harns (1887), attempted similar things using a variety of metals in different shapes after a certain period of postextraction healing.

Dahl (1940), proposed intramucosal implants or button implants. The subperiosteal implants were suggested in 1941.

There was a period of lull in the implant activity all over the world till 1952, when Bränemark demonstrated that under controlled conditions, titanium could be structurally integrated into living bone with a high degree of predictability of success.

Thereafter, the expedition moved to Linkow's blade vent implants (1967), followed by Robert and Roberts, ramus frame implants (1970). The first screw shaped implant, however, was placed in a patient in 1965.

Bränemark coined the term "*Osseointegration*" which has, probably been, derived from Latin "Os" (meaning "bone") and integration (meaning "being contained").

Osseointegration as defined by Bränemark and co-workers (1989) is "total integration of an implant in bone".

Osseointegration logically, should be better known as *osteointegration*. This phenomenon has also been called as "ankylotic bond".

IMPLANTATION

It is defined as insertion of any object or material, which is alloplastic in nature, either partially or completely into the body for therapeutic, experimental, diagnostic or prosthetic purpose.

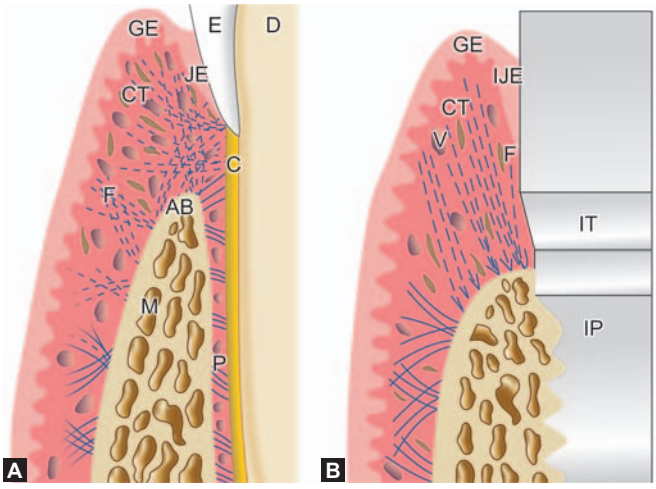
Dental Implant (According to Glossary of Prosthodontic Terms, 8th Edition)

It is a prosthetic device of alloplastic material(s) implanted into oral tissues beneath the mucosal and/or periosteal layer, and a substance that is placed into and/or upon the jaw bone to provide retention and support for a fixed or removable prosthesis. Dental implants may be classified by their silhouette or geometrical form (fin, screw, cylinder, blade, basket, root form, etc.). Generally, dental implants are classified based on their anchorage component (the dental implant body), as it relates to the bone that provides support and stability. Thus, there are three types of basic dental implants: epiosteal, endosteal and transosteal dental implants. Some dental implants possess both epiosteal and endosteal components (by design or subsequent anchorage change); the decision as to what anchorage system provides the most support at initial placement, determines which category is used to best describe the dental implant.

OSSEOINTEGRATION OR OSSEOUS INTEGRATION (1993) [GLOSSARY OF PROSTHODONTIC TERMS–8TH EDITION]

- It is the apparent direct attachment or connection of osseous tissue to an inert, alloplastic material without intervening connective tissue **(Figs 49.1A and B)**.

- The process and resultant direct connection of an exogenous material's surface and the host's bone tissue without intervening fibrous connective tissue present.
- The interface between alloplastic material and bone. *Osseointegration is also defined as: "the formation of a direct interface between an implant and bone, without intervening soft tissue"*.
  - Osseointegrated implant is a type of implant defined as "an endosteal implant containing pores into which osteoblasts and supporting connective tissue can migrate".
  - Applied to oral implantology, this refers to bone grown right up to the implant surface without interposed soft tissue layer. No scar tissues, cartilages or ligament fibers are present between the bone and implant surface. The direct contact of bone and implant surface can be verified microscopically.
    - Two theories regarding the chemical mechanism by which endosteal implants integrate with bone have been proposed. That type of integration contrasts with fibrosseous integration, in which soft tissues such as fibers and/or cells are interposed between the two surfaces.



Figs 49.1A and B: In the normal periodontium at (A) Collagen fibers are highlighted extending from the gingival alveolar bone (AB) crest to the cementum (C) gingiva and periodontal ligament (P) to form a cross-hatch pattern at the connective attachment. The rich blood supply (V) and fibroblastic (F) components can be seen to a lesser extent in the cervical peri-implant connective tissue (CT); (B) Bundles of collagen fibers in the peri-implant cervical connective attachment to run parallel to the surface of the intermediate prosthesis (IT).
Abbreviations: GE, gingival epithelium; JE, junctional epithelium, IJE, implant junctional epithelium; D, dentin; M, marrow space; IP, implant

Brånemark's Theory of Osseointegration

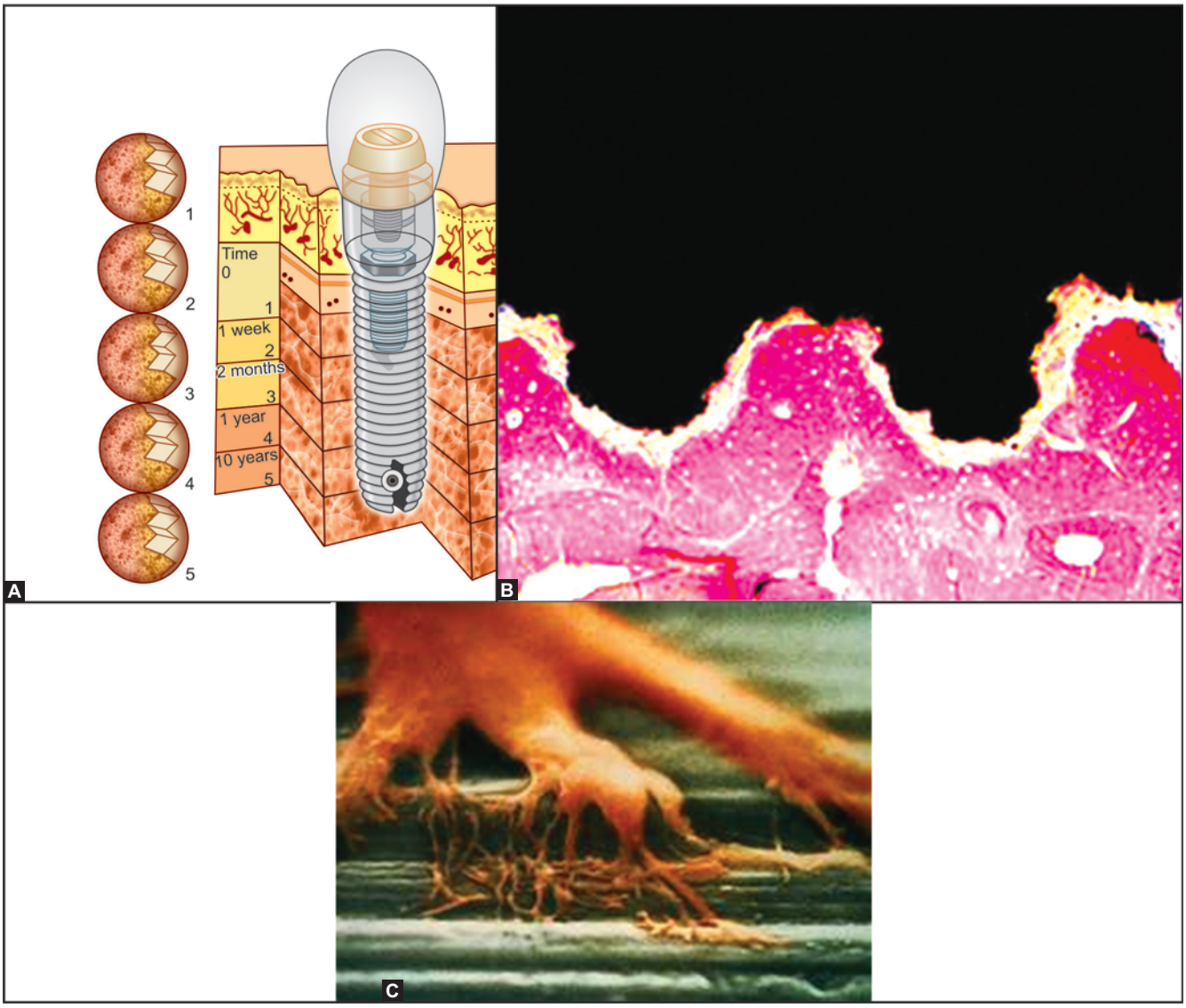
Brånemark proposed that implants integrate such that the bone is laid very close to the implant without any intervening connective tissue. The titanium oxide permanently fuses with the bone, as Brånemark showed in the 1950s.

Weiss' Theory of Fibro-osseous Integration

Weiss' theory states that there is a fibro-osseous ligament formed between the implant and the bone and this ligament can be considered as equivalent of the periodontal ligament found in the gomphosis. He defends the presence of collagen fibers at the bone-implant interface. He interpreted it as the peri-implantal ligament with an osteogenic effect. He advocates the early loading of an implant.

Osseointegration Process

For osseointegrated dental implants, metallic, ceramic, and polymeric materials have been used, in particular, *titanium*. To be termed osseointegration, the connection between the bone and the implant needs not be 100% and the essence of osseointegration derives more from the stability of the fixation than the degree of contact in histologic terms. In short, it represents a process, whereby, clinically asymptomatic rigid fixation of alloplastic material is achieved, and maintained in bone during functional loading. When osseointegration occurs, the implant is tightly held in place by the bone. The process typically takes several weeks or months to occur, which is well enough for the implant dentist to complete the restorations. The fact is that the degree of osseointegration of implants is a matter of time. First evidence of integration occurs after a few weeks, while more robust connection is progressively effected over the next months or years. Though the osseointegrated interface becomes resistant to external shocks over the time, it may be damaged by prolonged adverse stimuli and overload, which may result in implant failure. In studies performed on dental implants, it was noted that the absence of micromotion at the bone-implant interface was necessary to enable proper osseointegration. Further, it was noted that there is a critical threshold of micromotion, above which a fibrous encapsulation process occurs, rather than osseointegration. Already, Brånemark stated that the implant should not be loaded and left out of function during the healing period for osseous integration to occur **(Figs 49.2 and 49.3)**.



Figs 49.2A to C: (A) Titanium implant (Blue) integrated into bone (Brown)—1 at the time of implantation, 2 after 1 week, 3 after 2 months, 4 after 1 year, 5 at 10 years; (B) Histologic section; (C) Its comparison to the roots of a tree

RATIONALE FOR IMPLANT TREATMENT

There is an increased need for implant supported prosthesis due to the following factors:

- An aging population; longer life span
- Age-related tooth loss
- As a consequence of failure of fixed prosthesis
- Unacceptability or poor performance of removable prosthesis
- Psychological aspects of tooth loss
- Anatomical consequences of edentulism
- Advantages of implant prosthesis such as conservation of adjacent tooth structure and bone loss
- Predictable long-term results.

CLASSIFICATIONS FOR IMPLANT TREATMENT

Based on placement within the tissues

- **Epiosteal:** When the dental implant receives its primary support by resting on the bone, e.g. subperiosteal implants

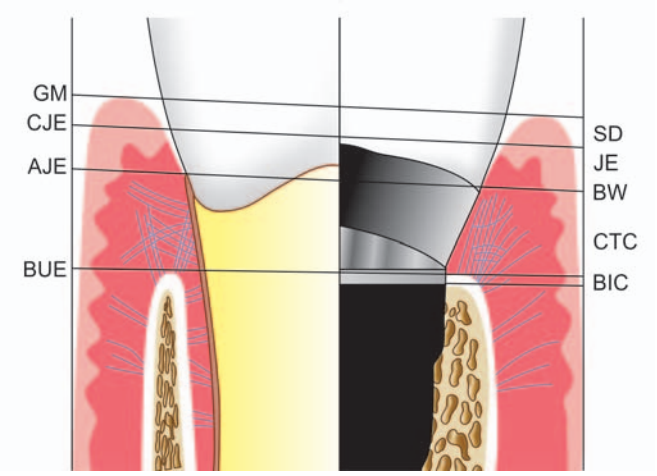


Fig. 49.3: Comparison of the periodontal structures in the natural tooth and in the implant.
Abbreviations: GM, gingival margin; CJE, coronal junctional epithelium; AJE, apical junctional epithelium; BUE, bone upper edge, BIC, bone implant contact; SD, sulcus depth between GM and CJE; JE, junctional epithelium between CJE and AJE; CTC, connective tissue contact between AJE and BIC; BW, biological width between GM and BIC

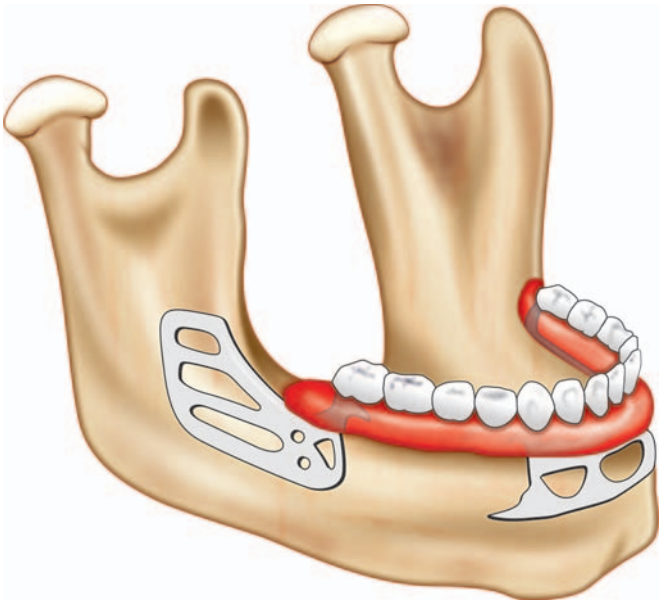


Fig. 49.4: Blade implants

- **Transosteal:** When the dental implant penetrates both cortical plates and passes through the thickness of the entire alveolar bone
- **Endosteal:** When the dental implant extends into the basal bone for support. It transects only one cortical plate and is further classified into:
  - **Root form:** Used over a vertical collar of bone. Available forms: cylindrical/press fit, screw root form, combination
  - **Plate/blade form (Fig. 49.4):** Used for a horizontal column of bone, which is flat and narrow in the faciolingual direction.

Based on Classification of Edentulous Spaces

Misch and Judy classified implant bone volume based on Kennedy-Applegate's classification of partially edentulous spaces. Accordingly, each of Kennedy's classification is divided into four divisions of varying bone volume:

- **Kennedy's class I division A bone (Fig. 49.5):** Greater than 10 mm bone height, greater than 5–7 mm bone length, crown to implant ratio of less than 1. Root -implants and independent prosthesis is indicated
- **Kennedy's class I division B bone (Fig. 49.6):** Moderate bone width (2.5–5 mm), adequate bone height greater than 10 mm, adequate bone length greater than 15 mm, crown to implant ratio smaller than 1. Direction of load is within 20 degrees of implant body axis. Surgical options include osteoplasty, small diameter implants, and augmentation
- **Kennedy's class I division C bone (Fig. 49.7):** Inadequate bone height and width for endosteal implant placement, too little bone width (c-w), length,

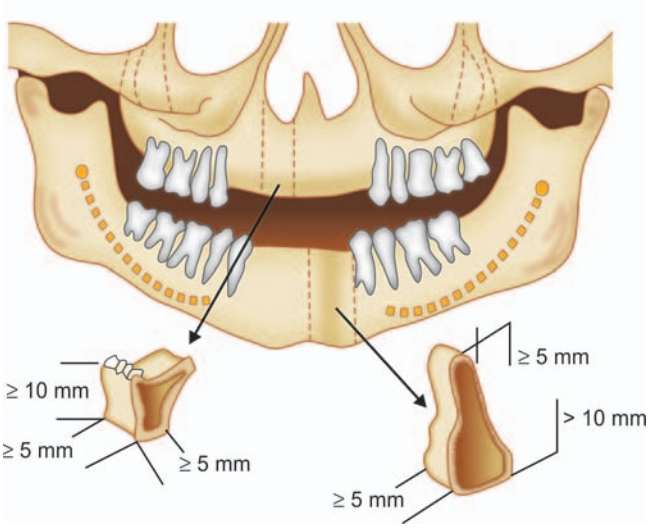


Fig. 49.5: Kennedy's class I division A bone. Greater than 10 mm bone height. Seven mm bone length. Crown implant ratio smaller than 1

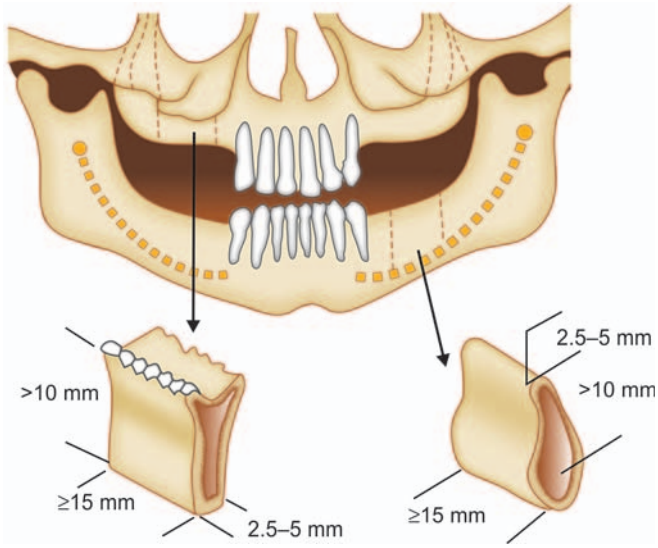


Fig. 49.6: Kennedy's class I division B bone: Moderate bone width (2.5–5 mm). Adequate bone height (>10 mm). Adequate bone length (>15 mm). Crown implant ratio is smaller than 1

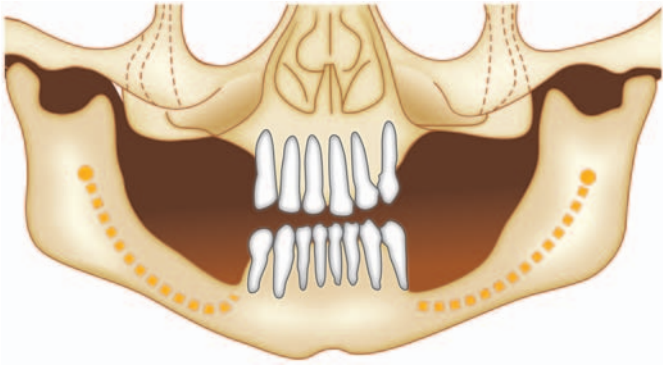


Fig. 49.7: Kennedy's class I division C bone: Inadequate bone width, height and thickness not sufficient for endosteal implant placement, crown implant ratio is greater than 1

height (c-h), or angulation of load (c-a), crown height is greater than 15 mm. Crown implant ratio is greater than 1, surgical options for c-w include osteoplasty and augmentation: for c-h, subperiosteal implants and augmentation. Root-form implants may be considered after augmentation and/or nerve repositioning

- **Kennedy's class I division D bone (Fig. 49.8):** Edentulous areas with severely resorbed ridges, involving a portion of basal or cortical supporting bone. Crown to implant ratio greater than 5. Surgical options usually require augmentation before implants can be inserted **(Fig. 49.9)**.

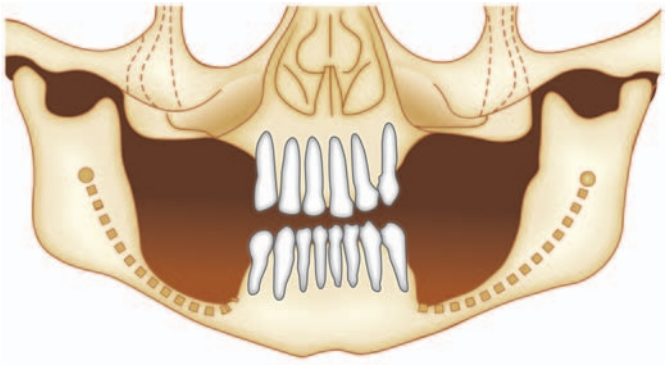


Fig. 49.8: Kennedy's class I division D bone: Edentulous areas with severely resorbed ridges. Crown implant ratio is greater than 5

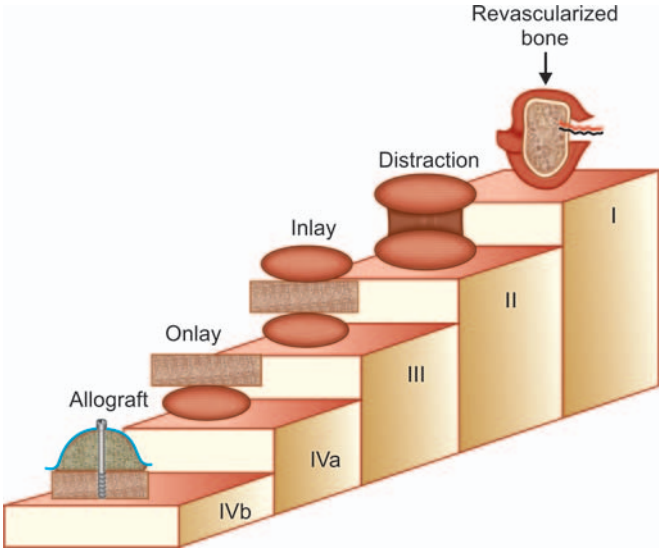


Fig. 49.9: Classification of absolute alveolar ridge augmentation. The assessment is based on vascularization and hence the ability to form new bone or resorb and remodel foreign material

- Kennedys class II division A bone in upper arch and division B in lower arch
- Kennedy's class II with division C bone in upper arch and division D in lower arch
- Kennedy's class III with division A bone in upper arch and division B bone in lower arch

- Kennedy's class III with division C in upper arch and division D in the lower arch
- Kennedy's class IV with division A in upper arch and B in lower arch
- Kennedy's class IV with division C in upper arch and D in lower arch.

In Case of Completely Edentulous Ridges

Misch divided each arch into three segments **(Fig. 49.10)**:

1. Anterior.
2. Right posterior.
3. Left posterior.

The clinical conditions are divided according to bone density present in different locations in each segments **(Table 49.1, Figs 49.11** and **49.12)**.

The clinical conditions are grouped as:

- **Type 1/D1:** Dense compact bone—offers excellent stability to implant.
- **Type 2/D2:** Dense to porous compact bone—coarse trabecular bone inside, dense bone outside. Threaded or cylinder implants are indicated.

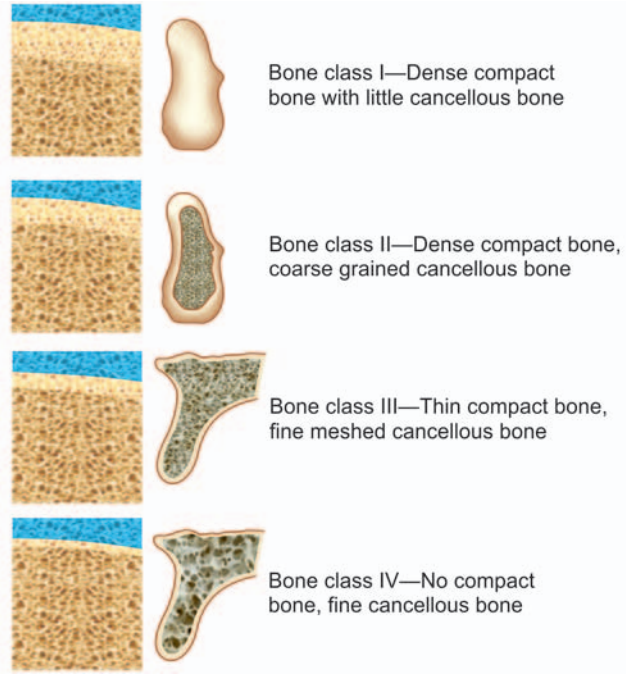


Fig. 49.11: Macroscopic description of the four densities

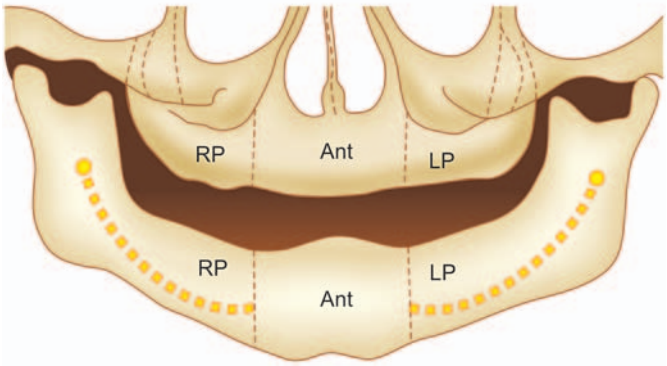


Fig. 49.10: Completely edentulous jaw is divided into three segments for convenience. Anterior component (Ant.) is between the mental foramen. Right posterior (RP) and left posterior (LP) segments correspond to patient's right and left sides

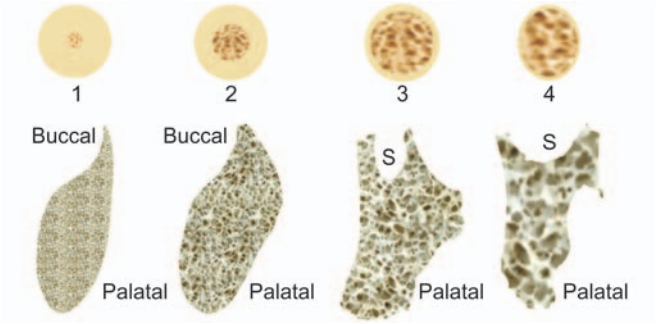


Fig. 49.12: Qualitative bone supply based on the Lekholm and Zarb, (1985) classification

Table 49.1: Misch bone density classification

Bone Density	*Description*	*Tactile Analog*	*Typical Anatomical Location*
D1	Dense cortical	Oak or maple wood	Anterior mandible
D2	Porous cortical and coarse trabecular	White pine or spruce wood	Anterior mandible Posterior mandible Anterior maxilla
D3	Porous cortical (thin) and fine trabecular	Balsa wood	Anterior maxilla Posterior maxilla Posterior mandible
D4	Fine trabecular	Styrofoam	Posterior maxilla

- **Type 3/D3:** Porous compact, coarse trabecular bone-implants coated with hydroxyapatite are indicated with gradual loading.
- **Type 4/D4:** Fine trabecular bone—very less density and no cortical crestal bone. Larger implant should be used with bone graft.

Based on Mode of Retention of Prosthesis

- Removable prosthesis
- Fixed prosthesis
  - Screw retained
  - Cement retained
- Hybrid prosthesis.

Based on Treatment Options (Prosthetic Classification)

Misch in 1989, reported five prosthetic options of the implants. The fixed prostheses are classified based on the amount of hard and soft tissue structures to be replaced. Removable prosthesis are derived based on the support derived **(Fig. 49.13)**.

- **FP1:** Fixed prosthesis replaces only the crown and looks like a natural tooth
- *FP2:* Fixed prosthesis replaces the crown and a portion of the root
- **FP3:** Fixed prosthesis replaces missing crown and gingiva, prosthesis most often uses denture teeth with acrylic gingiva, but may also be made of metal or porcelain
- Removable restorations have two categories based on implant support **(Fig. 49.14)**.
- **RP4:** Implant supported over denture removable prosthesis. Complete support, anterior and posterior is on implants. In mandible, the superstructure bar is often cantilevered from implants positioned between the mental foramen. The maxillary prosthesis usually has more implants and little or no cantilever.
- **RP5:** This type of restoration has primarily anterior implant support and posterior soft tissue support in the maxilla or mandible. Often fewer implants are required and bone grafting is less indicated.

Based on Loading Protocols

- **Conventional loading/delayed loading or two-stage protocol:** Where in first stage, implants are surgically placed and the patient is made to wait for 6 months for osseointegration; second stage surgery is then performed, where the healing cap is placed and after a week of satisfactory formation of a gingival collar for emergence profile is achieved, impressions are made for implant prosthesis, which may be cement or screw retained.
- **One stage protocol**—further divided into *immediate loading* and early loading:

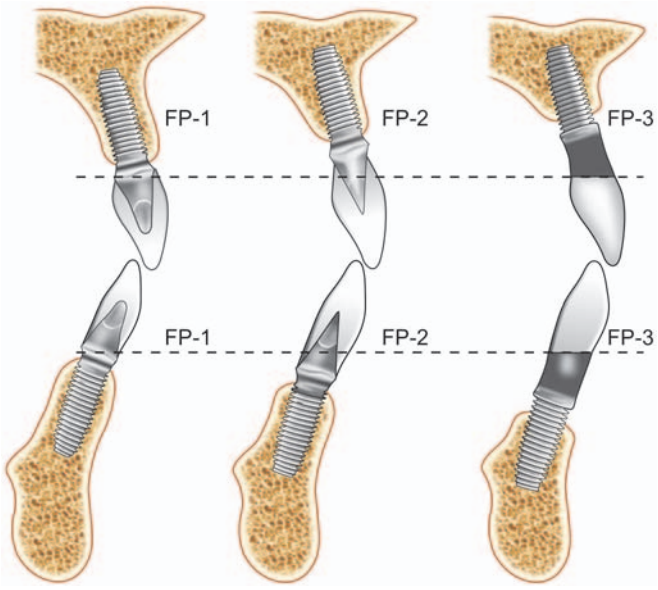


Fig. 49.13: Misch prosthetic options

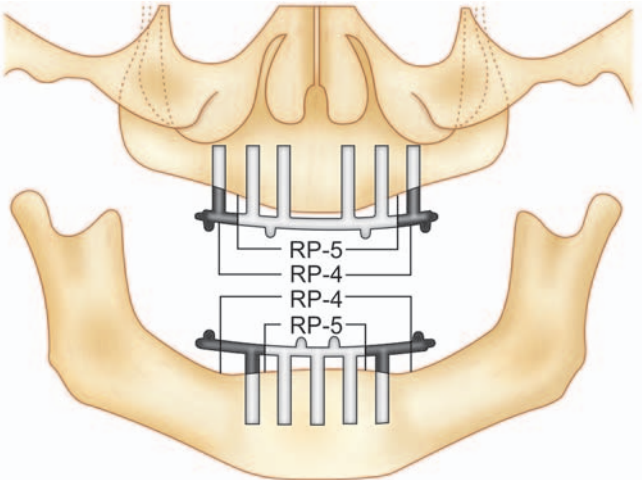


Fig. 49.14: Options for implant supported removable prosthesis

- **Immediate loading:** When a provisional prosthesis is placed during the same session as the surgery.
- Immediate loading is further divided based on the biomechanical definition:
  - Immediate loading with provisional prosthesis out of or shy of occlusion.
  - Immediate loading with provisional prosthesis in occlusion.
  - **Early loading:** When the implant prosthesis is placed after a delay of 48–72 hours.

IMPLANT MATERIALS

Many metals and nonmetals have been used as implants materials. These could broadly be classified as:

- **Metal and alloys:**
  - Titanium (Pure) — 100% pure (cpTi)
  - Titanium alloy — Titanium 90%, Chromium 2%, Molybdenum 7%
  - Chromium cobalt alloy — Cobalt 66%, Chromium 37%, Molybdenum 7%
  - Stainless steel — Iron 70%, Chromium 18%, Nickel 12%
  - Tantalum — 100% pure
  - Zirconium — 100% pure
  - Gold — 100% pure
  - Platinum — 100% pure
- **Inert ceramics**
  - Aluminium oxide — Al_2O_3
    - Polycrystalline
    - Single crystal
  - Zirconium oxide Zirconia — ZrO_2
  - Titanium oxide — TiO_2
- **Calcium phosphate ceramics** — $CaPO_4$
- **Bioactive and biodegradable ceramics:**
  - Hydroxyapatite — $Ca_{10}(PO_4)_6(OH)_2$
  - Tricalcium phosphate — $Ca_3(PO_4)_2$
  - Bioglass — $CaPO_4$
  - Calcium aluminates
  - Carbon
  - Carbon silicone
  - Polycrystalline glassy carbon
- **Polymers:**
  - Polymethyl methacrylate
  - Polytetrafluoroethylene
  - Polyethylene
  - Polyethylene terephthalate
  - Polypropylene
  - Silicon rubber
  - Polysulfone.

Out of the above, pure titanium is highly reactive, but when it comes in contact with air or body fluids, becomes "titanium oxide", which is probably the most bioinert. Pure titanium, when exposed to environment quickly undergoes oxidation and forms a thin layer (5–20 μm thick) of titanium oxide, this titanium oxide is almost totally inert. Even this metal is considered to release some amount of titanium in the patient's body. This titanium "load" is considerably less (about 10,000 times as per rough estimates) than the total ingestion of titanium via various foods. Therefore, it will be seen that this "release" appears to be nonsignificant. Furthermore, the biologic half-life of titanium is 320 days, far too short to accumulate in human body to any levels of clinical importance.

Titanium, in its implanted form offers considerable strength (both crushing and shearing) to withstand the occlusal or functional load that would be put on the final prosthesis ultimately. This coupled with osteointegration makes it, so far, the closest to ideal implants materials.

TITANIUM IMPLANTS

Titanium implants are also classified based on surface characteristics:

- Titanium plasma—Sprayed coating
- Sand blasting—Surface etching
- Laser-induced surface roughening
- Hydroxyapatite coating.

These various coatings are meant to further help in osteointegration, but the rough surface of the implant, so prepared is unsuitable for soft tissue (gingival cuff) and leads to inflammation in the gingiva, much in the same way as the plaque and calculus on the natural teeth.

To overcome this difficulty, the neck of the implant, (the portion which is above the alveolar crest of bone but is encompassed by the gingiva) is highly polished which obviates gingival irritation and ensures a healthy interface between implants and the gingiva.

ADVANTAGES OF DENTAL IMPLANTS

- Aids in bone maintenance—Prevents the progress of residual ridge resorption.
- Restoration and maintenance of occlusal vertical dimension.
- Maintenance of facial aesthetics (muscle tone) Implants also provide a natural emergence profile.
- Improved phonetics
- Improved occlusion
- Improved occlusal awareness
- Improved masticatory performance, maintenance of masticatory muscles and muscles of facial expression
- Reduced size of prosthesis (elimination of palate or flanges)
- Provision for fixed or removable prosthesis
- Improved stability and retention of fixed prosthesis-implants provide stable retention due to osseointegration
- Eliminates need to alter adjacent teeth
- More permanent replacement
- Improved psychological health
- Improved comfort level.

ANATOMY OR PARTS OF AN IMPLANT SYSTEM

- **Implant body/fixture screw:** Portion of the implant system placed within the bone.
- **Cover screw/sealing screw/healing screw/first stage cover screw:** Seals the occlusal surface of the implant during osseointegration. Prevents the overgrowth of the tissues over and in the implant **(Fig. 49.15)**.
- **Healing abutment/temporary gingival cuff/healing collar/healing cap:** A dome-shaped screw that is attached to the implant in the second stage, to maintain the opening through the tissue until the restoration is completed. Length varies from 2 mm to 10 mm **(Fig. 49.16)**.
- **Healing cap/comfort cap/temporary screw/ abutment healing cap (Fig. 49.17):** A cover that is attached to the top of a transmucosal abutment protecting the internal threads and interface surfaces of the abutment.
- **Standard abutment/tissue extension/permucosal extension/transmucosal extension (Fig. 49.18):** An intermediate component placed between the implant and metal framework/restoration providing support and retention for a fixed removable restoration.

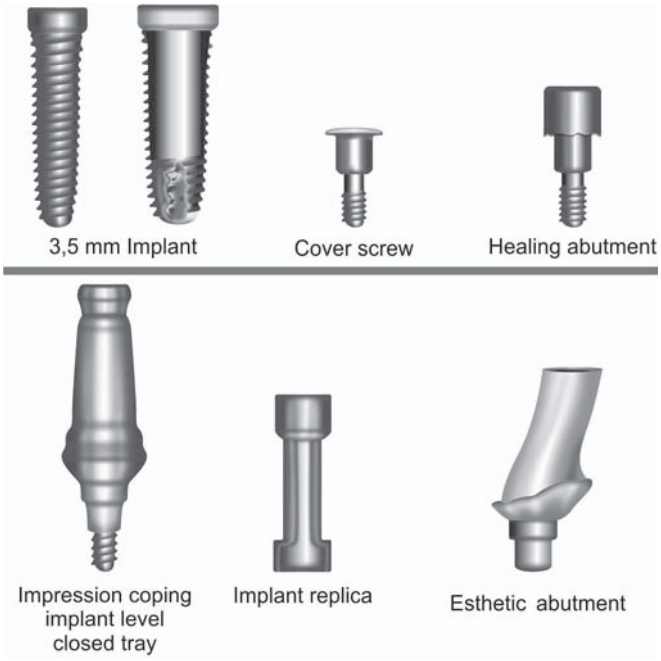


Fig. 49.15: Various parts for implant fixture

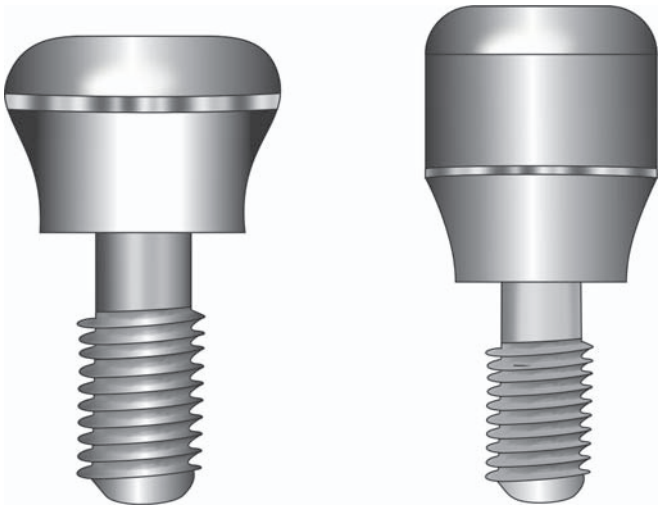


Fig. 49.16: Healing cap

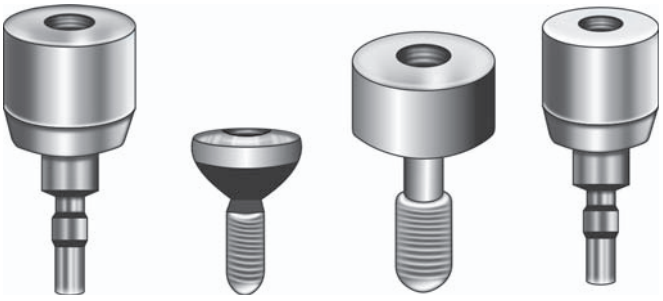


Fig. 49.17: Abutment healing cap

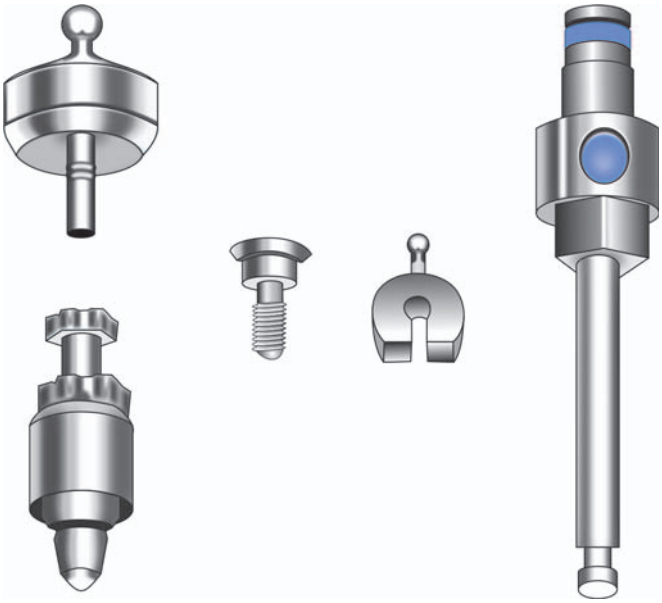


Fig. 49.18: Transmucosal extension



Fig. 49.19: Hex driver

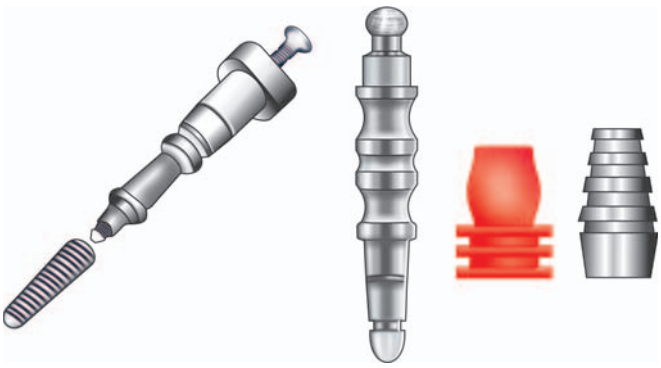


Fig. 49.20: Post and lab analog

- **Tapered abutment/conical abutment/trans- or permucosal abutment:** An intermediate component placed between the implant and restoration, providing support and restoration for a fixed removable restoration.
- **Hex driver/hex tool/screw driver (Fig. 49.19):** Used for placing and removing all hex screws (abutment fastening screws, impression post and healing abutments).
- Available in two lengths short for posterior and long for anterior.
- **Abutment driver/seating tool:** Used to seat abutments directly into implants.
- **Impression post/impression pin/transfer pin/post/impression coping:** Component used during the impression procedure to transfer the intraoral position of the implant to the same position on the cast.
- **Laboratory analog/implant/abutment analog/fixture replica/implant body analog (Fig. 49.20):** Replicates the implant for use in the laboratory cast in order to fabricate an implant supported prosthesis.
- **Temporary coping/cylinder or provisional abutment:** Provides support and retention for acrylic temporary and provisional restorations.
- **Fixed abutment/straight abutment/coping abutment/abutment post (Fig. 49.21):** An abutment used for cement retained restorations available in 15 and 25 degrees.
- **Plastic sleeve/waxing sleeve/castable/plastic coping (Fig. 49.22):** A castable wax pattern used to form an abutment during the laboratory waxing procedure.
- **Gold cylinder/gold sleeve/gold coping:** Pre-machined abutment that is waxed and cast to its interfaces directly on to the transmucosal abutment.
- **Prosthesis retaining screw/coping screw:** Screw used to secure a screw-retained metal bar framework or restoration onto transmucosal abutments (conical or standard).
- **Universal ratchet or torque wrench:** Used for torquing the implant and abutment **(Fig. 49.23)**.

PATIENT SELECTION CRITERIA

It includes an extensive medical and dental examination, as to whether the patient is an ideal candidate for implant therapy.

Indications (Adell, Zarb and Lindquist)

- Patients who do not accept removable prosthesis
- Patients who lack neuromuscular control



Fig. 49.21: Prosthetic abutments

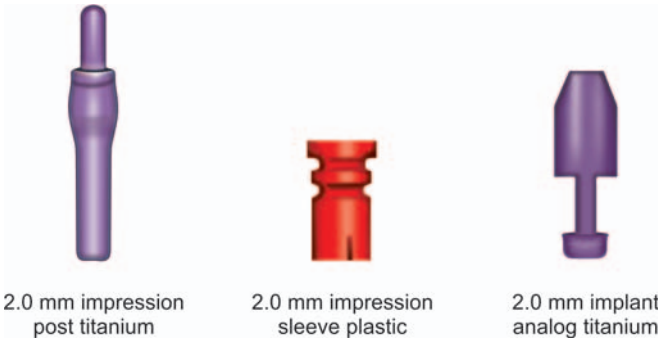


Fig. 49.22: Plastic coping

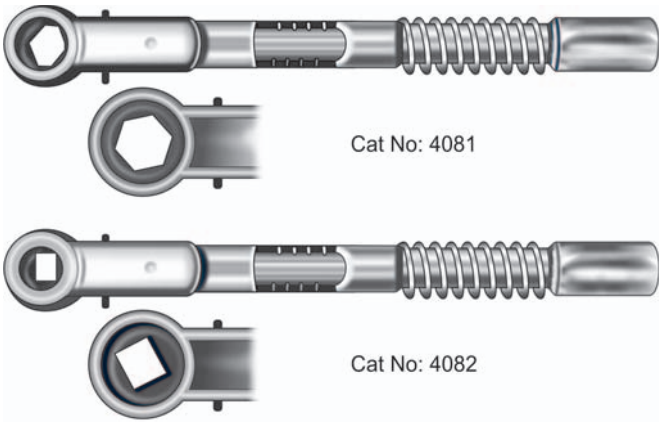


Fig. 49.23: Universal ratchet or torque wrench 10–45 Ncm

- Single tooth replacements
- Where complete denture has deleterious effect on tissues
- High gag reflex
- Long edentulous span
- Low tissue tolerance
- Unfavorable number and location of abutments
- Unrealistic expectations from complete dentures
- When it offers to solve psychological problems associated with edentulism
- In situations, where it can achieve superior results in terms of function and aesthetics.

Absolute Contraindications: Medical/Systemic and Other Factors

- Boxers and wrestlers
- Cerebral palsy patients
- Irradiated tissues
- Psychogenic disorders
- Drug or alcohol dependence
- Immunocompromised patients
- Patients on bisphosphonate therapy
- Uncontrolled diabetes mellitus
- Blood dyscrasias
- Patients who lack manual dexterity
- Ischemic heart disease
- Musculoskeletal disorders
- Limited mouth opening as a sequel to oral submucous fibrosis.

Relative Contraindications

- Smokers (smoking cessation protocol to be followed prior and after surgery)
- Well-controlled diabetes
- Cardiac patients with stable condition
- Patients on antidepressants or anticoagulants
- Bruxism and tongue thrust (night guards and habit breaking appliance prior to implant therapy)
- Trismus—which can be treated
- Endocrine disorders
- Chronic sinusitis (for implant therapy in the maxilla which may require sinus lift procedures—direct or indirect).

Intraoral Examination of a Partially Edentulous Patient

- Length of the edentulous span
- Periodontal health
- Estimation of adequate access to edentulous areas (fixture mount connector + hand piece = 4 cm)
- Adequate distance between adjacent teeth 2 mm on either side of the implant and sufficient bone volume

- Palpation and inspection of ridge crest, buccal or lingual fossa may be concave, narrow crest may require augmentation/bone splitting, knife edge or uneven crest may require mild alveoloplasty
- Inspection of covering mucosa whether it is normal, atrophic, thick, dense or loose crestal mucosa
- Bone mapping or bone sounding—to know the width of the edentulous implant site
- Comparison of position of adjacent natural tooth crown to determine likely position of artificial tooth crown by a wax up (prosthetically driven implant placement)
- Interocclusal clearance
- Parafunctional habits (wear facets on natural teeth).

Evaluation of Occlusion

- Freeway space/path of mandibular closure
- Absence/presence of tooth wears facets
- Areas of natural tooth contact to determine occlusal stability
- Occlusal derangements or discrepancies
- Occlusal plane/supraeruption of teeth
- Sufficient space for abutment and prosthesis.

Intraoral Examination for Completely Edentulous Patients

- Inspection of ridges and volume of bone
- Palpation of ridges for sharp crest or remnants of teeth
- Palpation for fibrous or flabby ridges and buccal and lingual concavities
- Ridge relationship
- Interocclusal space
- Examination of previous dentures for short comings.

Radiographic Assessment

- It is complementary to clinical examination
- Provides a comprehensive analysis of the edentulous space, dentition and supporting structures
- Reveals pathological conditions of the dentoalveolar region
- Reveals pathological conditions of the basal bone, maxillary sinus and temporomandibular joint (TMJ)
- Enables assessment of the available bone volume in three dimensions
- Enables assessment of bone quality to some extent
- Precisely, locates anatomical structures and boundaries such as inferior alveolar nerve, incisive canal, nasal cavity, maxillary sinus
- Enables measurement of limiting bone height and width
- Enables selection of optimal site and angulation for implant placement
- Enables selection of implant system, length and width of the implant
- Minimizes risk during surgery.

Periapical Radiographs Aids in Assessing

- Inter-radicular space
- Infection in adjacent teeth or bone
- Identifying critical structures
- Limited value in determining quantity of bone and bone density
- Used primarily for single tooth implant therapy in regions of abundant bone height and width.

Cephalometric Radiograph

- Demonstrates the geometry of the alveolus in the anterior region and the relationship of the lingual plate to the patient's skeletal anatomy.
- Loss of vertical dimension, skeletal interarch relation and crown to implant ratio may be ascertained.

Panoramic Radiographs

- Opposing landmarks can be identified
- Vertical height of bone can be assessed
- Gross anatomy of the jaws and related pathological findings
- General dental status
- Can be used to identify implant location
- Monitor prosthetic outcome.

COMPUTED TOMOGRAPHY

It provides imaging analysis of the proposed surgery by enabling the exact evaluation of the proposed implant site in relation to height, width, bone density, distance from vital structures, position and orientation of implants. As implant surgery must be prosthetically driven, a diagnostic template may be used during imaging—these diagnostic templates may be an acrylic reproduction of a diagnostic wax up using radiopaque denture teeth or coated with a thin film of barium sulfate or by filling a hole drilled with gutta-percha through the occlusal surface of denture teeth, thus rendering them radiopaque. This procedure results in a natural tooth like appearance to the proposed restoration in the CT scan, which helps to precisely identify the position and orientation of the proposed implant. This diagnostic template may latter be modified into a surgical template.

Cone Beam Computer Tomography

Cone beam computer tomography (CBCT) is a medical imaging technique that has become increasingly important in treatment planning and diagnosis in implant dentistry. The advantage over the regular CT scan is that the patient is in a seated position and sectional areas may be scanned, thus reducing radiation exposure to the patients. During CBCT, the scanner rotates around the patients head obtaining up to 600 distinct images. The scanning software collects the data and reconstructs it composed of three dimensional voxels of anatomic data that can then be manipulated and visualized using specialized software.

Interactive Computer Tomography Software

It is a technique, which enables the practitioner to view and interact with the images received either from CT or CBCT scans. There are specialized softwares, which can convert the dentascan images, so that the dentist can perform electronic surgery by selecting and placing arbitrary size cylinders that simulate root form implants, enables determination of bone quality, quantity, critical structures, prospective occlusion and aesthetics, implant position and orientation. The number and size of implants can be accurately determined using the interactive software. A three-dimensional computer generated surgical template may be constructed from a steriolithographic model based on this digital data **(Figs 49.24A and B)**.

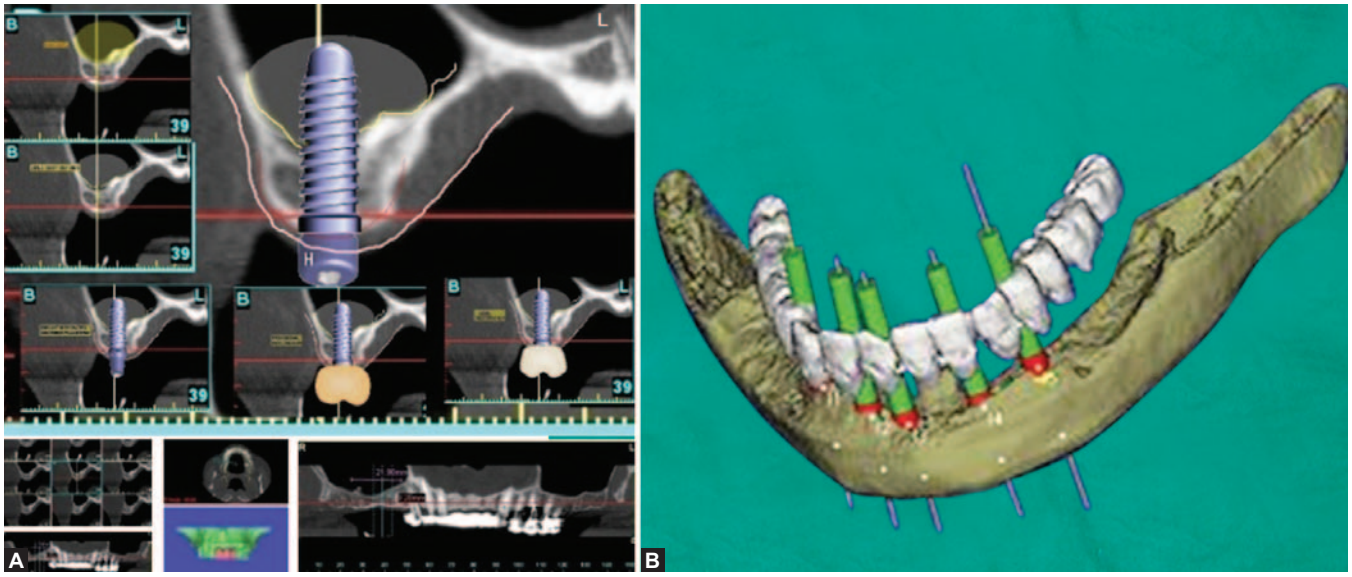
Basic Treatment Order

Decision regarding the treatment order may vary, based on the degree of difficulty. But, for cases involving a traditional plan, the following may be used.

- Examination—Clinical and radiographic/medical history/pathological test, etc.
- Diagnostic set up, provisional restoration and specialized radiographs (CBCT), if required
- Discussion of treatment options with the patient and mutual consent on final restoration
- Completion of any adjunctive necessary treatment such as extraction of hopeless teeth, periodontal treatment, restorative or endodontic treatment
- Fabrication of provisional or transitional prosthesis
- Fabrication of surgical guide or stent
- Surgical placement of implants
- Allow adequate time for osseointegration based on bone quality and loading protocol
- Prosthodontics phase
- Maintenance phase.

ARMAMENTARIUM FOR IMPLANT SURGERY

- Operator gowns/patient gowns/head cap/masks/sterile gloves **(Figs 49.25A and B)**
- Suction apparatus
- Blood pressure apparatus and pulse oximeter



Figs 49.24A and B: Clinical use of interactive computer tomography for implant placement

- Disposable needles and syringes.
- Autoclaved implant surgical kit
- Local anesthetic (LA) cartridges, needles
- Mouth retractors
- Mosquito forceps
- Periodontal probe
- Mouth mirror, explorer
- Periosteal elevator
- Scissor
- Tissue-holding forceps
- Curettes
- Suction tips
- Needle holder
- Bard-Parker® blade handle and blades no 11, 15
- Bone gauge
- Osteotomes
- Suture material (vicryl/polypropylene)
- Physiodispensor and reduction handpiece (20:1)—a physiodispensor is a must. The basic requirements are minimum torque of 70 Ncm to 1,500 rpm speed, reduction gear of 16:1, integrated pulsating pump for sterile solution, stand for saline solution bottle.

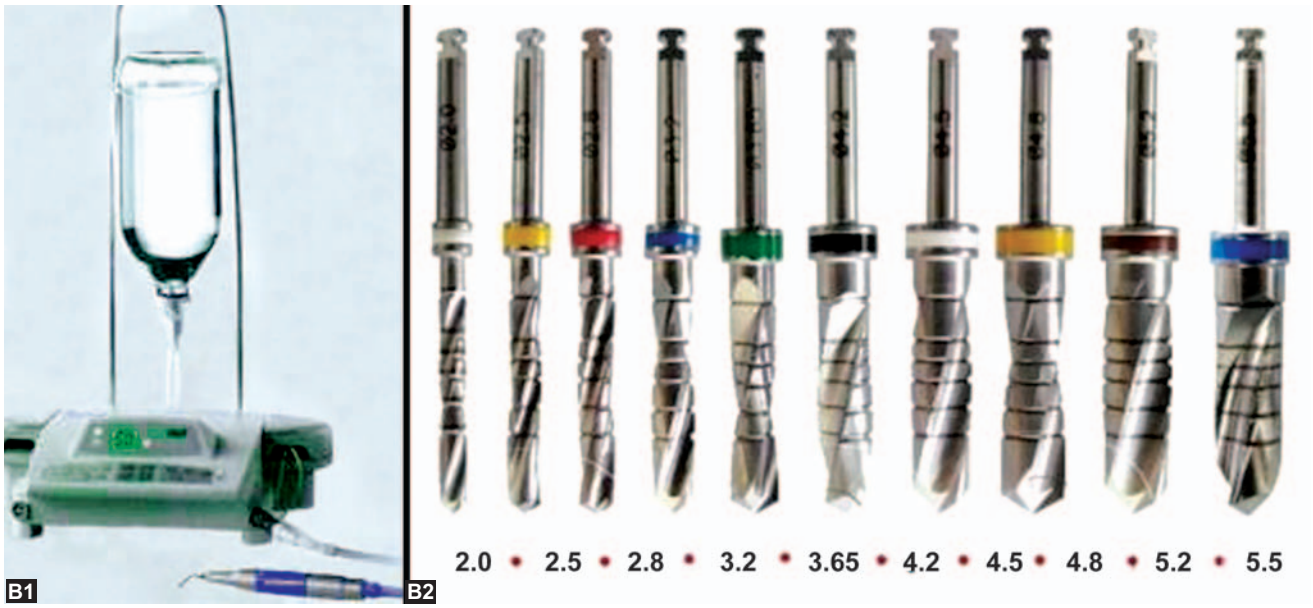
BASIC FACTORS IN IMPLANT SURGERY

- A sterile technique, avoiding any contamination of the implant surface
- Avoid damage to the bone by thermal injury during the drilling process
- Careful preparation of the osteotomy, so that the implant is stable on placement



A

Fig. 49.25A: Instruments/armamentarium for implants surgery



Figs 49.25B1 and B2: (B1) Physiodispensor unit along with speed reduction handpiece for implant placement; (B2) Osteotomy drills of various diameters

- Placement of the implant in an aesthetic and prosthetically driven position
- Avoidance of excessive loading during the healing period depending on the type of implant used and the loading protocol followed.

Avoidance of Thermal Injury to the Bone

Bone cells are irreversibly damaged if the temperature of the bone is raised above 47 degrees for more than 1 minute, resulting in bone necrosis, extensive resorption and failure of osseointegration.

This may be avoided by:

- Careful cooling of bone and drills with copious sterile saline solution using internal or external irrigation through a physiodispenser.
- Use of sharp drills
- Control of cutting speeds (1,500–2,000 rpm)
- In all implant systems, the implant site is first prepared using a pilot drill to mark the position of the implant and then the site is gradually made larger with increasing diameter drills of the ascertained length. In addition to minimizing heat production, the initial use of small diameter drills allows for small changes in implant position and modification of angle if required.

Ensuring good initial or primary stability is one of the main aims of surgical preparation. This can be judged by:

- Clinical examination
- Minimum torque insertion of 45 Ncm
- Perio test where the mobility is measured using an electronic device
- Resonance frequency analysis—is one of the latest devices that measures the stability of the implant within the bone through vibration and recording.

An implant which is loose in the prepared site, will never osseointegrate. In the initial healing phase the implant must not be subjected to movement, micromovement of 100 micron meter may lead to osseointegration, but beyond that there will be fibrous encapsulation and implant failure.

Initial primary stability of an implant depends on the:

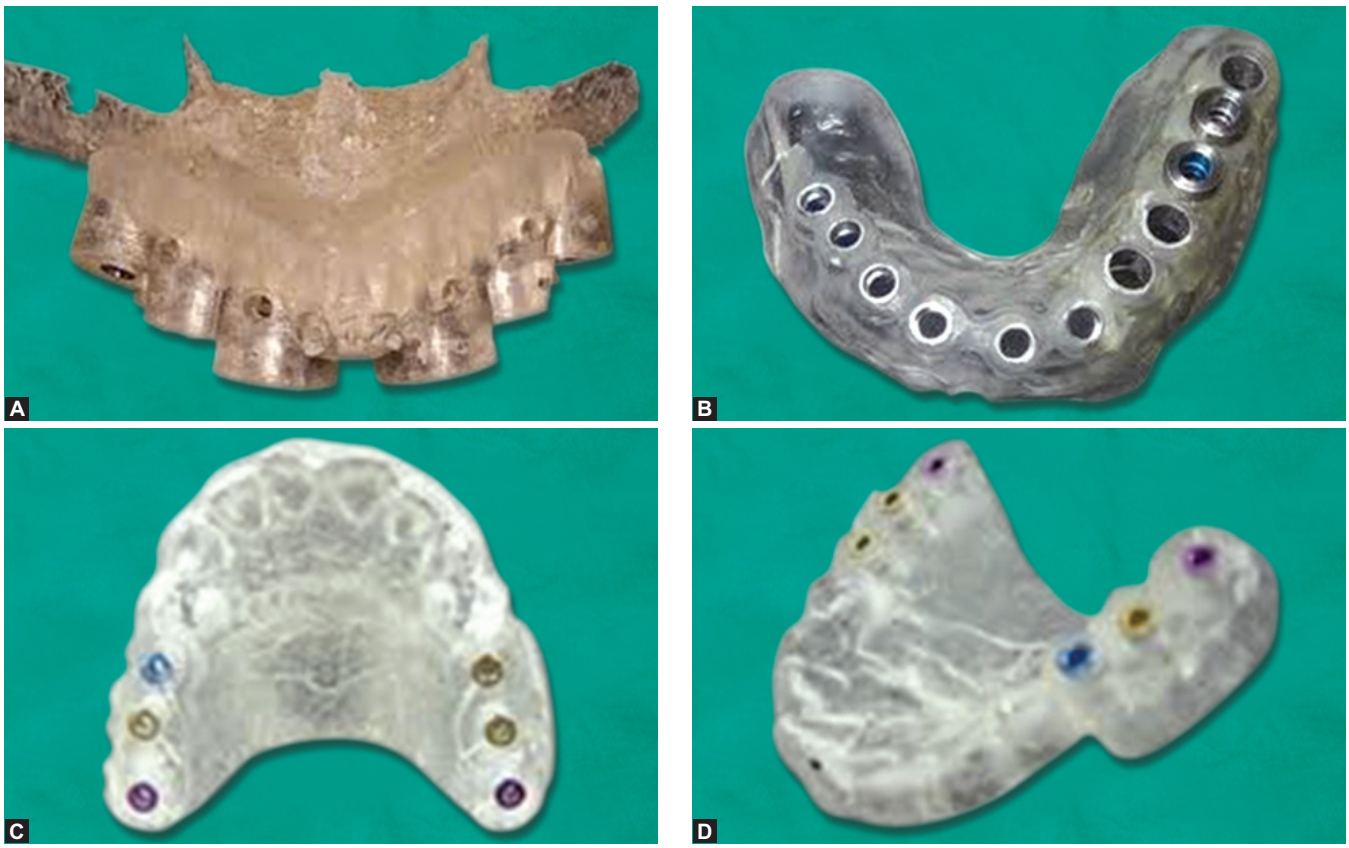
- Length of the implant
- Diameter of the implant
- Design of the implant
- Surface characteristics of the implant
- Thickness of the bone cortex and how many cortices the implant engages
- Density of the medullary bone trabeculation
- Dimension of the preparation site compared to the implant size.

PLACEMENT OF THE IMPLANT IN AN ACCEPTABLE POSITION

- Careful treatment planning/case selection
- Use of surgical stents
- Reviewing each stage of the preparation process
- Surgical templates/stents **(Figs 49.26A to D)** should be constructed using diagnostic set ups or provisional prosthesis. They should be rigid and stable. The stent helps the surgeon to ascertain the mesiodistal, buccolingual position and angulation. When replacing anterior teeth, it is important to profile the buccal aspect of the prosthesis, to plan emergence profile and optimize esthetics.
- The surgical stents may be bone supported, teeth supported, tissue supported.
- The stages of implant placement can be reviewed using indicator posts in the prepared sites for determination of the length of the osteotomy.
- Paralleling pins may also be used to review parallelism of multiple implants prior to the final osteotomy drill. Failure to do so may result in surprising errors.
- The indicator post should also be reviewed in relation to opposing dentition, e.g. in patients with normal buccopalatal relation. The maxillary indicator should be directed toward the buccal cusp of the lower teeth and mandibular indicators toward the palatal cusp of maxillary teeth. This ensures that the implant is placed in the central fossa of the opposing tooth and forces are directed along the long axis of the implant.

PREOPERATIVE CARE

- Oral prophylaxis and antiseptic rinsing of the oral cavity with the solution such as chlorhexidine gluconate 1.2/2% for 1 minute and perioral skin preparation with betadine scrub.
- Administration of antibiotics standard protocol of 3 g of amoxicillin preoperatively followed by a 5 days course.



Figs 49.26A to D: (A) Bone supported; (B) Tissue supported surgical stents; (C and D) Teeth supported

- Oral analgesics (200–400 mg) of Ibuprofen or comparable alternatives.

ANESTHESIA

Local anesthesia is generally sufficient, depending on the skill of the clinician and attitude of the patient. Sedation techniques may also be considered. The advantage of local anesthesia, is that the conscious patient is able to cooperate by performing normal jaw movements in centric and lateral excursions to verify appropriate implant positioning. The vasoconstrictor in local anesthesia provides local hemostasis. Full mouth rehabilitation or extensive grafting procedures may warrant the use of general anesthesia.

INCISIONS

- A midcrestal incision is employed in most cases. The incision can be extended within the gingival crevices of adjacent teeth and mucoperiosteum elevated in an apical direction to allow adequate visualization of the bone contour
- Relieving incisions may aid flap reflection, they must be kept vertical and parallel to the overlying sound bone, so that on closure, blood supply is not compromised
- Obliquely inclined relieving incisions should be avoided over prominent root surfaces as it could lead to wound dehiscence and gingival recession
- Relieving incisions must also be done carefully over anatomical structures as injury to vital structures/ nerves could result in bleeding or paresthesia
- The crestal incision may be located palatally in the maxillary arch, where there is more keratinized tissue and also in cases, where bone augmentation and graft material or membranes have to be placed on the labial aspect.
- In single tooth implants, it is prudent to preserve the papilla for the sake of aesthetics, but if the mesiodistal space is narrow, then elevation of the papilla becomes unavoidable, hence the following is recommended.
  - In sites less than or equal to 7 mm mesiodistally, reflect the papilla
  - In sites 8 mm or greater, a mesiodistal crestal incision of 5–6 mm, will allow nonreflection of an adequate width of papillary tissue
  - If anatomical structures are present, such as incisive nerve or augmentation techniques are indicated then a wider flap design involving the papilla is indicated.
- In edentulous maxilla or mandible, a midline labial relieving incision extending into the sulcus enables the surgeon to elevate under the periosteum more easily, especially when the crest of the ridge is knife edged or uneven. The relieving incision also reduces tension on the buccal flap and makes retraction easier.

DIFFERENT FLAP DESIGNS OPTIONS FOR IMPLANT PLACEMENT

- **Punch option:** It is appropriate when tissue quality is good with 2–3 mm of attached and keratinized gingival. It can be done with a surgical blade or a punch tool. When used with a surgical guide and a planning software, it gives accurate result
- **Half punch approach:** Can be used when the buccal tissue is deficient. A mid-crestal incision is created and a full thickness flap is reflected. Then a punch is used to remove only lingual/palatal tissue to place an implant. Useful for a one stage procedure with simultaneous bone grafting
- **Midcrestal approach:** Incision is made in the middle of the crest, with intrasulcular incision on the adjacent teeth, full thickness buccal and lingual/palatal flaps are reflected. It can be used for a one-/two-stage procedure with simultaneous bone grafting
- **Palatal/Lingual crestal approach:** It is used when buccal tissue is deficient
- **Mesial papilla preservation:** The mesial papilla is preserve by using a vertical releasing incision connected to a crestal incision and an intrasulcular incision on the distal tooth. This allows for a two-stage placement and uncovering to maximizing esthetics by not losing the more important mesial papilla
- **Distal papilla preservation:** The distal papilla is preserved by using a vertical releasing incision connected to a crestal incision and intrasulcular incision on the mesial tooth. This allows for a preparatory bone grafting procedure
- **Double papilla preservation:** Both, mesial and distal papillae are preserved with two vertical releasing incisions connected with a lingual/palatal crestal incisions. This can be used for a two stage procedure and/or uncovering good quality tissue on the buccal side.

BASIC FLAP DESIGN AND SOFT TISSUE HANDLING

Some operators recommend implant placement without flap elevation, but this can readily lead to lateral perforation of the bone in inexperienced hands. Flapless procedure is more suited to single implants in extraction sockets or when using tissue-supported surgical templates which have been derived accurately via computer aided design/computer aided manufacture (CAD/CAM) from steriolithographic models.

- Flap design and elevation should achieve complete exposure of the edentulous ridge including bone concavities and identification of anatomic structures **(Figs 49.27A and B)**.
- Elevation of flaps is best accomplished using periosteal elevator with a flat sharp edge. Fibrous and muscle attachments that tether the flap margins, may need to be relieved by sharp dissection.
- Good flap reflection on the lingual side of the lower premolars is advised, as implant preparation may perforate the lingual plate in a natural concavity and damage a branch of the sublingual artery.
- During drilling of the bone for implant placement, instructions from the manufacturer should be followed and mucoperiosteal flap should be protected by proper retraction **(Figs 49.28A to C)**.
- Before closure of the flap, it is important to check that there is no residual bone debris, by careful irrigation with sterile saline and inspection with suction.
- Flap should be closed with minimum tension with resorbable or nonresorbable sutures. 4-0 vicryl sutures may be used. Vertical mattress sutures over grafted sites for a more secure seal can be used. Gortex, poly propylene 5-0 or 6-0, 7-0 sutures are also recommended, but require special microsurgical instruments and use of dental loops by the operator.

Drilling Speed and Drilling Procedure

The first drill invariably is the round one, to perforate the cortex at crest thereafter the drills are used in ascending order of thickness (diameter).

Bone must be drilled at a low speed. Generally, a speed less than 800 rpm is recommended. The slower the better, as higher speed tends to raise the local temperature in bone and may be detrimental for the bone to remain viable and creep into the implant surface (roughened by plasma spraying or etching) to ultimately bring about osteointegration.

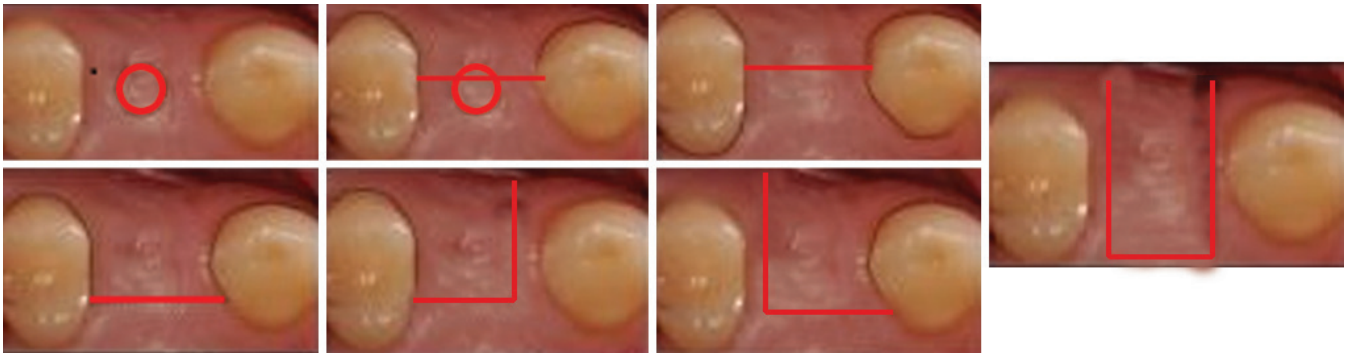


Fig. 49.27A: Various flap design options for implant placement

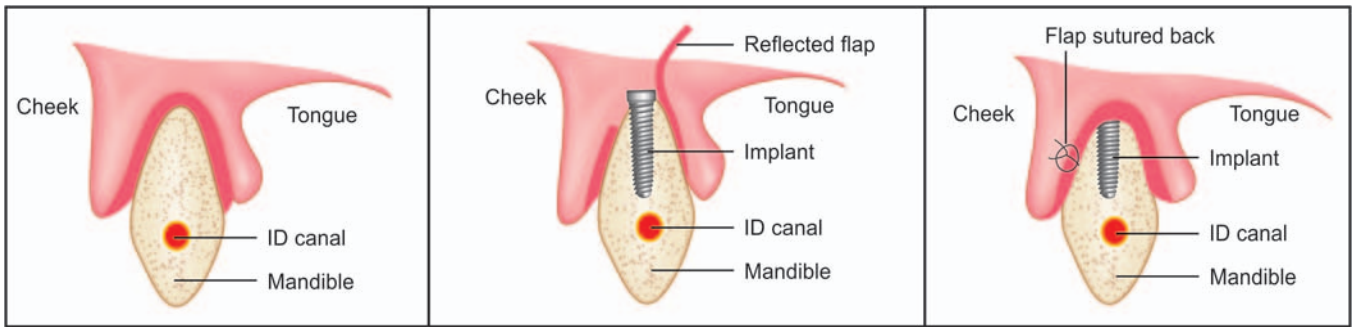


Fig. 49.27B: Diagrammatic representation of flap reflection for an implant

The drills are marked for depth **(Figs 49.28A to C)** to guide the surgeon as to how deep is the hole. Finally, when the required depth is reached it is checked by the provided depth gauge. A little (1 mm or so) over drilling is better than under, as it prevents crushing of bone "apical" to implant. If the implant is not self-tapping, the required bone tap is used to cut "thread" in bone and then the implant is screwed in.

Irrigation

It is one of the most important steps during the entire drilling process to keep the local bone temperature at

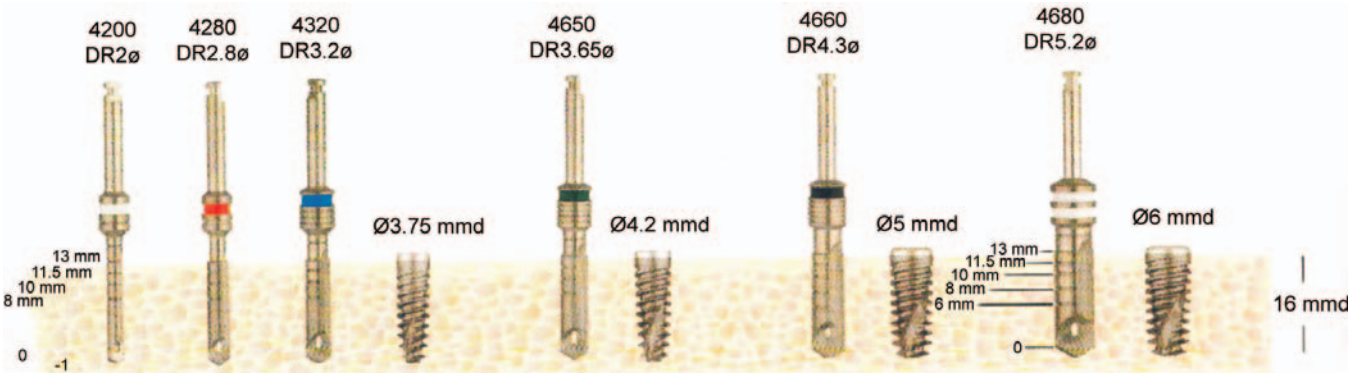


Fig. 49.28A: Schematic representation of sequence in implant placement. The manufacturer gives a guide to the sequence of drills (sizes) to be used in order to make proper-sized drill hole for a particular implant

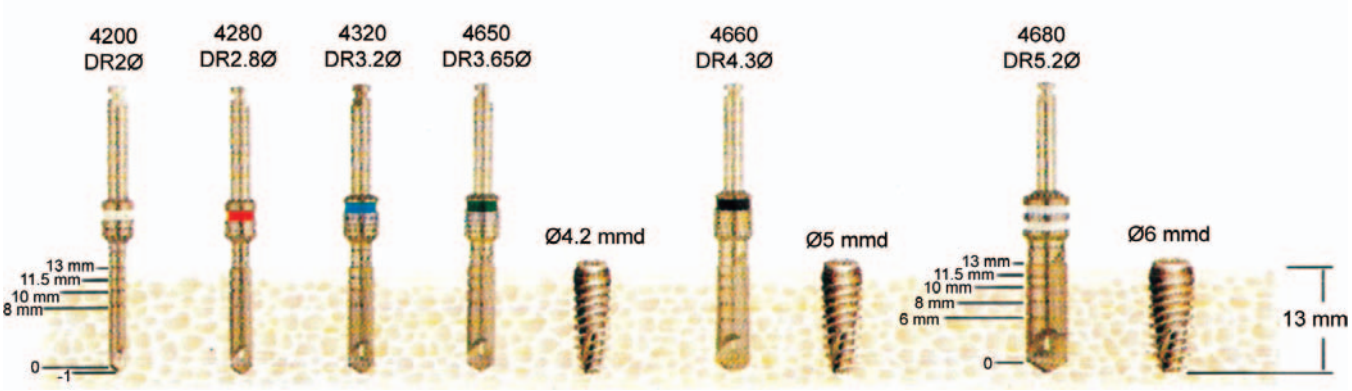


Fig. 49.28B: Schematic representation of sequence in implant placement

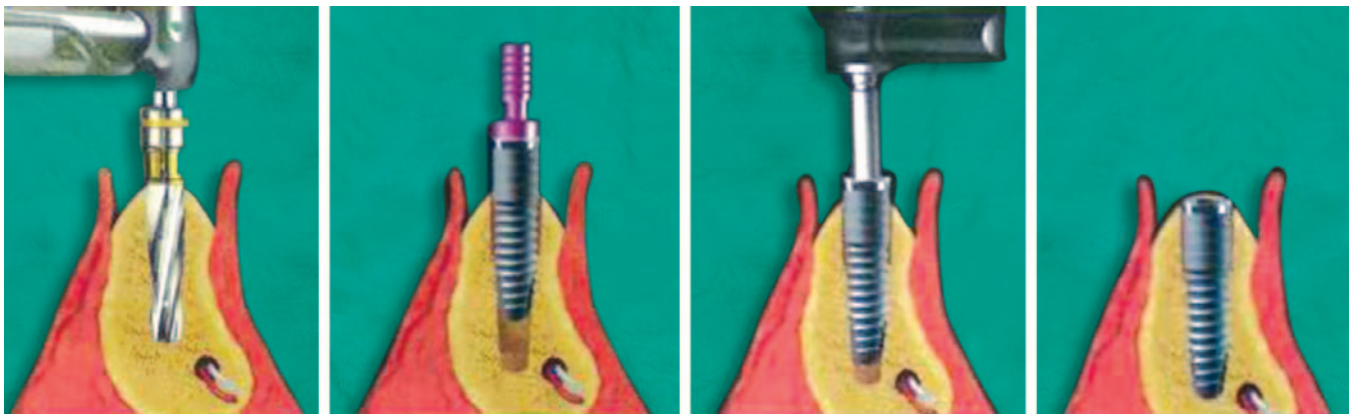


Fig. 49.28C: Diagrammatic representation of sequence in implant placement

normal body temperature and also to flush out the bone debris from the drill hole.

Normal saline at room temperature is ideal for this purpose. "Very cold" saline should be avoided as this might cause "thermal shock" in the local area in a restricted sense and it may be injurious to bone.

Various types of "physiodispensers" are available commercially, generally the manufacturer either provides one of their own or recommends a particular model.

Insertion

Implants are provided in sterile prepacked container with an implant carrier, which is gently taken to the drilled site and hand twisted to engage a few threads and then a special ratchet is used to screw the implant up to its required depth. The implant carrier is removed at this stage and the "healing cap" or "cover screw" is screwed on to the visible implant top.

Closing the Wound

A 3'0 black silk is the preferred suture material with atraumatic curved needle. Interrupted sutures are placed and are removed 5–7 days postoperatively.

Suitable antibiotics and nonsteroidal analgesics are prescribed for 3–7 postoperative days.

Chlorhexidine 0.2% w/v mouth wash is added to the prescription at least 3–6 times daily for 7–20 days or even longer. This may be alternated with warm saline mouth rinses.

POSTOPERATIVE INSTRUCTIONS

- No spitting or gargling, drinking with a straw (in case of maxillary sinus lift procedures)
- No smoking or alcohol consumption
- Fingers and tongue should be kept away from the surgical area
- Follow the antibiotic and anti-inflammatory regimen
- Ice-pack application extraorally
- Sleep with the head slightly elevated to reduce swelling
- Avoid brushing in the surgical area
- A fairly soft diet must be maintained, avoid hard and crusty food
- Addition of multivitamin supplements and 500 mg of vitamin C
- Rinsing with chlorhexidine or saline after meals from the second postoperative day
- In case of maxillary posterior implants, avoid swimming and blowing through the nose
- Temporary prosthesis may require periodic adjustments; old dentures may be worn after adequate soft lining procedures.

ABUTMENT CONNECTION

The abutment connection surgery in a two stage protocol it is carried out after 3 months in the mandible and 6 months in the maxilla (Brånemark):

The fixture may be exposed by:

- Scalpel technique
- Tissue-punch technique
- Laser technique.

A long incision along the crest, exposing all fixtures in case of multiple implants or a smaller individual incision over each fixture, where there is ample keratinized tissue. On exposure, the cover screw is removed and healing caps are placed for 1 week or until there is a good formation of gingival cuff for good emergence profile of the prosthesis. This is then followed by the prosthetic phase, wherein the healing cap is removed and impression post is placed during the impression procedures either by the open or closed tray technique.

Impressions for Loading

In single stage implant (where no second surgery is required to remove the healing caps), the healing cap is unscrewed and gingival former is screwed in and left for 7–17 days for gingival cuff to form around the future abutment.

- In two-stage implants, second surgery is undertaken to remove the cover screw and put gingival former.
- After the requisite period, the provided impression posts (coping) are put onto the implant and impression is taken.
- Then implant analog is fixed on to the impression posts (coping) and the impression is poured in die stone.
- Once the plaster is set, the post is removed and abutments are placed.
- The cast can then be sent to the laboratory for fabrication of prosthesis (crown).
- The abutment is taken off the cast leaving the implant analog in the cast. This abutment can now be transferred and screwed onto the implant and prosthesis affixed to it (either cemented or screwed to the abutment).
- Occlusal adjustment is undertaken if required, **(Figs 49.29A and B)**.

Clinical application of implant placement is shown in actual clinical photographs in **Figs 49.30 to 49.34**.

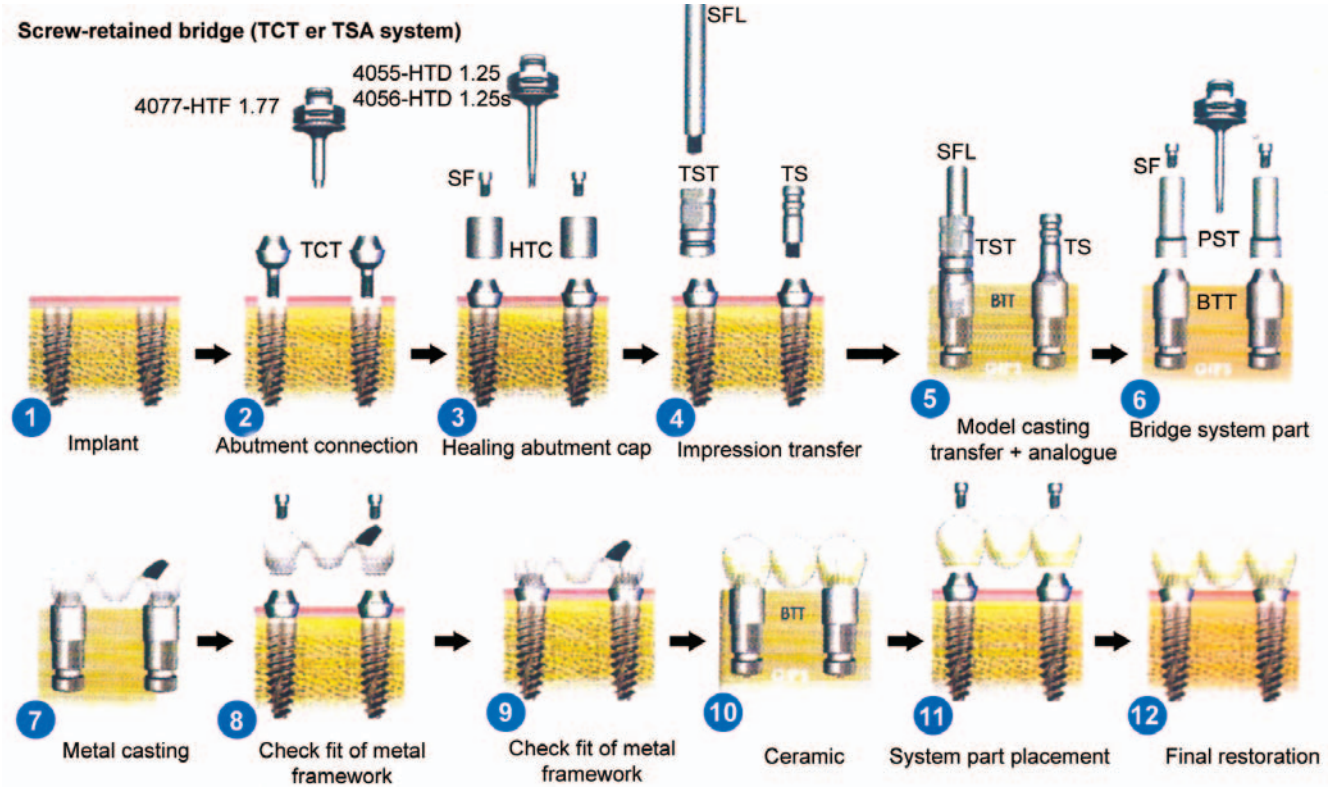


Fig. 49.29A: Schematic representation of stages of screw retained prosthesis

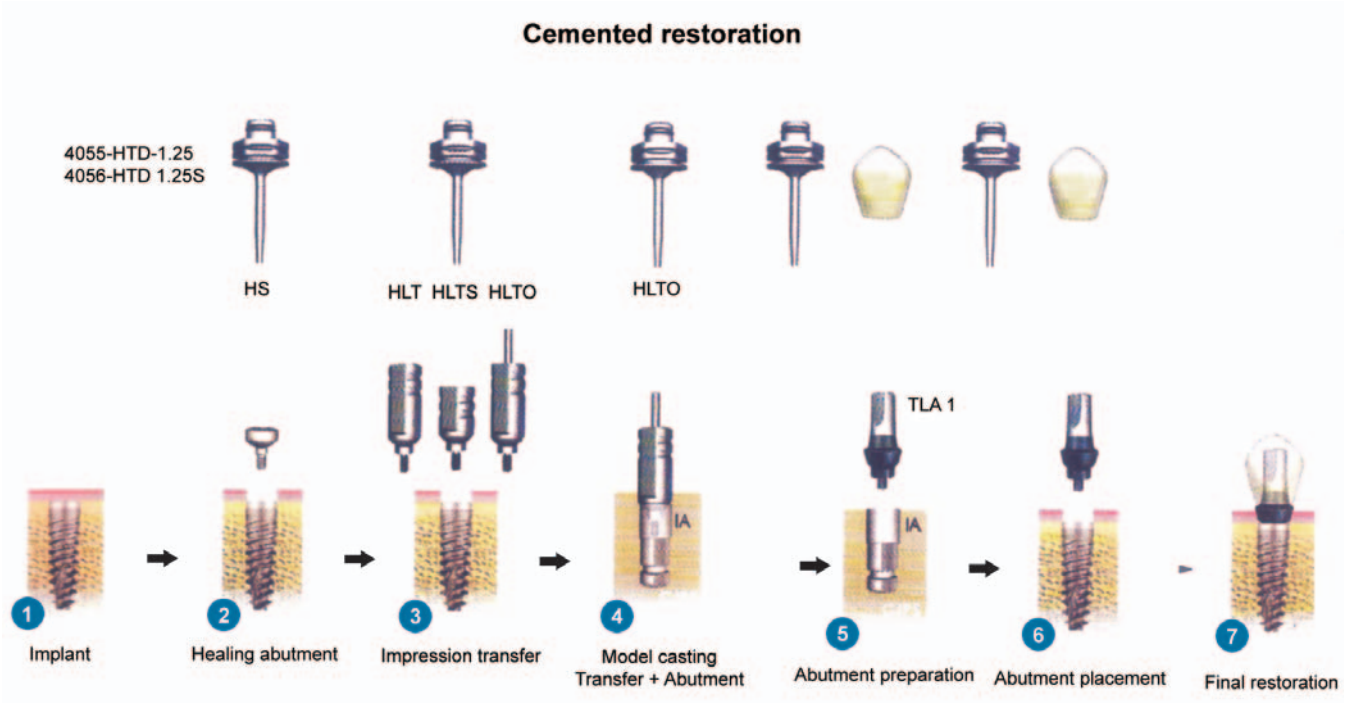
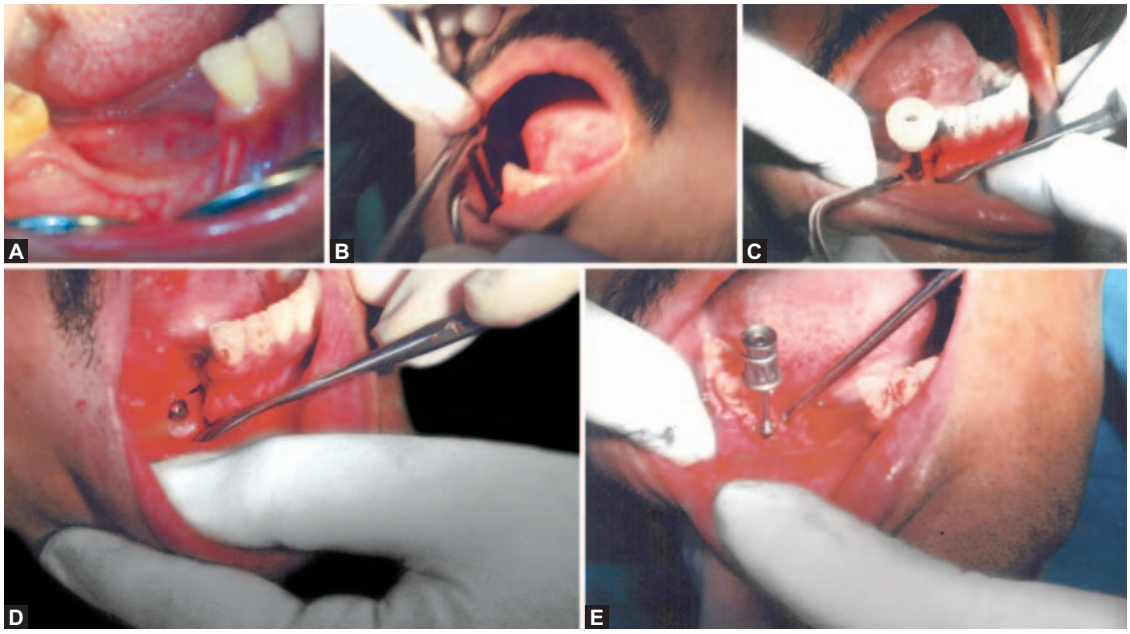
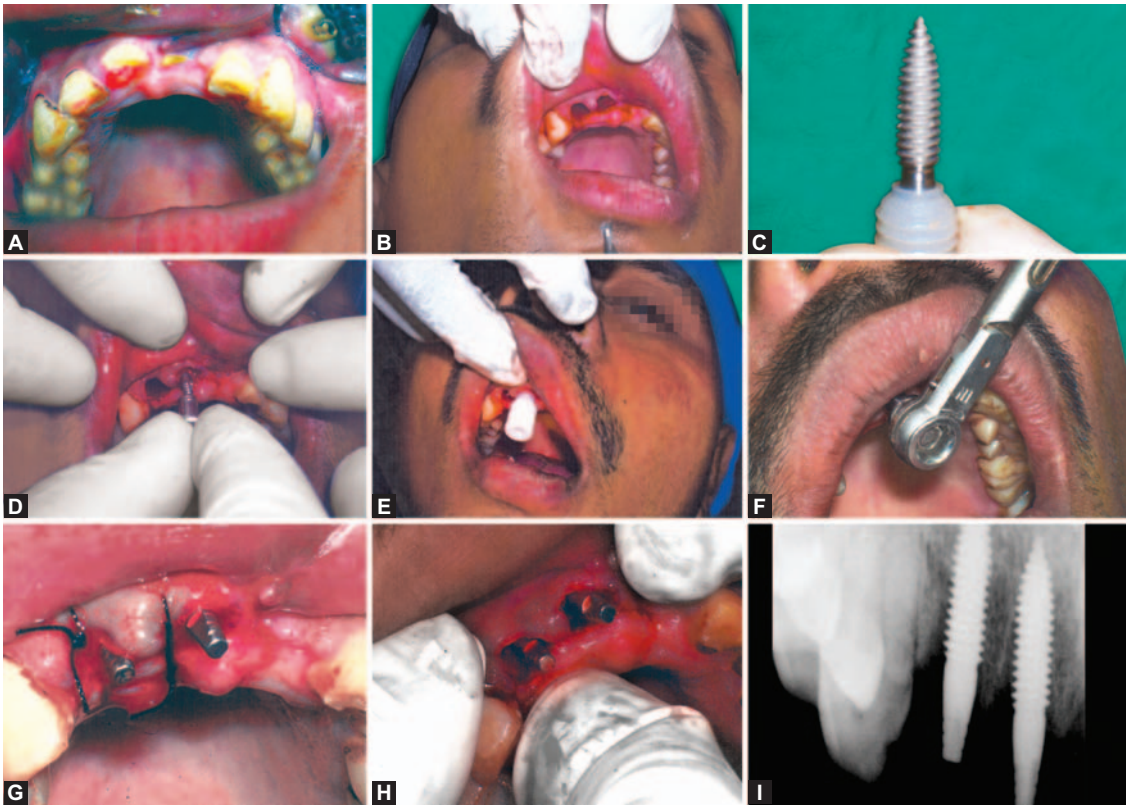


Fig. 49.29B: Schematic representation of stages of cemented restorations



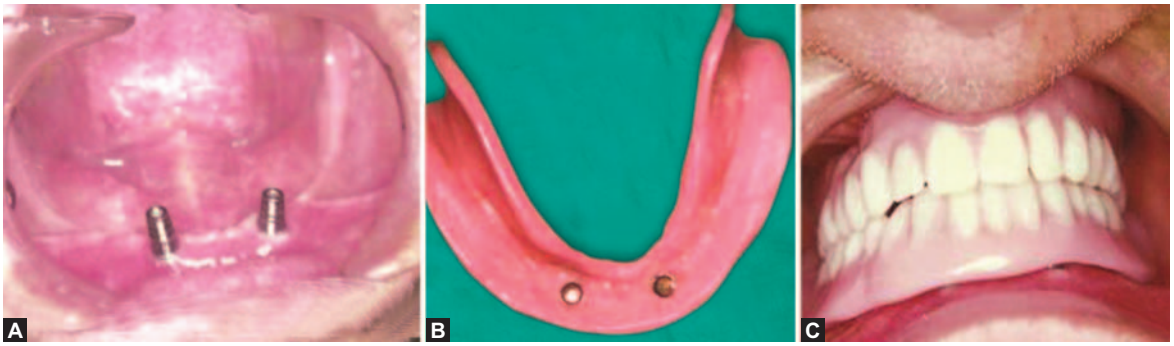
Figs 49.30A to E: (A) Preoperative intraoral view showing edentulous ridge; (B) Drilled hole being tapped; (C) Implant with implant carrier, being placed in the drilled hole; (D) Implant placed; (E) Cover screw being screwed on



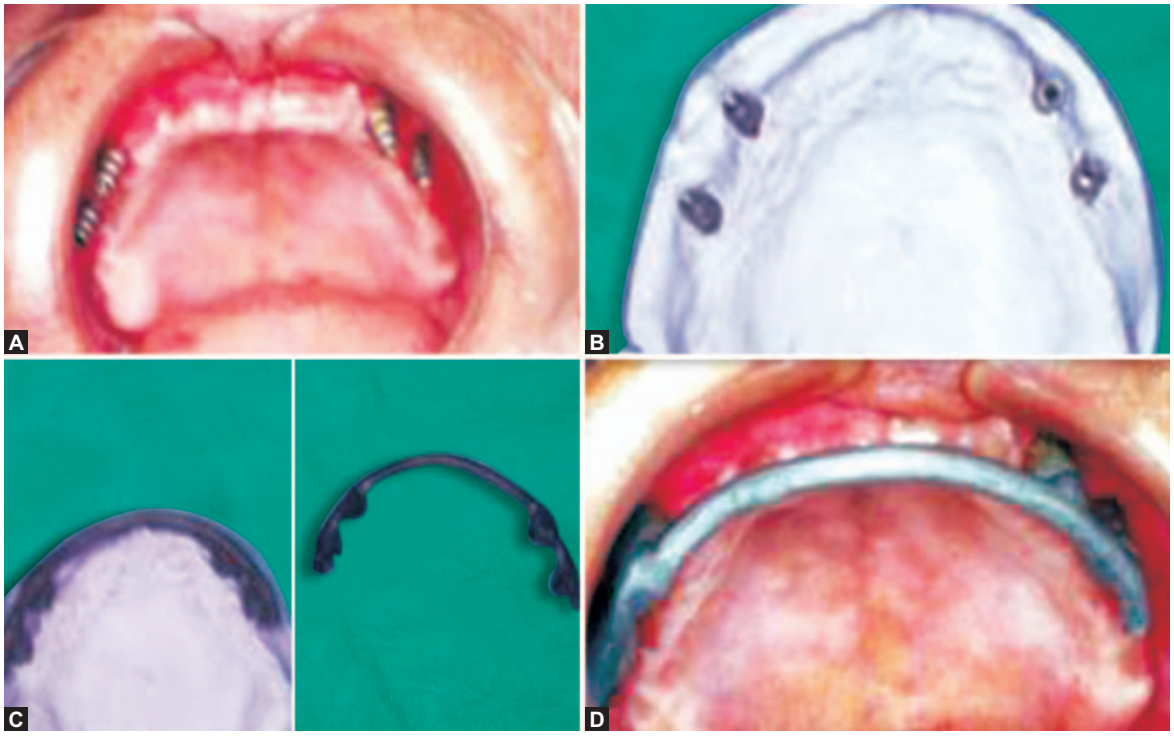
Figs 49.31A to I: (A) Preoperative intraoral view; (B) Socket of freshly extracted teeth; (C) Implant with carrier; (D) Implant being hand tapped; (E) Implant in the socket with its carrier; (F) Implant being screwed in with ratchet; (G) Implants in place and wound sutured; (H) After suture removal; (I) Intraoral periapical X-rays showing osseointegration



Figs 49.32A to C: (A) Preoperative intraoral view, immediate extractions with implants placement; (B) Implants with cover screws in place; (C) Healing of the wound



Figs 49.33A to C: (A) A 72-year-old male patient could not retain his lower denture, requested for implant supported denture. (A) Two implants seen in mandibular canine region bilaterally; (B) Lower denture inner aspect— implant sockets in position; (C) Full denture in situ



Figs 49.34A to D: (A) Four implants in place in maxillary edentulous ridge; (B) Plaster model with implant analogs; (C) Castable dolder bar pattern prepared on the mode; (D) Checking for the fit of the dolder bar in the mouth, before final finish

SURGICAL COMPLICATIONS OF IMPLANT THERAPY

- *Preoperative conditions that may lead to complications:*
  - Inadequate vertical and horizontal restorative space
  - Limited jaw opening and interarch distance
  - Inadequate alveolar width for optimal buccolingual position.
- *Intraoperative complications in implant placement*
  - Incorrect angulations (buccolingual and mesiodistal)
  - Malalignment
  - Nerve injury
  - Irregular sharp or too narrow crestal ridge
  - Extensive resorption of mandibular alveolar bone, curved extraction socket
  - Acute or chronic infection at insertion site
  - Overheating the bone at the time of implant preparation
  - Sinus and nasal floor perforation
  - Accidental, partial or complete displacement of dental implants in the maxillary sinus, maxillary incisive canal.
  - Deep or shallow implant placement.
- Complications in flapless implant placement
  - Implant fracture
  - Excessive torque during insertion/compression leading to necrosis
  - Inadequate primary stability or loose implant.
- *Postoperative complications*
  - Postoperative pain and its management
  - Incision line opening. (Improper suture technique)
  - Cover screw exposure during healing period
  - Bone loss during healing period/thread exposure
  - Implant mobility during second stage surgery
  - Implant periapical lesion and retrograde peri-implantitis, radiotherapy and dental implants-osteoradionecrosis
  - Shallow vestibule secondary to ridge augmentation.

Diagnosis and Management of Complications

Wound Dehiscence

If the cover screw is exposed or a portion of the implant head, the area must be kept clean with 0.2–0.12 percent chlorhexidine rinse to prevent inflammation and marginal bone loss. The situation may be improved by changing the cover screw to a healing abutment.

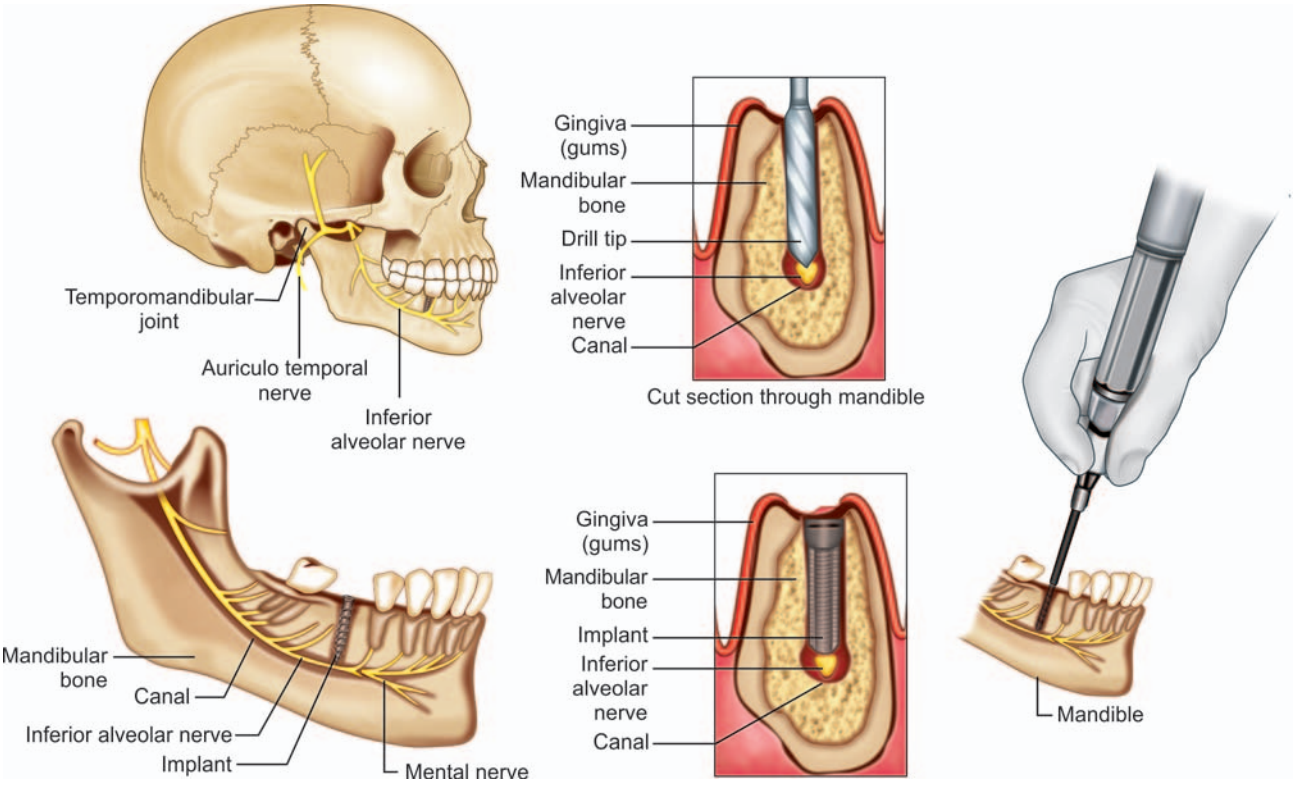


Fig. 49.35: Inferior alveolar nerve injury from dental drill

Early Implant Failure

Most surgical failures of osseointegration are due to poor surgical technique or placement of implants into bone of poor density or lack of bone volume.

Damage to bone, resulting in necrosis, pain and subsequent infection is more likely, where dense bone has been prepared with inadequate cooling and blunt drills. It is more likely in preparations deeper than 13 mm. The resultant pain can be severe and can lead to a deep seated track through soft tissues.

Damage to Neurovascular Structures

Loss of sensation to the lower lip caused by trauma to the inferior dental or mental nerve **(Fig. 49.35)**.

To avoid this complication:

- Infiltration rather than block anesthesia
- Avoid relieving incisions in the region of the mental nerve
- No crestal incisions over superficially located mental foramen in severely resorbed mandible
- Adequately expose, identify and protect the nerve when operating close to it
- Check for anterior loops of the nerve, by radiography
- Careful planning through CT scan
- Careful measurement of height and width of bone above the canal
- Avoid thermal damage to the bone left between the implant tip and nerve canal.

Fractures

Severely resorbed mandible may be compromised by implant placement, such that a fracture occurs at the time of surgery or a short time thereafter. CT scans must be used to assess severity of the resorbed mandible to avoid placement of too many implants within the zones of low bone volume (e.g. mandibular 1st premolar region).

Soft Tissue Complications

The mucosa around the abutments should be free from inflammation and bleeding or exudate, probing depth must be evaluated at regular intervals with clinical examination along with radiographic evaluation **(Figs 49.36 and 49.37)**.

Surgical correction of soft tissue problems may be required in case of:

- Soft tissue overgrowth
- Soft tissue deficiency
- Persistent inflammation/infection
- Continuing bone loss.

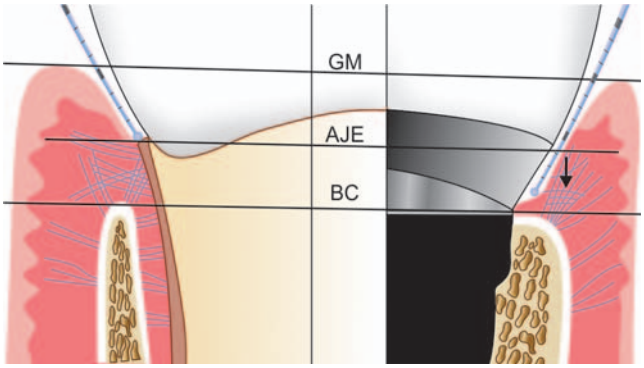


Fig. 49.36: Different probe depths in the natural tooth and in the implant, caused by the absence of direct fiber insertion into the titanium

Abbreviations: GM, gingival margin; AJE, apical junctional epithelium; BC, bone crest.

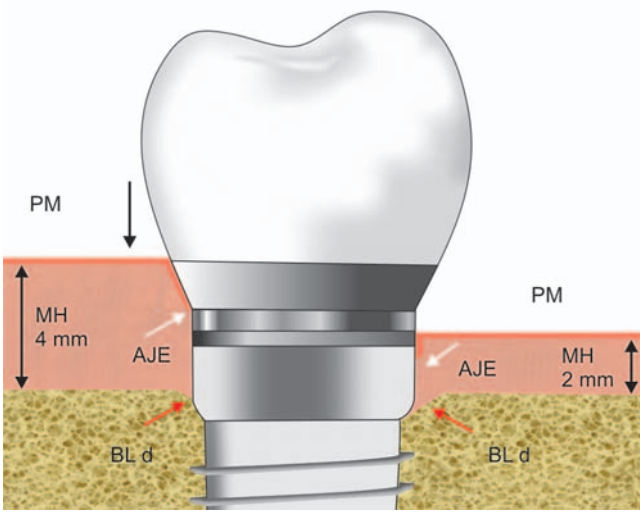


Fig. 49.37: Comparison of the normal peri-implant gingival condition with a peri-implant mucosa that is too thin, resulting in peri-implant bone resorption

Abbreviations: PM, marginal portion of the peri-implant mucosa; MH, mucosal height in mm; AJE, apical junctional epithelium; BL, degree of wedge shaped peri-implant bone loss.

In case of soft tissue hyperplasia: Simple excision may be required to thin out the excess tissue, but preserve the keratinized tissue to produce a zone of attached mucosa around the abutments. This may occur around poorly designed embrasures or bar attachments in over dentures.

Soft tissue deficiency: In cases of severe bone loss, nonkeratinized mucosa appears redder and delicate and may lack attachment to underlying bone. Persistent soreness and inflammation can be overcome by grafting keratinized mucosa such as a free gingival graft from the palate.

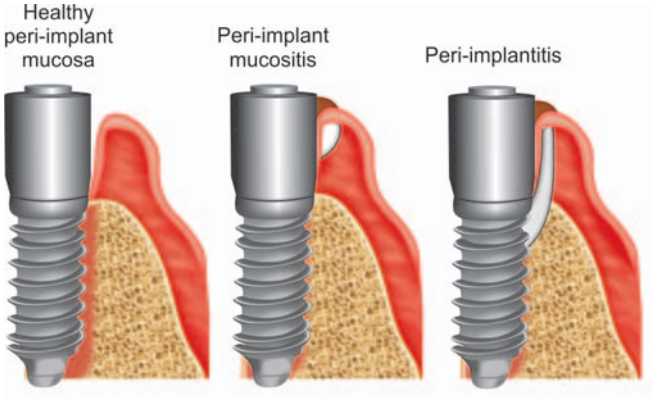


Fig. 49.38: Soft tissue problems following implant surgery

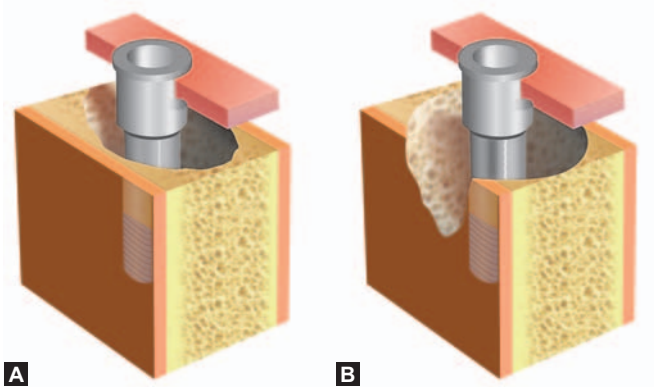
Persistent inflammation: May arise due to poor implant positioning. This may require soft tissue recontouring to allow patient hygiene and soft tissue esthetics.

Peri-implantitis (Fig. 49.38): It is an inflammatory lesion which has caused obvious bone loss, the marginal soft tissue will appear inflamed. Bacterial colonization is one of the prime factors which may be induced due to:

- Poor oral hygiene
- Cement retained in the subgingival area
- Microscopic gaps between implant components
- Inflammation, exudation and soft tissue proliferation
- Wide saucerization areas of bone loss on the radiograph.

Spiekermann's Classification of Defects Following Peri-implantitis (Figs 49.39A and B)

- Class I—Horizontal defect
- Class II—Bowl-shaped defect
- Class III—Funnel-shaped defect.



Figs 49.39A and B: (A) Bowl shaped defect; (B) Funnel-shaped defect

NONSURGICAL MANAGEMENT OF PERI-IMPLANTITIS

- Mechanical cleaning of implant surface—with curettes of titanium or steel or prophy jets
- **Local medicaments:**
  - Chlorhexidine chips (PerioChips)
  - Chlorhexidine lavage/citric acid or powder jet devices
  - Local doxycycline or metronidazole gel application
  - Ligosan—260 mg slow release ligosan or 12 days direct delivery
- **Laser decontamination**—with either CO_2 or erbium – Yag laser of 1.5 w frequency
- **Photodynamic therapy**—Photochemical decontamination of peri-implant tissues and implant surface with a photosensitizer dye in combination with laser light
- Ozone therapy
- **Systemic antibiotics:** Metronidazole 400 mg TDS + Amoxicillin 500 mg TDS for 7 days or clindamycin 300/600 mg 4 times a day for 7 days.

SURGICAL MANAGEMENT OF PERI-IMPLANTITIS

- Resective therapy—Clean the exposed implant surface with the above-mentioned chemical agents. Polish the implant surface with Arkansas stone. Resection of peri-implant soft tissue and readapt the mucosal flap with connective tissue attachment
- Regenerative therapy (as yet only experimental)—Guided bone regeneration, autologous bone, bone substitute and membrane.

ABSOLUTE INDICATION FOR EXPLANTATION

- Mobility of implant with advanced bone depletion
- Therapy resistant peri-implantitis **(Table 49.2)**.

Prosthetic Complications

Screw loosening, fixture fracture, abutment loosening may be a sign of implant overload due to:

- Poorly fitting prosthesis
- Poorly designed cantilevers
- Poor implant to crown ratio
- Inadequate occlusal adjustments

Table 49.2: Statistical review of implant failure causes

Reason for Implant Failure	
Peri-implantitis	75%
Insufficient maintenance by patient	58%
Insufficient maxillary bone	44%
Prosthetic difficulties (other than premature loading)	33%
Premature loading	29%
Illness/systemic disease	29%
Insufficient maintenance by doctor	28%
Insufficient mandibular bone	19%
Increased periodontal involvement throughout mouth	16%
Bone augmentation needed but not initially provided	15%

- Too few number of implants to establish adequate occlusal table
- Uncontrolled parafunctional activity.

LONG-TERM MAINTENANCE PROTOCOL FOR IMPLANTS

Patient's Role

- Maintain plaque control
- Use interdental brush, waterpik, etc.
- Dip brush in 0.12% solution of chlorhexidine
- Use floss/yarn/tapes dipped in chlorhexidine at night
- Use cotton swab dipped in chlorhexidine for implants with tooth color materials or composites.

Dental Hygienist's Role

- Check for effectiveness of plaque control
- Check for inflammatory changes
- If pathological conditions are present, probe gently with plastic probe (sensor)
- Scale supragingivally or slightly subgingivally with implant care, implant-prophy
- Check for loose suprastructure, broken screw or sore spots.

Dentist's Role

- Check patient every 4 months
- Check for 85 percent plaque control effectiveness
- Radiographs every 12 to 18 months, if no pathological condition is present or as required, if pathology is present
- If implant needs repair, degranulate, detoxify and graft with guided bone regeneration if required. Wait for 10–12 weeks before loading implant into function
- Document all data.

Points to Remember

- Implantation definition
- Osseointegration or osseous integration (1993)
- Rationale for implant treatment
- Classifications for implant treatment
- Implant materials
- Advantages of dental implants
- Anatomy or parts of an implant
- Patient selection criteria
- Computed tomography
- Armamentarium for implant surgery
- Basic factors in implant surgery
- Avoidance of thermal injury to the bone
- Placement of the implant in an acceptable position
- Preoperative care
- Surgical procedure for implant placement
- Postoperative instructions
- Abutment connection
- Surgical complications of implant therapy
- Diagnosis and management of complications
- Damage to neurovascular structures
- Nonsurgical management of perimplantitis
- Surgical management of perimplantitis
- Absolute indication for explantation
- Long-term maintenance protocol for implants.

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Section 17

Management of Medical Emergencies

50. Hemorrhage and Shock: Its Management in Oral Surgery
51. Management of Medical Emergencies in Dental Clinic
52. Cardiopulmonary Resuscitation

CHAPTER 50 Hemorrhage and Shock: Its Management in Oral Surgery

INTRODUCTION

Hemorrhage (Hemo + rrhage) denotes the escape of blood from a blood vessel. The word hemorrhage is synonymous with bleeding. Any damage to the vasculature leads to outflow of blood. Blood carries oxygen and nutrients to the tissues and is vital for body functions. Loss of blood due to any reason beyond a certain point is potentially life-threatening and may lead to exsanguination.

This chapter provides an overview of the coagulation system, with emphasis on control of bleeding in oral surgery patients, who are otherwise normal or are having acquired or hereditary bleeding disorders. In this section, shock occurring as a result of blood loss and its management is also described.

Types of Hemorrhage

Depending on the Type of Blood Vessel Involved

Depending on the type of blood vessel involved, hemorrhage can be arterial, venous or capillary.

- In "arterial hemorrhage", there is bleeding from a ruptured artery. Arterial bleeding is pulsatile, brisk and bright red in color.
- Loss of blood from a vein is known as "venous hemorrhage". Bleeding from veins is dark in color and blood flows in an even stream. Due to lack of valves in veins of the facial region and extensive communication, there is relatively more flow from these veins as compared to other parts of the body.
- Oozing from the capillaries is known as "capillary hemorrhage". In capillary hemorrhage, blood oozes from the area and no bleeding point can be made out. The blood is bluish bright red in color as compared to arterial and venous blood. Bleeding is not severe and is easily controlled by simple pressure with gauze pads. In coagulation disorders, there can be extensive blood loss from capillaries.

Primary, Reactionary, Intermediate Bleeding and Secondary Bleeding

- "Primary bleeding" occurs at the time of injury. Hemostatic mechanisms in the body attempt to stop the bleeding by formation of a clot.
- If the primary bleeding has stopped once, and wound starts to bleed again after 24 hours to several days, it is known as "secondary bleeding". It may be due to (1) dislodgment of clot; (2) secondary trauma to the wound; (3) infection is also the most common reason for secondary bleeding. Infection causes softening of the blood clot or even erosion of the vessel wall. Attempt to control bleeding by ligating the bleeding vessel may fail as the ligature may easily cut through softened infected tissues; (4) elevation of patient's blood pressure enough to overcome pressure external to blood vessel is another common reason for secondary bleeding.
- According to some authors, bleeding occurring within 8 hours after stoppage of primary bleeding is labeled as "intermediate bleeding". Loose foreign body in the wound like calculus, broken bone piece, and preexisting extensive granulation tissues in the extraction socket are the most common causes for the intermediate bleeding.

Internal or External Bleeding

Bleeding that is confined within the body cavity and is not apparent on the surface is known as (1) "internal or

concealed bleeding". Whereas, blood escaping through a wound in the skin/mucosa is known as (2) "external bleeding".

Spontaneous Bleeding

Sometimes bleeding can occur without any provocation, e.g. in acquired (patients on oral anticoagulant agents—decreased platelets count) and hereditary coagulopathies, such type of bleeding is labeled as "spontaneous bleeding".

Hemostasis

It is important to understand the mechanism of stoppage of bleeding. There are four important steps in hemostasis:

1. First of all, the injured blood vessel, in an attempt to reduce blood flow undergoes constriction due to spasm in the vessel wall.
2. In the second step, there is activation of platelets and formation of platelet plug. This leads to primary hemostasis.
3. In the third step, there is activation of clotting mechanism and formation of clot leading to completion of secondary hemostasis.
4. In the final step, there is fibrous organization of the clot or retraction of clot.

Primary Hemostasis

Primary hemostasis is the process of platelet plug formation at the site of injury. It occurs within seconds of injury and is important in stoppage of blood from small arterioles, venules and capillaries. There is platelet adhesion, release of granules and platelet aggregation resulting in formation of a primary hemostatic plug.

Secondary Hemostasis

Secondary hemostasis is the activation of clotting process in plasma that ultimately results in the formation of fibrin, which strengthens the primary hemostatic plug. It is completed in several minutes and is important in bleeding from larger vessels. Coagulation mechanism is a continuous process and there are approximately 40 substances, which affect clotting, some promote clotting called procoagulants and others prevent clotting called anticoagulants. Normally, there is fine balance between these factors and blood usually does not coagulate inside the body. Whenever, there is an injury to the vessels, these procoagulant factors are activated and balance tilts in favor of coagulation and there is formation of a clot. There is a complex interaction of various factors of coagulation in the formation of a clot **(Table 50.1 and Flowchart 50.1)**.

For the purpose of simplicity and understanding, coagulation mechanism can be broken into a series of four reactions:

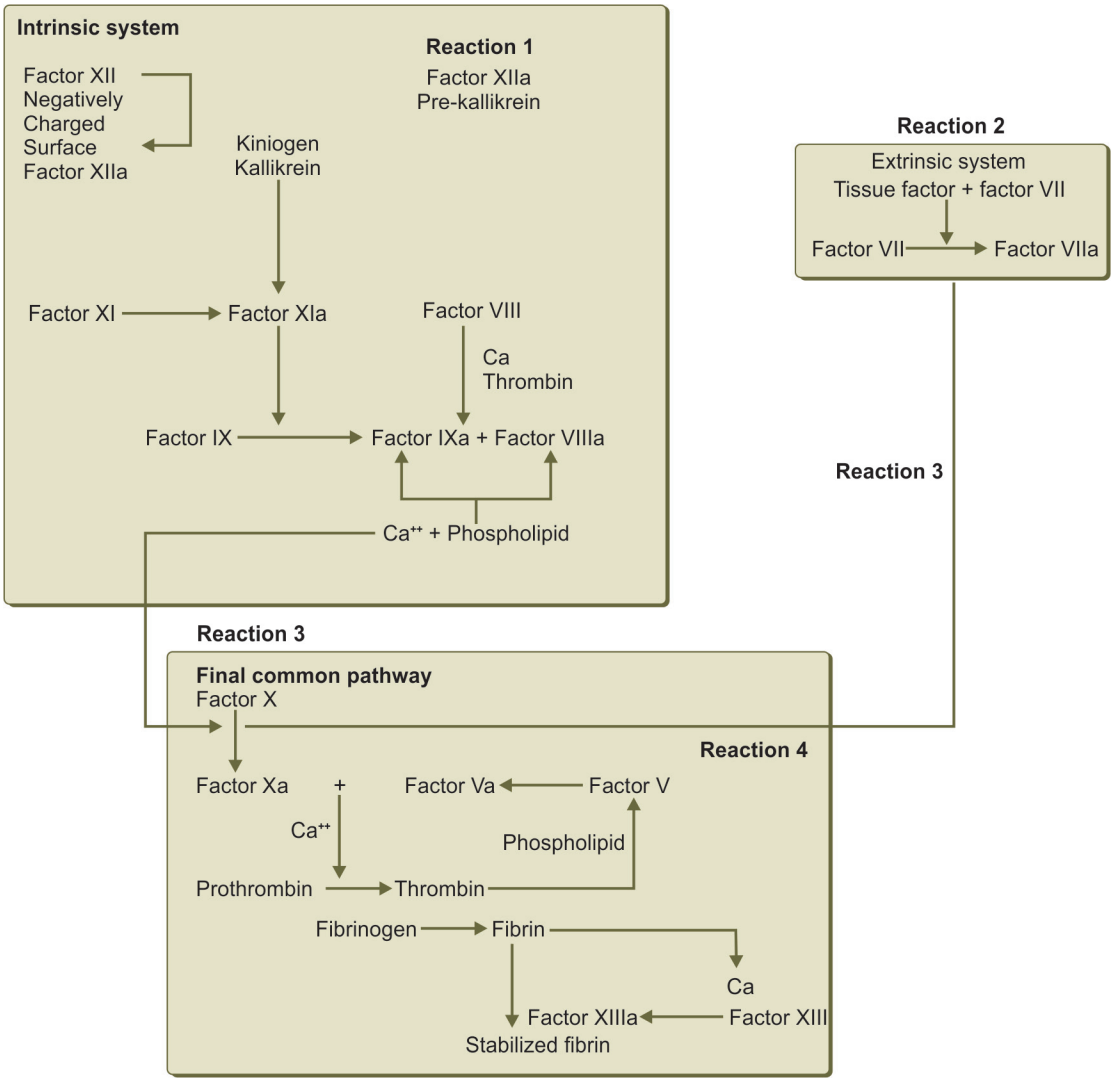
Reaction 1: This is intrinsic or contact phase of coagulation. In this phase, mainly factors VIII, IX, XI, XII along with calcium and plasma proteins take part. Partial thromboplastin time (PTT) screens this intrinsic limb of the coagulation.

Reaction 2: This is extrinsic pathway for initiation of coagulation. In this phase, there is release of tissue thromboplastin from injured tissues. A protease complex

Table 50.1: List of coagulation factors and their important features

	Factor name	*Half-life*	*Biosynthesis*	*Vitamin K dependency*
I	Fibrinogen	1.5–6.3 days	Liver	No
II	Prothrombin	2–4 days	Liver, brain	Yes
III	Tissue factor	Unknown	—	No
IV	Calcium	—	—	No
V	Proaccelerin, labile	12–24 hours	Liver, megakaryocytes	No
VI	Proconvertin	1–5 hours	Liver	Yes
VII	Antihemophilic factor	8–12 hours	Liver, spleen, endothelium, reticuloendothelial cells	No
VIII	Christmas factor	15–24 hours	Liver	Yes
IX	Stuart-Prower factor	2–9 hours	Liver	Yes
X	Plasma thromboplastin antecedent	40–84 hours	Liver	No
XI	Hageman factor	48–52 hours	Liver	No
XII	Fibrin-stabilizing factor	4.5–12 days	Liver, megakaryocytes	No

Flowchart 50.1: Coagulation cascade



is formed between factor VII, calcium and tissue thromboplastin, which activates factor X and takes part in reaction III—the common pathway. Prothrombin time (PT) (laboratory test) screens the extrinsic limb of coagulation.

Reaction 3: In this phase, factor X is activated by proteases generated in previous two reactions.

Reaction 4: In this phase, prothrombin is converted into thrombin in the presence of factor V, calcium and phospholipids. Thrombin has got multiple functions in hemostasis. Its main role is conversion of fibrinogen into fibrin, but it also further activates factor V, VIII and XIII and helps in platelet aggregation and secretion. Flowchart 1 summarizes all these reactions of coagulation cascade.

Clinical Evaluation of the Bleeding Patient

Careful evaluation of the patient with coordinated history and physical examination provides valuable clues as to whether the bleeding abnormality resides in: (1) the vessels walls; (2) platelets or (3) in the process of coagulation. Laboratory tests should supplement and not supersede a careful review of history and physical examination. The history should include the following questions:

- Is there any personal or family history of a bleeding tendency?

- Has the patient undergone surgery or dental extractions previously?
- Is there any history of hematuria, gastrointestinal hemorrhage, easy bruising, hemarthrosis, menorrhagia, or epistaxis?
- Is there any history of cancer or collagen vascular disease?
- What medications is the patient taking or has taken recently?
- Is the patient on any special diet?

A careful physical examination should note any adenopathy, splenomegaly, or hepatomegaly. Hepatic insufficiency should be assessed by seeking signs of jaundice, telangiectasias, gynecomastia, testicular atrophy, or any other stigma of liver disease. Assessment of the skin and mucosal surface is mandatory.

Bleeding into superficial skin and soft tissues usually seen as small capillary hemorrhages ranging from size of pinhead (petechia) to large areas of ecchymoses is usually characteristic of abnormalities of the vessels or the platelets. Hemorrhage into synovial joints is virtually diagnostic of a severe hereditary coagulation disorder.

Laboratory Tests for Screening

Majority of defects of hemostasis can be screened by four basic tests:

Bleeding Time

Bleeding time (BT) is a sensitive measure of platelet function. Usually there is a linear relationship between platelet count and bleeding time. Patients with bleeding time more than 10 minutes have increased risk of bleeding. There are various methods of measuring bleeding time, e.g. Ivy, Duke and template. It should be performed by expert technicians and small differences in technique have a big effect on outcome. BT is prolonged in thrombocytopenia, Von Willebrand disease (VWD) and platelet dysfunction.

Platelet Count

Normal platelet count is 150,000–450,000 per cu mm of the blood. When count becomes 50,000–100,000 per cu mm, there is mild prolongation of bleeding time, so that bleeding occurs after severe trauma, or surgery. Patients with count less than 50,000 per cu mm have easy bruising manifested as petechia and ecchymoses during trauma or surgery. Patients with platelet count below 20,000 per cu mm have an appreciable incidence of spontaneous bleeding, which may be intracranial or any other internal bleeding.

Minor oral surgical procedure can be safely done, if platelet count is above 80,000–100,000 per cu mm, otherwise patient needs transfusion of platelet-rich plasma.

Prothrombin Time

Prothrombin time screens the extrinsic limb of coagulation pathway (Factors V, VII and X) and factors I, II and V of the common pathway. It is prolonged in patients, who are on warfarin anticoagulant therapy, vitamin K deficiency or deficiency of factor V, VII, X, prothrombin or fibrinogen. The results obtained from PT must be related to control value. Normal PT is usually 12–14 seconds. As a general guideline for dental procedures, the PT should be less than 1 to 1½ of the control value.

Partial Thromboplastin Time

Partial thromboplastin time screens the intrinsic limb of coagulation pathway and tests for the adequacy of factors VIII, IX, X, XI, XII of intrinsic system and factors I, II, V of the common pathway. It is prolonged in hemophiliacs.

Both the tests PT and PTT together also screen the common coagulation pathway involving all the reactions that occur after activation of factor X. If both the tests are prolonged, then factor II, V, X or vitamin K deficiency and liver disease are suspected. Normal PTT is less than 45 seconds. It is important to note that PTT is relatively insensitive to changes in the intrinsic coagulation system. A 70% decrease in factor levels may still provide normal results; small changes in PTT, therefore, may be of great significance.

When abnormalities are noted in any of the screening tests, further specific tests (like bioassays of coagulation factors) are carried out in consultation with the hematologist to get the exact diagnosis.

Hemostatic Agents

They can be (1) local and (2) systemic.

Local Hemostatic Measures

In a patient with normal coagulation mechanism, the control of hemorrhage is dependent on vessel contraction, retraction, and clot formation. During any surgical procedure, complete hemostasis must be achieved before closure of the wound. Direct control of bleeding at the site of injury is the best method to achieve hemostasis. Surgical bleeding most of the times is caused by ineffective local hemostasis. The techniques for local hemostasis may

be classified as (1) mechanical; (2) thermal or (3) chemical methods.

Mechanical Methods

Pressure: Application of pressure basically counteracts the hydrostatic pressure within the bleeding vessel until such time, that a clot can form and occlude the bleeding orifice. Pressure on site of bleeding is usually able to control most of the hemorrhages. Pressure should be applied directly over the bleeding site firmly over a gauze pack for at least five minutes. One should not be in a hurry and should not lift pack every minute to see whether bleeding has stopped or not. Post-traumatic nasopharyngeal bleeding or pharyngeal bleeding due to maxillofacial trauma can be controlled by nasal packing. Sometimes posterior nasopharyngeal pack is required. This can be easily achieved with the use of a no. 20 Foley's inflated catheter. The catheter is inserted through one nostril into the nasopharynx and balloon is inflated with approximately 30 mL of saline. When traction is applied, the balloon will lodge in the nasopharynx and tamponade the bleeding. Along with this, anterior nasal packing can be done, if bleeding point is located anterior to the pressure area. In fractures of mandible, bleeding from inferior dental artery usually stops spontaneously or with the help of pressure packs. Severe maxillofacial bleeding due to facial fractures may be tamponaded with temporary or definitive reduction and fixation of the fractures.

Use of hemostat forceps: Hemostat (Mosquito artery) forceps are specially designed to catch bleeding points in the surgical area. These can be straight or curved. Curved hemostats are used more frequently, because of their versatility and ease in tying the ligature around the tip of forceps. Usually, electrosurgical thermocoagulation is done after catching the bleeding point with hemostat forceps, if the vessel is small. The large vessels are ligated with suture.

Sutures and ligation: Transected blood vessel may need to be tied with the help of ligature. When large pulsatile artery needs to be tied, non-absorbable material like 3-0 black silk is preferred. Smaller vessels can be ligated with 3-0 catgut, or polyglactin. The presence of nonabsorbable material in an infected wound can lead to extrusion or sinus tract formation. Large arteries with pulsation, such as external carotid artery, should have double transfixion suture passed through the wall of vessel to prevent chances of slipping of ligature. Ligation of major vessels in maxillofacial region is further described in detail in the subsequent text.

Embolization of the vessels: With the help of angiography, the exact bleeding point can be localized. Agents which can be used for embolization include steel coils, polyvinyl alcohol foam, gel foam, silicon spheres and methyl methacrylate. These particles are placed via a catheter superselectively into the bleeding vessel usually via femoral artery. The femoral artery is percutaneously punctured. A guidewire is then inserted into the vessel followed by a 100 cm long catheter. This catheter can be maneuvered into various branches of the external carotid artery under constant fluoroscopic control. Vessels that are usually investigated and catheterized for treatment of oral and perioral lesions include the facial, lingual, transverse facial and internal maxillary arteries. After the individual vessels are identified, contrast media are injected via the catheter and films are obtained. After the lesions are completely mapped angiographically, the angiograms are studied and embolization of the bleeding vessel can be carried out by various agents. The major risk is deposition of stray particles into normal territories via transcranial collaterals including internal carotid system and vertebral arteries. Careful mapping of the involved vessels and superselective technique reduces the risk of misplaced embolic material significantly.

Thermal Agents

Cautery: Heat achieves hemostasis by denaturation of proteins which results in coagulation of large areas of tissue. In cauterization, heat is transmitted from the instrument by conduction directly to the tissues. Electrocautery has replaced direct heat application. When an electrosurgery unit is not available, dental burnisher like instrument can be directly heated over a flame and applied directly to the bleeding point in the oral cavity.

Electrosurgery: In electrocautery, heating occurs by induction from an alternating current source. It is an effective and convenient way of controlling hemorrhage. Electrocautery can be applied directly to bleeding point or after catching the bleeding point with hemostat. Then cautery point is touched to the hemostat, causing sealing of the vessel through the action of heat. It causes tissue destruction producing a burning smell and smoke during application. This cannot control hemorrhage from large vessels, which need to be ligated.

Cryosurgery: Extreme cooling has been used for hemostasis. Temperature ranging from –20°C to –180°C is used. At these temperatures, the tissues, capillaries, small arterioles, and venules undergo cryogenic necrosis. This is caused by dehydration and denaturation of lipid

molecules. Cryosurgery is specially used to treat superficial hemangiomas.

Argon-beam coagulator: It represents a new form of electrocautery, shown to be more effective than standard electrocautery. In this, coagulator, monopolar current is transmitted to tissues through the flow of argon gas. This allows bleeding from vessels that are smaller than 3 mm in diameter to be controlled without the use of hemostats or ligatures. The tip of the coagulator is held approximately 1 cm from the tissue. A flow of argon gas clears the surgical site of fluids to allow current to be focused directly on tissue, with reduced carbonization. There is formation of 1–2 mm of escher, that covers the bleeding surface and remains attached to the tissues with less tendency to rebleed. There is a possibility of gas embolism, as there is stream of gas in direct contact with tissues. This risk can be eliminated by not placing handpiece tip in direct contact with tissues.

Lasers: Lasers usually result in bloodless surgery, as these effectively coagulate the small blood vessels during cutting of tissues.

Vessel ligating clips: Vessel ligating clips (Ligaclips®-Ethicon) are titanium clips used to permanently seal the vessel mechanically by occluding the vessel. These are applied with the help of clip applicator which compresses the clip like a staple over the vessel wall without damaging it. This is a quite efficient and convenient method of achieving vessel control during surgery as compared to conventional method of tying the vessel with thread.

Vessel sealing system: Vessel sealing system (LigaSureTM-Covidien, EnSeal®-Ethicon) utilizes the electrical energy as in electrocoagulation with an ability to adjust the current during sealing of vessel based on tissue impedance to current flow. A high flow current and low voltage is modulated by inbuilt computer with feedback performed 200 times or more per second. These devices can be used to seal and divide vessel up to 7 mm diameter without ligating it.

Plasma coagulation and tissue management system: In this system, radiofrequency energy is utilized to generate plasma field of highly ionized particles of normal saline. These particles are used to disrupt the organic molecular bond of tissues for tissue dissection. During plasma generation, it works on bipolar mode and current is not passed through whole body as in monopolar mode. Tissue temperature is in range of 40–70°C which is sufficient for cutting and coagulation of tissues. Absence of return current removes the risk of burns and cardiac pacemaker problems.

Chemical Methods

Local agents

- **Astringent agents and styptics:** Chemical agents vary in their hemostatic action. Monsel's solution contains ferric subsulfate and it acts by precipitating proteins. It is quite effective in arresting the capillary bleeding and post-extraction bleeding in medullary bone.
  Tannic acid also helps in precipitating proteins and causes clot formation. This is more helpful as a home remedy or prescription over phone until patient reaches the clinician. Patient can be asked to bite over a folded tea bag in case of post-extraction bleeding. Mann hemostatic is a mixture of tannic acid, alum and chlorobutanol.
  Silver nitrate and ferric chloride are other agents, which can be used in case of minimal capillary bleeding.
- **Bone wax:** When bleeding is occurring from a bony canal, it can be troublesome, because of inability to occlude the vessel that is confined within bony canal. In such a case, small quantity of bone wax can be applied to the bleeding bone. It acts by mechanical occlusion of the bony canal. Large quantity of bone wax can lead to foreign body granuloma and infection. Therefore, it should be used judiciously.
- **Thrombin:** Topical use of thrombin acts by converting fibrinogen into fibrin clot. It is very kind to tissues and quite effective. It is applied to the bleeding surface via a pack, gelatin sponge or Surgicel®.
- **Gelfoam®:** It is made from gelatin and is sponge like. Gelfoam® has no intrinsic hemostatic action. Its main hemostatic activity is related to large surface area, which comes in contact with blood and further swells on absorbing blood. It exerts pressure along with acting as scaffold for fibrin network. It is absorbed by phagocytosis. Gelfoam® should be moistened in saline or thrombin solution prior to application and all the air should be removed from interstices.
- **Oxycel:** It is oxidized cellulose and on application releases cellulosic acid, which has marked affinity for hemoglobin, leading to formation of artificial clot. It should be applied dry, because acid formed during wetting process inactivates the thrombin or other hemostatic agent. Acid produced also inhibits epithelialization, therefore, it is not recommended for use over epithelial surfaces.

- **Surgicel®:** It is glucose polymer based sterile knitted fabric prepared by the controlled oxidation of regenerated cellulose. Its local hemostatic mechanism depends on binding of hemoglobin to oxycellulose, allowing the dressing to expand into a gelatinous mass, which, in turn, acts as scaffold for clot formation and clot stabilization. Surgicel® can be applied dry or it can be soaked in thrombin solution. It is removed by liquefaction and phagocytosis over a period of 1 week–1 month. This product does not inhibit epithelialization and can be used over epithelial surfaces.
- **Fibrin glue:** It is a biological adhesive containing thrombin, fibrinogen, factor XIII and aprotinin. Thrombin converts fibrinogen to unstable fibrin clot, factor XIII stabilizes the clot and aprotinin prevents its degradation. During wound healing, fibroblasts move through the fibrin meshwork forming more permanent framework composed of collagen fibers. The product poses virtually no risk of transmission of viral infections because of pasteurization of the plasma components and has little or no antigenic potential.
- **Adrenaline:** Adrenaline or epinephrine, applied topically, induces vasoconstriction and thus helps in achieving hemostasis. Extensive application or undiluted preparation can cause systemic effects, therefore, one should be careful while using adrenaline. The drug is applied with the help of gauze pack in a concentration 1:1,000 over oozing sites. It can also be injected along with local anesthetic in concentration of 1:80,000–1:200,000. This drug should not be used in patients who have hypertension or previously existing cardiac disease. The vasoconstrictor effect is reversible and one should be careful to watch for recurrence of bleeding when its effect wears off.

Systemic agents

- **Whole blood:** When there is excessive blood loss due to hemorrhage, and there are symptoms of hypovolemic shock, whole blood transfusion may be indicated. Fresh whole blood contains all the factors for coagulation. When specific blood components are not available to treat the patient's hemostatic defect, whole blood may be used. It is necessary to type and cross-match the blood before transfusion. Blood must be checked for hepatitis B, C and human immunodeficiency viruses before transfusion. Banked blood is a poor source of platelets. Factors II, VII, IX and XI are stable in banked blood. Fresh whole blood refers to blood that is administered within 24 hours of its donation. Fresh whole blood is rarely indicated because of specific component therapy available these days. One unit of platelet concentrates has more viable platelets than one unit of fresh whole blood, but it is an inadequate source of factor VIII.
- **Platelet-rich plasma:** It is advisable to elevate the platelet levels to the range of 50,000–100,000 cells per cu mm to provide continued protection. Platelets can be collected from donated whole blood or directly from the donor via plasmapheresis. Platelet concentrates are viable for 3 days when stored at room temperature. If they are refrigerated, its viability decreases. They must be infused quickly via a short IV transfusion set with no filter. One unit of platelet-rich plasma raises the platelet count approximately by 7,000–10,000 cells per cu mm.
- **Fresh frozen plasma:** A unit (150 mL) of fresh frozen plasma (FFP) is usually collected from one donor and contains all coagulation factors including 200 u factor VIII, 200 u factor IX and 400 mg fibrinogen. FFP is stored at –30°C and should be infused within 2 hours once defrosted.
- **Cryoprecipitate:** A 15 mL vial of cryoprecipitate contains approximately 100 u factor VIII, 250 mg fibrinogen, factor XIII and Von Willebrand factor (VWF) and is stored at –30°C. Each bag of cryoprecipitate is derived from a single donor and is not treated to inactivate viruses. Therefore, the use of cryoprecipitate is associated with a substantial risk of viral transmission.
- *Adrenochrome monosemicarbazone and ethamsylate:* These systemic chemical agents are of doubtful efficacy. Adrenochrome monosemicarbazone (1 mg/mL injection) is given 2 mL/6 hourly before the surgical procedure. Ethamsylate reduces capillary bleeding in the presence of normal number of platelets. It probably acts by correcting abnormal platelet adhesion.

Control of Hemorrhage from Major Arteries

The best control of hemorrhage is directly at injured site and in majority of cases local measures can adequately control hemorrhage. One must always be prepared to tie off a major vessel, if bleeding cannot be controlled locally. Major vessels should be ligated in a planned surgical manner. If one is dealing with a vascular tumor, hemangioma or arteriovenous malformation, major feeding vessels should be exposed and ligature passed around the concerned vessels before proceeding for the surgery of the tumor, so that in case of inadvertent bleeding major vessel can be tied without any delay.

In order to control bleeding, the clinician must be able to visualize clearly the exact point of bleeding. This can be achieved with the help of good light source, adequate suction, adequate anesthesia and sound workable knowledge of the anatomy of the area concerned. One should approach bleeding problem with utmost confidence. Majority of times, the problem arises from inadequate preparation on the part of clinician before surgery, poor visibility in the operative field, poor cooperation from the patient, and incomplete armamentarium to implement the procedure.

Greater Palatine Artery

Greater palatine artery runs anteriorly from the greater palatine foramen in the submucosa of the hard palate in a groove between the horizontal palatine process of the maxilla and the inner plate of the alveolar process. The incisions over the palate should be made parallel, rather than perpendicular to this vessel. If accidental injury occurs, bleeding is copious and application of clamp is difficult. Most of the times, the hemorrhage can be controlled by a pressure pack. A round bolus of gauze is made of adequate size, so that it does not cause gagging. It is kept in place by tie over sutures for 24–48 hours. Pressure pack can be safely removed after 48 hours.

Sublingual Artery

Injury to sublingual artery can occur accidentally by rotating disks or slipping of sharp instrument, while working on mandibular teeth. Injury to this artery during mandibular implant placement has been reported and it may lead to large sublingual hematoma which, if not controlled, can compromise airway and may be life-threatening.

It is a small artery and local clamping of the artery and application of electrocautery usually controls the bleeding. There is anatomic variation in the origin of this artery. In most of the cases, it is a branch of lingual artery, but in significant number of cases, it is a branch of submental artery, which is a further branch of facial artery. So, sometimes ligation of lingual artery may not stop bleeding from sublingual artery. In that case, facial artery needs to be ligated.

Ligation of Lingual Artery

Lingual artery is second anterior branch of external carotid artery. It arises just below the facial artery or it can arise as a common linguofacial trunk, from the external carotid artery. Its exposure is done in submandibular triangle. Submandibular curvilinear incision is taken from the gonial angle to mental region, extending inferolaterally overlying hyoid bone. The skin, platysma and deep fascia are incised and lower pole of the submandibular gland is exposed. The gland is lifted upwards and tendon of digastric muscle is exposed. Mylohyoid and hyoglossus muscles are identified forming floor of digastric triangle.

Hypoglossal nerve is identified at the posterior border of mylohyoid muscle. Lingual triangle or Lesser's triangle is formed by digastric tendon, posterior mylohyoid border and the hypoglossal nerve. Within the triangle, vertical fibers of hyoglossus muscle are separated bluntly and in the gap between these fibers, lingual artery is identified and ligated.

Control of bleeding can also be achieved by ligating lingual artery at its origin from external carotid artery. Even by ligating external carotid artery bleeding can still continue because of rich venous supply and anastomosing arteries from opposite side. Expanding hematoma from lingual artery can compromise airway and sometimes tracheostomy is required.

Ligation of Facial Artery

Facial artery is third anterior branch of external carotid artery. It can be easily ligated at the point where it crosses lower border of mandible just anterior to masseter muscle. If patient is asked to clench the teeth, the pulsations of facial artery can be easily felt externally.

Facial vein accompanies the facial artery and lies posterior to it in majority of cases. Marginal mandibular branch of facial nerve crosses superficially over facial artery and vein. To prevent damage to this nerve submandibular incision is given 1–2 cm below the lower border of mandible. The skin, subcutaneous tissue, platysma and deep fascia are cut. These tissues are retracted upwards and here artery lies just anterior to masseter muscle. It is isolated, tied and cut.

Ligation of Maxillary Artery

The maxillary artery is terminal branch of external carotid artery. It is situated deep and direct ligation is difficult. Transantral approach for ligation of maxillary artery has been described. This artery is at risk during surgery of temporomandibular joint, as it lies medial to condylar neck. Ligation is difficult due to limited access. Direct pressure with packing can control the bleeding in majority of cases. If direct packing cannot achieve hemorrhage control, the ligation of external carotid artery becomes necessary.

Superficial Temporal Artery

It is also one of the terminal branches of the external carotid artery. Bleeding from temporal region (scalp) can be best managed by direct identification of the bleeding point and electrocoagulation. The pulsations of superficial temporal artery can be felt just anterior to preauricular region. This artery is usually encountered during surgery of the temporomandibular joint through the preauricular incision. The artery can be exposed through same incision as used for exposure of temporomandibular joint.

External Carotid Artery

The common carotid artery divides into internal and external carotid artery at the level of superior border of the thyroid cartilage. However, sometimes, this division can take place at the level of hyoid bone or slightly superior. The internal carotid artery is branchless in its vertical course in the carotid triangle. This point helps in differentiating of external carotid artery from the internal one.

The external carotid artery gives rise to three anterior branches, two posterior branches, one medial branch and two terminal branches. Superior thyroid artery, lingual artery and facial artery are anterior branches. Occipital artery and posterior auricular artery are posterior branches. Ascending pharyngeal artery is the medial branch. Maxillary artery and superficial temporal artery are the terminal branches. There is extensive anastomosis of all the branches of external carotid artery and the anastomoses of right and left arteries, across the midline. This means that unilateral ligation of these vessels will not stop the hemorrhage completely or will not allow dry bloodless surgery.

The external carotid artery can be ligated at two places depending on the site of bleeding. Firstly, external carotid artery can be ligated just above the origin of superior thyroid artery in carotid triangle. This will eliminate bleeding from all the branches of external carotid artery except the superior thyroid artery. Secondly, external carotid artery can be ligated higher up in retromandibular fossa, when bleeding is exclusively from the maxillary artery or its branches.

Ligation of External Carotid Artery in Carotid Triangle

The patient is placed supine and neck is extended and rotated towards contralateral side by placing a pillow below the shoulders. An incision is placed through skin and superficial fascia at the level of the hyoid bone. Next the platysma muscle and superficial layer of deep investing fascia is cut gaining an entry into the carotid triangle. Sternocleidomastoid muscle is retracted back and blunt dissection is done to expose the contents of carotid sheath. Pulsations of carotid artery can be felt and help in direction of dissection. Blue internal jugular vein covers the common carotid artery superficially. Lying between the two vessels and deep to them, there is yellow vagus nerve. External carotid artery is identified by its branching. Umbilical tape is passed and fixed superior to superior thyroid artery and its effect seen by occluding the artery. If need be, ligatures and transfixion sutures are passed.

Ligation of External Carotid Artery in Retromandibular Fossa

Retromandibular incision is planned. Skin is incised behind the ramus and angle of mandible starting at tip of mastoid process continued till just below the mandibular angle. Skin and platysma muscle are incised. Retromandibular vein, external jugular vein and branches of great auricular nerve are encountered and these are sectioned. Parotid gland is separated from anterior border of sternocleidomastoid muscle by sharp dissection and retracted. Posterior belly of digastric and above it stylohyoid muscle becomes visible. The mandible is pulled forward to widen the retromandibular fossa. Here pulsations of external carotid artery can be felt. Blunt dissection is done to expose the external carotid artery. Here it can be ligated.

Hereditary Coagulopathies Disorders

Ninety percent of inherited hemostatic disorders consist of Hemophilia A, B and VWD. Hemophilias are inherited disorders caused by a decreased activity or absence of coagulation factor VIII or IX. Hemophilia A is factor VIII deficiency and is most common. It occurs in 70–80% of the affected persons with hereditary coagulopathies, whereas, hemophilia B (Christmas disease, or factor IX deficiency) accounts for 6%.

Hemophilia A

The severity of the disease is dependent on the amount of factor present in the blood stream. Normal plasma contains 1.0 unit of a factor per milliliter or level that is defined as 100%. Deficiency of a factor is expressed as percentage (0.25 unit/mL = 25%). There is a close correlation between plasma factor VIII levels and severity of disease. Patients with less than 1% factor VIII activity have severe disease. They bleed frequently into soft

tissues, muscles and weight-bearing joints even without discernible trauma. Patients with levels between 1% and 5% have moderate disease with less severe bleeding episodes. Those with levels above 5% have mild disease with infrequent bleeding usually secondary to trauma or surgery. Majority of patients of hemophilia A have levels of factor VIII below 5%.

The recommended level of replacement therapy of factor VIII varies from 30 to 75%. For extensive surgical procedure, the levels of factor should be raised to 50–75%. Factor VIII has half-life of 8–12 hours, uncomplicated procedure may not require further replacement therapy. Each unit of factor VIII transfused is estimated to raise factor VIII levels 2% per kilogram of body weight. The following formula can be used to calculate the dose of Factor VIII needed to achieve desired plasma concentration:

$$\text{Dose of factor VIII in units} = (\text{desired \% activity} - \text{initial \% activity}) \times \frac{\text{weight in kg}}{2}$$

The more extensive procedures like surgical extraction or major oral surgery may require further infusion at 12–24 hours intervals and adequate levels of factor VIII may have to be maintained until healing is complete. **Table 50.2** summarizes the sources of factor VIII. Local hemostatic measures such as application of topical thrombin, Surgicel® or Gelfoam® is indicated. Stabilization of clot with antifibrinolytic drugs such as epsilon-aminocaproic acid (EACA) and tranexamic acid (5%) mouthwash four to six times daily is indicated. Analgesics such as aspirin and nonsteroidal anti-inflammatory drugs (NSAIDs) are contraindicated as they alter platelet function. Routine comprehensive dental care can be provided to the patients with hemophilia on an outpatient basis, if the practitioner is familiar with the type and severity of factor deficiency and plans accordingly. Surgical procedures should be done after admitting the patient and a minimum of 50% of normal levels should be maintained by daily monitoring of the patient. Supragingival scaling can be managed by a single infusion of cryoprecipitate or factor VIII concentrate coupled with administration of 4–6 g of EACA four to six times daily for 72–96 hours after the dental procedure. Inferior alveolar nerve block and posterior superior alveolar nerve block injections should be administered only after replacement therapy of factor VIII, because of possibility of a dissecting hematoma. EACA is a potent antifibrinolytic agent that inhibits plasminogen activators present in oral secretions and stabilizes clot formation in the oral tissues.

Table 50.2: Sources of factor VIII

Sources	*Concentration of factor VIII*
Fresh frozen plasma (blood bank)	1 unit/mL
Cryoprecipitate (blood bank)	5–10 units/mL or 80–100 units/bag of 10–15 mL
Plasma derived lyophilized factor VIII concentrate (commercially available)	250–500 units/vial
Genetically engineered factor VIII (commercially available)	250–500 units/vial

Tranexamic acid is a more potent and longer acting antifibrinolytic drug. It is available as both oral and parenteral forms. Intravenous dose is 10 mg/kg body weight, the dose being repeated 4–6 hourly. It can be used as 5% mouthwash (500 mg tablet dissolved in 10 mL of water) and this solution can be swallowed.

Development of antibodies to factor VIII occurs in 5–20% of the patients with deficiency of factor VIII and presents a major problem in treatment. These antibodies are generally IgG antibodies and act as inhibitors, because these rapidly neutralize factor VIII activity. Control of bleeding in patients with inhibitors may require either infusion of porcine factor VIII, which may not cross-react with inhibitors, or prothrombin complex concentrates, which contains trace quantities of activated factors and can bypass the inhibitor. This prothrombin complex is administered over a 30–60 minutes period and exhibits short duration of action. Local hemostatic measures are indicated; however, systemic EACA or tranexamic acid is contraindicated. Other methods of treating patients with inhibitors include plasmapheresis, which has been advocated in patients to reduce antibody titer, and a synthetic vasopressin analog desmopressin, which has been shown to produce increase in VWF and factor VIII activity. Conventionally, it is given in a dose of 0.3 µg/kg in 100 mL normal saline by intravenous infusion over 30 minutes.

Hemophilia B

Factor IX deficiency is clinically indistinguishable from factor VIII deficiency, therefore, accurate laboratory diagnosis is critical. It requires therapy with FFP or factor IX concentrates. Unlike factor VIII, which is maintained within the circulatory system, factor IX enters the extravascular space, from where it is released slowly. Therefore, there is more biologic half-life (32 hours) as compared to factor VIII. Replacement therapy consists

of raising the plasma level factor IX to 30–50% of normal by using FFP or prothrombin complex concentrates. Plasma infusion can begin 24–36 hours before the scheduled procedure due to long half-life of factor IX. This allows multiple units of plasma transfusion to be given without overloading the circulating system. Use of cryoprecipitate offers no advantage over plasma since it is not concentrated in plasma. The lyophilized factor IX concentrates have significant quantities of factors II and X and variable amount of factor VII, and have the potential for inappropriate thrombosis as well as risk of transmitting hepatitis. Local hemostatic measures are indicated. Systemic use of EACA or tranexamic acid can be done with plasma replacement therapy, but it is contraindicated with prothrombin complex concentrates.

Management of Patients with Von Willebrand Disease

Von Willebrand disease is an autosomal dominant inherited disorder of coagulation, that results from a quantitative or qualitative abnormality of the plasma protein, i.e. VWF. It is a glycosylated protein which is synthesized in endothelial cells of blood vessel and megakaryocytes.

Three Main Roles of VWF in Hemostasis

- It enables the binding of platelets to the subendothelial collagen matrix at the sites of vascular injury.
- It mediates subsequent platelet aggregation allowing the formation of platelet plug.
- It acts as carrier protein for factor VIII protecting it from proteolytic degradation.

The most common bleeding manifestations are easy bruising, epistaxis, gingival bleeding, menorrhagia and excessive bleeding postoperatively or after dental extractions. Patients with severe VWD may have hemophilic bleeding pattern with spontaneous bleed into joints and muscles. VWF activity can be measured by specific enzyme-linked immunosorbent assay.

There are three different types of VWD, which have been described depending upon quantitative, qualitative or complete deficiency of VWF.

1. **Type I:** Accounts for approximately 70% of VWD, typically mild decrease in quantity of VWF.
2. **Type II:** VWD results from qualitative abnormalities in the VWF. It has got four subtypes depending on defect in VWF protein. These subtypes are type II A, type II B, type II M, and type II N.
3. **Type III VWD:** In this type, patients have severe quantitative deficiency of VWF.

Patient with mild VWD respond favorably to desmopressin in a dose of 0.3 μg/kg in 100 mL; normal saline infused over 30 minutes. The response is rapid with maximum concentration reaching within one hour of administration. It results in 2- to 10-fold rise in plasma concentration of VWF and F VIII with a mean rise of 3-fold. People with baseline concentration greater than 10 IU/dL should respond favorably to desmopressin. Concentration usually falls to baseline within 12–24 hours. Further, daily dose of desmopressin can be given, if necessary. Patients undergoing minor surgery and dental extraction should be adequately covered with single infusion of desmopressin. To cover major soft tissue and hard tissue surgery, VWF and factor VIII concentration should be checked after infusion of desmopressin prior to surgery to ensure adequate response. It should be given postoperatively daily for at least 5 days and VWF activity and F VIII concentrations monitored daily after surgical procedure.

Type II B and type III of VWD do not respond to desmopressin and these patients can be managed by blood product replacement therapy. Fractionated virally inactivated factor VIII concentrates have good concentration of VWF and provide adequate hemostasis. When these products are not available, FFP and cryoprecipitate can be used.

Local hemostatic measures and use of antifibrinolytic agents such as tranexamic acid can be used. An appropriate antibiotic should also be given to minimize risk of infection that may cause secondary hemorrhage. Aspirin and other NSAIDs should not be prescribed for pain relief because they exacerbate hemorrhage by disturbing platelet function.

Acquired Coagulation Factor Disorders

Vitamin K Deficiency

Vitamin K is a necessary cofactor for carboxylation of factors II, VII, IX, X. Vitamin K deficiency results in abnormal blood coagulation and bleeding. Vitamin K deficiency can occur in biliary obstruction, malabsorption syndrome, prolonged antibiotic therapy, nutritional deficiency and warfarin ingestion. Hospitalized patients who are unable to eat and are receiving antibiotics that suppress intestinal flora may become vitamin K deficient in 1–2 weeks. PT is usually prolonged.

Deficiency can be usually corrected by administration of vitamin K injection 10 mg for 1–3 days. Intravenous administration of vitamin K has been associated with anaphylaxis in rare patients; therefore, it should be

given in a closely monitored setting. Patients with severe hemorrhage due to vitamin K deficiency can be managed by transfusing FFP.

Coagulopathy Associated with Liver Diseases

Severe liver disease causes decreased synthesis of fibrinogen, prothrombin and factors V, VII, IX, X and XI. Thrombocytopenia due to accompanying hypersplenism may complicate the hemostatic defect. Bleeding in a patient with liver disease presents a difficult therapeutic problem. Empirical therapy with vitamin K injection may be tried, although majority of patients will not respond. Replacement therapy with FFP is indicated in such a patient, and platelet transfusion may be considered if thrombocytopenia is present.

Management of a Patient on Oral Anticoagulants and Antiplatelet Drugs

Antiplatelet drugs are used to prevent and treat many cardiovascular disorders such as heart attack and stroke. Aspirin, clopidogrel and ticlopidine, dipyridamole are most widely prescribed antiplatelet drugs. Many patients who have increased risk of thrombosis are prescribed two antiplatelet drugs. Prasugrel and ticagrelor are newer antiplatelet drugs, which increasing numbers of physicians have started prescribing for antithrombosis. Most common indications for anticoagulant therapy are prevention of thromboembolism from prosthetic heart valves and arrhythmias, prevention of stroke, and prevention of deep venous thrombosis. Warfarin (Coumarins) and its derivatives are the most commonly prescribed oral anticoagulants. Recently new oral anticoagulants such as dabigatran, rivaroxaban, apixaban and edoxaban have been launched, which do not require regular monitoring with international normalized ratio (INR).

Antiplatelet drugs may prolong bleeding time after surgery and the surgeon is tempted to stop or reduce dosage of these medications before surgical procedure. Systematic reviews and meta-analysis of published literature especially on aspirin and clopidogrel has consistently shown that there is no need to stop these medications for patients undergoing single or multiple dental extractions. The risk of stopping these medications far outweighs the excessive bleeding risk. A thromboembolic event such as myocardial infarction or stroke is potentially life-threatening whereas, bleeding from dental extraction or oral surgical wound can be easily controlled with local hemostatic measures. The procedures that carry a significant risk of excessive bleeding such as major surgery under general anesthesia may require cessation of antiplatelet medication 5–7 days prior to the surgical procedure. In certain cases if patient is on dual antiplatelet therapy one of the drugs can be discontinued, where the surgical procedure carries significant risk of bleeding. The patient's physician must be consulted prior to altering or stoppage of antiplatelet or anticoagulant therapy and it should be started as the surgical wound starts to heal and risk of bleeding reduces.

The PT has been the conventional means used to monitor the degree of anticoagulation. Prothrombin ratio (PTR) is the ratio of patient's PT divided by control PT from the laboratory. A PTR of 2 to 2.5 is considered to be the therapeutic range. World Health Organization (WHO) has recently recommended monitoring of these patients with INR, because PT has been shown to be not precise and variable. There is little comparability of PT values taken in different laboratories. These differences are primarily due to the thromboplastin used in performing the test as thromboplastin can be obtained from different sources and the type of instrumentation used in performing the test.

In an effort to standardize the results of the PT, the WHO introduced the concept of INR. INR is the PTR that would have been obtained if a standard thromboplastin reagent had been used. The INR relates all thromboplastins to the standard of human brain thromboplastin with the use of internal sensitivity index (ISI). The ISI established the reference standard of 1.0 to human brain derived thromboplastin.

$$INR = (\text{patient's PT}/\text{control PT})^{ISI}$$

With the use of INR variations due to differences in nature of source and potency of thromboplastin has been standardized. INR for a normal healthy adult is 1.0. Recommended intensity of INR for patients on oral anticoagulants varies from 2.0 to 4.5 depending on indication for use. For example, recommended INR for deep vein thrombosis, valvular heart disease, pulmonary embolism, myocardial infarction is 2.0 to 3.0 and in case of artificial mechanical heart valve is 3.0 to 4.5.

Many patients seeking dental treatment are on oral anticoagulant therapy. Extraction of teeth is generally considered a good test of the efficacy of the hemostatic mechanism, as both hard and soft tissues are torn during the process, and usually there is no primary closure of soft tissues. The clinician who is faced with warfarinized patients requiring extraction has to balance the risk of reducing or stopping the anticoagulant therapy with that of excessive bleeding from the extraction sockets.

Bleeding can be troublesome and excessive bleeding into the soft tissues particularly sublingual, retropharyngeal areas can compromise the upper airway. On the other hand stoppage of anticoagulation therapy puts the patients on greater risk of thromboembolism, which is potentially life-threatening.

There is no current consensus on how to manage these patients. Each patient has to be individually assessed and risks and benefits of stoppage of therapy or altering the therapy are assessed in consultation with the treating cardiologist or physician.

In patients, where stoppage of anticoagulant therapy can lead to significant risk of thromboembolism, they are shifted to heparin therapy after stoppage of the oral anticoagulant and then surgical procedures are carried out. Current literature suggests that, if INR of prothrombin is below 3.5, then simple extractions can be done safely without altering the oral anticoagulant therapy. Hemostasis can be achieved with the use of local hemostatic measures and use of topical antifibrinolytic agent such as 5% tranexamic acid mouthwash.

SHOCK

Shock is a pathophysiologic condition, clinically recognized as a state of inadequate perfusion. Due to inadequate blood flow, there is inadequate delivery of nutrients to the tissues and inadequate removal of cellular waste products from the tissue cells, which results in disruption of vital organ functions. In late stage, even the cardiovascular system itself begins to deteriorate, so that the shock becomes progressively worse. Early identification and elimination of the underlying cause of shock usually reverses the chain of events resulting from cellular dysfunction. Delay in treatment may result in permanent cellular and organ damage leading to irreversible shock and ultimately death. Shock can be classified mainly into four types based on pathophysiology and hemodynamic changes.

Classification

1. Hypovolemic shock
2. Cardiogenic shock
3. Septic shock
4. Neurogenic shock.

Hypovolemic Shock

Hypovolemic shock results from a decrease in the circulating or effective intravascular volume. It is the most common type of shock in the victim of maxillofacial trauma. Hypovolemic shock can be further classified into hemorrhagic and nonhemorrhagic.

- Hemorrhagic shock is due to loss of blood from the body as a result of injury. Hemorrhage decreases the mean systemic filling pressure and a resultant decrease of venous return and there is fall of cardiac output. Approximately 10–15% of the total blood volume loss will have no significant effect on arterial pressure or cardiac output. 15–25% loss of blood volume may not cause hemodynamic change, if the blood loss is not rapid, but the metabolic changes associated with shock may be initiated. Rapid loss of 30–40% of the blood volume causes shock and if not treated, it becomes progressive and may lead to death.
- In nonhemorrhagic shock, there is massive fluid shift from intravascular compartment to extravascular compartment. This can result from burns, crush injuries, pancreatitis, peritonitis, pleural effusion and ascites. Water loss due to severe diarrhea, vomiting, diabetes insipidus, hyperglycemia, nephritis and excessive diuretic use can also lead to nonhemorrhagic hypovolemic shock.

Decrease in arterial pressure caused by blood loss, stimulates powerful sympathetic reflexes, that result in constriction of arterioles, veins and venous reservoirs and there is an increase in heart activity. The body tries to maintain cardiac output and arterial pressure to normal levels. There is formation of angiotensin and vasopressin, which constricts the peripheral arteries and causes increased conservation of water and salt by the kidneys. If body reflex mechanisms are not able to raise the arterial pressure sufficiently and no urgent intervention is done by replacement of fluids, there is depression of myocardium and vasomotor center. Blood flow through the tissues becomes sluggish, there is accumulation of acids due to continued tissue metabolism. These acids and other deterioration products from the ischemic tissues, cause blood agglutination in the capillaries. Due to prolonged hypoxia, the permeability of capillaries gradually increases and large quantities of fluid transude into the tissues. This further decreases blood volume and there is generalized cellular deterioration, generalized and local tissue acidosis and tissue necrosis in vital organs. This leads to a vicious cycle, i.e. each increase in degree of shock causes a further increase in the shock. After the shock has progressed to a certain stage, transfusion or any other therapy becomes incapable of saving the life of the person. Therefore, the person is said to be in irreversible stage of shock.

Table 50.3: Clinical manifestations of shock

Blood loss	*Clinical manifestations*
Mild less than 20%	Postural hypotension; patient feeling cold; tachycardia; cool, pale, moist skin; collapsed neck veins; concentrated urine
Moderate more than 20–40%	Thirst; supine hypotension and tachycardia; oliguria or anuria
Severe more than 40%	Agitation, confusion; supine hypotension and tachycardia are invariably present; rapid deep respiration

Therefore, it is prudent that the oral surgeon "should be able to recognize early features of shock". Physiologic response to hemorrhage ranges from tachycardia, poor capillary perfusion, and a decrease in pulse pressure to hypotension, tachypnea, and delirium. Serum hematocrit and hemoglobin concentrations are not accurate indicators of acute blood loss. "The degree of hypotension" on presentation to emergency room and operating room "correlates strongly with mortality rate".

Table 50.3 gives clinical manifestations of shock depending on the loss of blood volume.

Monitoring

Whenever possible, patient should be treated in intensive care unit. Vital signs should be monitored periodically. Continuous electrocardiography, pulse oximetry should be performed. Blood pressure and heart rate should remain stable. Tachypnea, worsening of hypotension and tachycardia indicate inadequately treated shock.

Urine output should be measured and it should be greater than 40 mL/hour. Arterial blood gases, pH and electrolyte levels are monitored.

Central venous pressure should be monitored. In patients with moderate and severe shock, fluid therapy is monitored by right heart catheterization with a balloon tipped, flow directed (Swan-Ganz) catheter. This not only provides diagnostic hemodynamic assessment of pulmonary capillary wedge pressure and cardiac output, but also helps in monitoring the response to therapy.

Treatment

Replacement of fluids and tissue perfusion are the mainstay of the treatment of shock. Volume resuscitation must be undertaken promptly. The legs raised and body supine is the preferred posture, as this increases venous return and cardiac index. In addition to this, the patient should be kept warm.

Fluid replacement: When hemorrhage is massive, type specified matched transfused blood is the preferred method to correct hypovolemia. Typing and cross-matching of blood takes time sometimes. Uncrossed type O –ve blood should be reserved for life-threatening blood loss that cannot be adequately replaced by other fluids. Initial resuscitation is done with crystalloids, such as normal saline or Ringer's lactate. It requires up to several liters of fluids, but replacement of interstitial fluid with crystalloids is preferred. After initial resuscitation, colloids such as albumin or starch solution can be used, as these restore intravascular volume more effectively. All these fluids should be warmed before transfusion, because hypothermia worsens acid-base disorders, and myocardial function. The amount of fluid administration is based upon improvement of clinical signs, particularly, blood pressure, pulse pressure and heart rate. Central venous pressure and urinary output also provide indication of restoration of vital organ perfusion. Hypotension in patients with hypovolemic shock should be aggressively treated with intravenous fluids and not vasopressors. Exception to this dictum includes cardiogenic shock, severe hypotension unresponsive to fluid replacement and cardiac arrest. The role of vasopressors is further discussed in septic shock.

Cardiogenic Shock

Cardiogenic shock occurs as a result of inadequate cardiac output, impaired oxygen delivery, and reduced tissue perfusion, caused by loss of effective contractile function of myocardium (acute myocardial infarction, hemodynamically significant brady- or tachyarrhythmias, cardiomyopathy) or from mechanical processes, reducing adequate forward output (acute valvular regurgitation, acute ventricular septal defect, critical aortic stenosis). Pulmonary artery wedge pressure is elevated (>18 mm Hg), cardiac output is decreased (cardiac index < 2.0 l/min/m^2), peripheral vascular resistance is increased, and mean arterial pressure is less (<60 mm Hg). Initial treatment is directed towards identifying the cause, maintaining adequate systemic blood pressure, cardiac output and tissue perfusion with volume expansion and inotropic drugs. Dopamine is the vasopressor of first choice. It is diluted in normal saline or 5% dextrose drip and given at 5–10 μg/kg/min. Other drugs like norepinephrine and dobutamine can be used.

Septic Shock

Septic shock describes the clinical syndrome corresponding to acute circulatory failure resulting from

serious infection. Mostly, it is provoked by Gram-negative bacteria, but fungi, viruses and parasites can also lead to septic shock. This presents as arterial hypotension (systolic blood pressure below 90 mm Hg or mean arterial pressure below 60 mm Hg) associated with altered mental status, changes in organ perfusion and signs of organ failure, such as reduction in urine output, increased blood lactate levels (>2 mEq/L) reflect alteration in cellular metabolism. Septic shock is extremely important to the clinician, because it is this type of shock, which has higher mortality in the hospital.

Development of sepsis is related to complex interplay between endotoxins, release of pro- and anti-inflammatory mediators, like tumor necrosis factor-alpha, interleukins and prostaglandins. The pathophysiology of septic shock involves an extremely complex interplay between tissue hypoxia and the host's immune response. Most frequent cause of death is sepsis-induced multiorgan failure, e.g. acute respiratory distress syndrome, renal failure, and disseminated intravascular coagulopathy. Due to severe sepsis, there is increased oxygen demand, because of direct cellular activation, hormonal stress response and hyperthermia. There is altered oxygen extraction and oxygen transport.

Management of septic shock should be based on: (1) early and effective volume replacement; (2) restoration of tissue perfusion; (3) adequate oxygen supply to cells and; (4) control of infection with antibiotic therapy and control of source of infection.

In most patients, systolic blood pressure of 90–100 mm Hg or a mean arterial pressure of 70–75 mm Hg is acceptable. In minor cases, fluid administration alone can be sufficient to restore hemodynamic stability. In majority of cases, administration of a vasopressor is required to increase arterial pressure. Dopamine or noradrenaline should be selected for this purpose. Dopamine is usually the first choice, because it can better maintain organ blood flow, preserving renal and mesenteric circulation. If hypotension still persists, despite dopamine administration at doses of 20–25 μg/kg/minute, noradrenaline should be added to regimen. Once minimal tissue perfusion pressure has been restored, attention should focus on the restoration of a sufficient oxygen delivery to the tissues. The maintenance of a hemoglobin saturation in the arterial blood (SaO_2) above 95% is a fundamental goal in any type of acute circulatory failure. This implies that arterial oxygen tension (PaO_2) should be above 60 mm Hg. Hematocrit should be maintained above 30%. Myocardial depression can limit oxygen supply to tissues, even when cardiac output is normal or elevated. The addition of dobutamine, in this condition, has been shown to be effective. Use of dobutamine should result in increase in cardiac output, but no change in arterial pressure, so that systemic vascular resistance will decline resulting in restoration of oxygen delivery to tissues.

Neurogenic Shock

Occasionally shock results without any loss of blood volume whatsoever. Instead, the vascular capacity increases so much that even the normal amount of blood becomes incapable of adequately filling the circulatory system. One of the major causes of this is loss of vasomotor tone throughout the body, causing massive dilatation of veins, and the resulting condition is known as neurogenic shock. "Vasovagal syncope" or emotional fainting most commonly seen in dental clinics is caused by excitation of the parasympathetic nerves to the heart and vasodilator nerves to the skeletal muscle, thereby slowing the heart and reducing the arterial pressure. There is a decrease in cerebral blood flow below a critical level and the patient usually falls down. Consciousness returns almost immediately, and within a short period of time, the victim appears to be completely recovered. The early signs and symptoms include pale or ashen gray skin, heavy perspiration, nausea, tachycardia and feeling of warmth in neck or face. The late symptoms show coldness in hands and feet, hypotension, bradycardia, dizziness, visual disturbance, pupillary dilation, hyperpnea and loss of consciousness. Duration of the syncope is extremely brief, once the patient is placed in supine position. Placing the patient in supine position is the most important and first step in the management. This increases the blood flow from the periphery to the cerebral tissues thus aiding in recovery.

Points to Remember

- Types of hemorrhage
- Hemostasis
- Clinical evaluation of a bleeding patient
- Laboratory tests for screening
- Different hemostatic agents
- Control of hemorrhage from major arteries
- Hereditary coagulopathies disorders
- Management of a patient on oral anticoagulants and anti-platelet drugs
- Shock-classification, monitoring and management.

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CHAPTER 51 Management of Medical Emergencies in Dental Clinic

INTRODUCTION

Medical emergency is defined as a sudden unexpected condition demanding urgent attention and treatment. Medical emergencies in dental clinic do occur and it can happen while performing treatment or by chance when patient or accompanying person is sitting in waiting area. If a medical emergency is not recognized and managed appropriately it can lead to significant morbidity and mortality. Therefore, dental clinic must be well-equipped and dentist and the support staff must be adequately trained to handle any medical emergency, including provision of basic life support (BLS) in an effective manner.

This chapter aims to provide an overview of measures for preparing a dental clinic and staff to handle commonly occurring medical emergencies.

RECOGNITION OF PATIENT AT RISK

Medical emergency can happen to anybody, but it is important to recognize patients at risk, so that treatment plan can be modified and appropriate measures are taken. A thorough medical history and drug history is mandatory and should be taken by the dentist in person. Several medical history questionnaires are available or one can formulate a standard history sheet and it can be filled by patients or supporting staff. The dentist should review the questionnaire and take appropriate dialogue history. The main goal is to evaluate current health and identify the medical treatments, allergy risk and the drugs being taken by the patient.

After thorough medical history, a detailed physical examination should be carried out; this includes evaluation of vital signs such as pulse, blood pressure, respiration and temperature. American Society of Anesthesiology (ASA) system of grading the physical status of patient into ASA I, II, III and IV is a good risk indicator for developing complications. ASA grade III and IV patients are at more risk of developing complications. Therefore, a medical review or consultation with treating physician may be required before treating these patients.

Anxious and apprehensive patients are at risk of developing syncope and hyperventilation. Recognition of signs and symptoms of fear and anxiety in these patients is very important to avoid complications. A suitable stress reduction protocol including pharmacological sedation may be needed to treat these patients.

DRUGS AND RESUSCITATION EQUIPMENT

Preparation of emergency kit is a well thought process and each clinician should prepare it with utmost diligence depending upon needs and training level. The team should be familiar with the equipment, appropriate dosages and routes of administration of the drugs. Each member of the team should have completed BLS provider course. It is recommended that an oral and maxillofacial surgeon should take advanced cardiac life support (ACLS) provider course. The dentist and dental nurse should be able to give intramuscular and intravenous injections. American Heart Association (AHA), Red Cross and American Dental Association run online BLS and ACLS courses for healthcare professionals. Many institutions have dedicated teams which train healthcare professionals for these courses.

Essential Drugs to be included in Emergency Kit

Tables 51.1 and **51.2** summarizes the list of drugs to be kept in emergency kit. These drugs should be kept preferably in a designated crash cart **(Fig. 51.1)**. If there is lack of space, then these drugs and equipment can be kept in a large tray or box which should be readily available and can be transported quickly **(Fig. 51.2)**.

Table 51.1: Essential drugs to be included in emergency kit

Serial no.	Drug	Indication	Dosage and route
1.	Epinephrine 1:1,000: 1mg/mL Epinephrine 1:10,000; 0.1 mg/mL	Anaphylaxis Cardiac arrest	0.3 mL IM, 1 mg (10 mL) in 5 minutes. 10 mL IV 1:10,000 in cardiac arrest
2.	Pheniramine maleate (22.5 mg/mL)	Allergy	1–2 mL, 45 mg IM, or IV
3.	Nitroglycerin (0.4 mg tablets)	Angina	Sublingual over 5 minutes. Maximum of 3 tablets in 15 minutes. Tablet not to be swallowed or chewed
4.	Ephedrine (50 mg/mL)	Hypotension	IV 0.1–0.2 mL over 2–3 minutes maximum dose of 50 mg or 0.5 mL IM or sublingual injection
5.	Atropine (0.5 mg/mL)	Bradycardia	0.5 mg sublingual injection or 0.5 mg IV over 2–3 minutes. Maximum dose 3 mg
6.	Salbutamol (inhaler)	Bronchospasm in asthma and allergy	2–3 inhalations over one 2 minutes and can be repeated as per need
7.	Hydrocortisone (100 mg/mL)	Allergy	IM or IV 100 mg stat
8.	Glucose or sugar cubes (50 g)	Hypoglycemia	In a conscious patient can be asked to chew or drink
9.	Normal saline or Ringers lactate 500 mL bottles	Hypotension	IV , 25–30 mL/kg
10.	Distilled water ampoules (5–10 mL per ampoule)		For dissolution and dilution of certain drugs

Table 51.2: Optional drugs and drugs for clinician with advanced training

Serial no.	Drug	Indication	Route and dosage
1.	Esmolol (10 mg/mL)	Hypertension, narrow complex arrhythmias, supraventricular tachycardia	0.5 mg/kg over one minute or 10–20 mg (1–2 mL) increments IV every 1–2 minutes. To be titrated
2.	Naloxone (0.4 mg/mL)	Opioid toxicity	0.2–0.4 mg IV over 2–3 minutes or titrate. Maximum dose 0.8 mg
3.	Flumazenil (0.1 mg/mL)	IV Benzodiazepine overdose reversal	0.2 mg over 2–3 minutes Maximum 1 mg IV
4.	Dextrose 50%	Hypoglycemia	25–50 mL IV
5.	Glucagon (1 mg/mL)	Hypoglycemia	1 mg IM/SC/IV
6.	Aspirin 75 mg tablets	Myocardial infarction	4 tablets to be chewed and swallowed
7.	Diazepam (5 mg/mL)	Seizure/status epilepticus	10 mg IV over 2 minutes
8.	Aromatic ammonia (granules or vaporoles)	Vasovagal syncope	To be inhaled

Instruments and Equipment

Following instruments and equipment are recommended for effective management of various medical emergencies.

Automatic External Defibrillator

Every clinic should have an automatic external defibrillator (AED). It is most important equipment to reverse the ventricular fibrillation to normal cardiac rhythm **(Fig. 51.3)**.

Oxygen Source/Cylinder and Delivery Devices

Oxygen is the most important emergency lifesaving gas. In a large hospital setting. there should be provision of central piped oxygen supply and delivery **(Fig. 51.4)**. In a small dental clinic an E type oxygen cylinder with flow meter and Ventimask® should be available on wheels **(Fig. 51.5)**. An E type fully filled cylinder can provide oxygen at the flow rate of 6 L/min for approximately 2 hours.



Fig. 51.1: Well-equipped designated crash cart for handling medical emergencies



Fig. 51.4: Centralized pipe line outlet for oxygen. Suitable for multichair setup

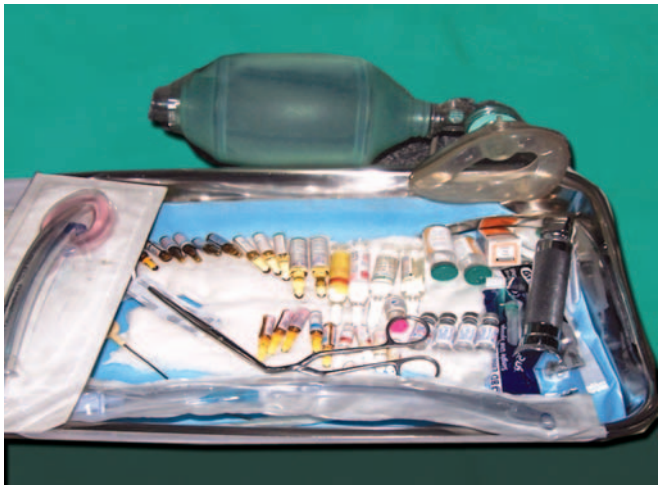


Fig. 51.2: Large tray serving as emergency kit



Fig. 51.5: E type oxygen cylinder on wheels with attached flow meter, humidifier and tubing



Fig. 51.3: Automatic external defibrillator (AED)

Face Masks

Various sizes of masks should be available to deliver oxygen **(Fig. 51.6)**. These can be attached to bag-valve device.

Bag-Valve-mask Device (Ambu Bag)

It is a useful tool for providing room air positive pressure ventilation to unconscious victim **(Fig. 51.6)**. These can also be attached to oxygen source for further enrichment of room air with oxygen.

Oropharyngeal and Nasopharyngeal Airways

These are required to maintain patency of the airway during ventilation in an unconscious patient **(Fig. 51.7)**.



Fig. 51.6: Ambu bag: Bag-valve-mask device for positive pressure ventilation and various sizes of face masks



Figs 51.7A and B: Oropharyngeal airway and nasal prongs with tubing



Fig. 51.8: Endotracheal tubes, Magills forceps and Macintosh laryngoscope

Magills Forceps

It is a useful tool for assisting orotracheal and nasotracheal intubation. It can also be used to pick up the foreign body from the oropharynx **(Fig. 51.8)**.

Laryngoscope

It is used to visualize the larynx at the time of intubation **(Fig. 51.8)**.

Endotracheal Tubes

These are used for orotracheal or nasotracheal intubation. Various sizes are available and No. 7 or 8 is used in adults **(Fig. 51.8)**.

Supraglottic Airway Devices: Laryngeal Mask Airway

These are very helpful in securing the airway as these are designed to be inserted blindly and is useful for prehospital use or when the operator lacks the skill for endotracheal intubation. It comes in various sizes and No. 3 or 4 is suitable for use in adults **(Fig. 51.9)**.

Pulse Oximeter

It is noninvasive tool to measure oxygen saturation with the help of a finger probe **(Fig. 51.10)**.

Glucometer

It is very handy to measure blood glucose level chair side. After pricking the finger with a 26 G needle, a drop of blood is placed over glucose strip to know the blood glucose level instantly.

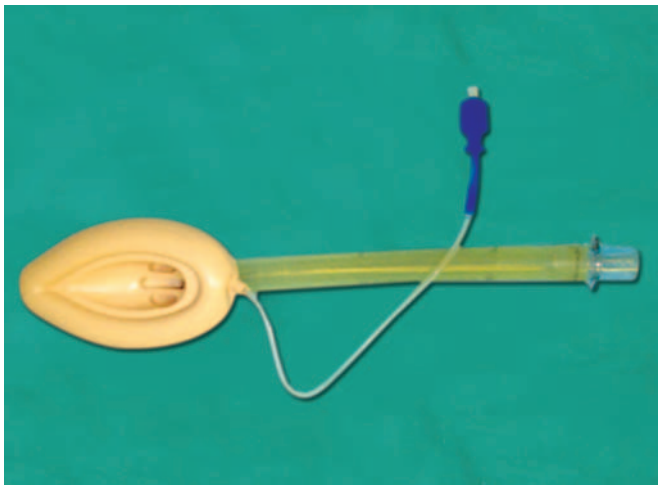


Fig. 51.9: Laryngeal mask airway



Fig. 51.10: Pulse oximeter

Stethoscope

It is used to auscultate breath and heart sounds. It is also used during manual blood pressure monitoring with sphygmomanometer.

Sphygmomanometer: It is a tool to measure blood pressure.

Syringes and Needles

Disposable syringes and needles are used to prepare and administer drugs via intramuscular (IM), intravenous (IV) and sublingual route.

Intravenous cannula: It is used to gain IV access for administering various fluids and drugs. It comes in various sizes. 18–22 G four cannulas of different sizes should be kept in emergency kit.

Adhesive tape: It is used for fixation of IV cannula and airway.

Gauge and antiseptic solution: It is used for preparation of skin before injection.

Intravenous stand and intravenous blood transfusion tubing set: The stand is used to hang fluid bottles. IV tubing set is used to attach fluid bottle to IV cannula.

Cricothyrotomy Set

It is used for doing emergency cricothyrotomy. Commercially available cricothyrotomy set is preferred as it is minimally invasive. Cricothyrotomy can also be done surgically with just two instruments—scalpel and nasal speculum.

Vital Sign Monitor

It is used for monitoring vital signs such as blood pressure, electrocardiogram (ECG) and oxygen saturation.

Torch

It can be used to see pupillary reflexes.

Suction Apparatus with Suction Tips

It is used for suctioning the oral secretions, vomitus or foreign body

Administration of the Drugs

Epinephrine

Epinephrine is a direct adrenergic agonist. Its administration is indicated in patients with cardiac arrest, symptomatic bradycardia, severe hypotension, bronchospasm and anaphylaxis. In situations other than cardiac arrest such as asthma and anaphylaxis, it should be used with great caution as it can induce ventricular arrhythmias. Therefore, it should be used via IV route in small carefully titrate doses. It is available in ampoules at a concentration of 1:1,000 (1 mg/mL). During cardiac arrest epinephrine is administered as an IV bolus of 1mg (diluted in 10 mL of saline or in 1:10,000 concentration). This is followed by flushing the line with 20 mL of normal saline so that the drug reaches the circulation. The dose can be repeated every 3–5 minutes during cardiopulmonary resuscitation (CPR). For profound bradycardia or hypotension, epinephrine dose is 2–10 μg/



Fig. 51.11: Oxygen administration via face mask

min, infusion titrated to patient's response. It can be used via intratracheal route when the patient is intubated. In asthma and allergy 0.3 mg of 1:1,000 can be given via IM route.

Oxygen and oxygen delivery: Oxygen is essential for human metabolism and lack of oxygen is fatal within 5–6 minutes. Oxygen has almost no adverse effects in acute situation and should not be withheld if there is any suggestion of it being needed. Indications for oxygen therapy include cardiac or respiratory arrest, angina, myocardial infarction and hypoxia of any cause. Whenever possible, oxygen therapy should be monitored with pulse oximeter. General aim is to keep blood saturation above 90%.

Intranasal prongs provide oxygen concentration of 25–40% and should be used with oxygen flow rate of 1–4 liters per minute. Nasal prongs are suitable only for cases with mild hypoxia. Face mask provide oxygen concentration between 35% and 70%. The oxygen flow rate should be set between 4 liters and 15 liters per minute. When using face mask oxygen flow rate should be always kept above 4 L/min **(Fig. 51.11)**. This method of delivery is suitable for moderate hypoxia.

Diazepam

Diazepam is safe and effective first line drug in the treatment of epileptic seizure. It is given intravenously as IM route is painful and unpredictable. The usual IV dose is 0.1 mg/kg. The dose needs to be titrated as excessive dose can lead to respiratory depression.

Salbutamol

Salbutamol is a beta-2 adrenergic agonist. The main use of this drug is for bronchial asthma. It is best given in the inhaled form via inhaler or a nebulizer. It may be given via this route as often as necessary. The main side-effects are tachycardia, tremor and anxiety. The upper limit is defined in each patient by the adverse effects of tachycardia and tremor. IV route may be occasionally required in severe asthma with marked airway obstruction.

Normal Saline

The 0.9% saline contains 154 mmol per liter of sodium chloride. It is isotonic and iso-osmolar. It is fluid of choice in treatment of hypovolemia. It can be used for preparation and dilution of various drugs before administration. It is available in 500 mL bottles.

Atropine

Atropine is used in the treatment of asystole and severe bradycardia. It acts to block the effects of the vagus nerve on the heart. A dose of 3 mg in an adult produces complete atropinization, blocking all cholinergic receptors. The main adverse effect of atropine is to produce a sinus tachycardia which may be harmful in ischemic heart disease. Usual dose is 0.5 mg intravenously as bolus in asystole and sinus bradycardia.

Pheniramine Maleate

It is antihistaminic drug and reverses the action of histamine by blocking H1 receptors. It is effective in patients with mild to late onset allergic reactions. Usual dose is 22.5–45 mg (1–2 mL) via IV or IM route.

Nitroglycerin

It is available in various forms such as long-acting oral tablets, transmucosal patches, transcutaneous patches and IV solutions. The appropriate form for dental clinic is sublingual tablet and sublingual spray. It is drug of choice for managing episode of chest pain with a history of angina pectoris. It acts by relaxing vascular smooth muscle, dilating systemic blood vessels, decreasing venous return and vascular resistance. These actions combine to decrease oxygen requirement of heart.

The clinician should administer one tablet or sublingual spray (0.4 mg). The drug can be repeated thrice at interval of 5 minutes. Usually relief occurs within 1–2 minutes. If there is no relief then diagnosis of evolving myocardial infarction may be thought. Nitroglycerin causes

hypotension, therefore it should be given with caution when systolic blood pressure is below 90–100 mm of Hg.

Hydrocortisone

It has marked mineralocorticoid effects. It can be useful in asthma and anaphylaxis. The beneficial effects of it are delayed for several hours, therefore, it has got very little role in acute emergency. Its usual dose is 100 mg intravenously. It prevents relapse of symptoms in case of asthma and anaphylaxis.

Dextorse 50%

25–50 mL of dextrose can be given via IV route to correct hypoglycemia in an unconscious diabetic patient.

Esmolol

Esmolol is a beta adrenergic receptor blocker with a short duration of action (half-life less than 10 minutes). It is indicated for short-term treatment of tachycardia and hypertension. Esmolol is available as 100 mg/mL solution, which is diluted to 10 mg/mL prior to administration. An initial IV dose of 0.25 mg/kg of body weight (17.5 mg for a 70-kg patient), the drug decreases blood pressure by an average of 11/7 mm Hg.

Distilled Water

It is available in 5–10 mL ampoules. It is used for preparation of various medications for administration via parenteral route.

Ephedrine

It is an alpha and beta adrenergic drug and also stimulates endogenous norepinephrine release. Its action is similar to epinephrine, but is much longer and less powerful. It improves venous return and improves cardiac contractility. Therefore, it is indicated in management of hypotension. It is available in 1 mL ampoules containing 50 mg/mL. It can be injected IM or sublingually in dose of 25 mg (0.5 mL). Alternatively, it can be given intravenously with the help of tuberculin syringe 0.1–0.2 mL every 2–3 minutes carefully with close titration of blood pressure and heart rate.

Glucagon

It raises blood glucose levels by converting liver glycogen onto glucose. Glucagon will not reverse the hypoglycemia, if liver glycogen stores are depleted. It should be given when patient is unconscious due to hypoglycemia and not able to drink or chew sugary product. It is available as 1 mg of powder to be prepared with 1 mL of distilled water and injected IM or IV. Once patient regains consciousness, sugar should be given by oral route.

Naloxone

Naloxone is a specific opioid antagonist that reverses opioid induced respiratory depression. This drug should be available in clinics where sedation or general anesthesia with help of opioids is practiced. It is available as 0.4 mg/mL formulation in single and multidose vials. Its conventional dose is 0.4 mg (1 mL) by IM or IV route.

Flumazenil

Flumazenil is a specific benzodiazepine antagonist that reverses sedation and respiratory depression caused by benzodiazepines. It should be available in clinics where pharmacosedation with benzodiazepines such as midazolam is practiced. It is available as 0.1 mg/mL in 5–10 mL multidose vials. Dosage for reversal is 0.2 mg (2 mL) administered IV every 1–2 minutes to a maximum of 1 mg.

Aspirin

Aspirin is an antiplatelet drug which has been found to decrease mortality in case of evolving myocardial infarction. 150–300 mg of drug should be chewed and swallowed for quick absorption.

Aromatic Ammonia

Aromatic ammonia is a commonly used respiratory stimulant and is usually given to patients experiencing vasovagal syncope. It is available as granules and is kept in a closed container. In some countries vaporoles are available which are crushed and patient is asked to inhale. Aromatic ammonia has a noxious odor and irritates the mucous membrane of the upper respiratory tract, stimulating the respiratory and vasomotor centers of the medulla. This action, in turn, increases respiration and blood pressure.

BASIC LIFE SUPPORT

American Heart Association every 5 years updates its guidelines for BLS and ACLS based on current evidence. Last guidenlines were updated in 2015 and next update is expected in october, 2020. According to the current 2015 guidelines, the sequence of events for CPR has been changed from A-B-C (airway, breathing, circulation) to C-A-B (chest compression, airway, breathing) for adults, children and infants (excludes newborns).



Fig. 51.12: Palpation of carotid pulse



Fig. 51.13: Position of rescuer in case of cardiopulmonary resuscitation (CPR)

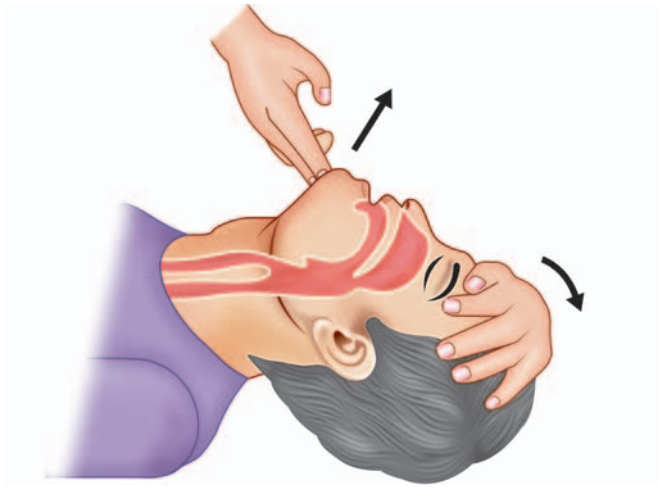




Fig. 51.14: Chin lift head tilt maneuver for opening the airway

Following steps are recommended to provide CPR to a person who is unresponsive and not breathing normally:

- Shout for help or activate emergency response system and ask for AED.
- Check the victim's pulse (carotid) for 5 seconds, but not more than 10 seconds **(Fig. 51.12)**.
- If you do not definitely feel a pulse or in doubt, start chest compressions. For chest compressions, ensure patient is supine and on hard surface. Effective chest compressions can be given on dental chair without need to shift the patient to floor **(Fig. 51.13)**.
- For chest compressions, place the heel of one hand on the center of victim's chest. Put heel of other hand on top of the first hand with your fingers interlaced.
- Press down so you compress the chest at least 2 inches in adults and children, 1.5 inches in infants. Deliver compressions at a rate of 100–200 times per minute **(Fig. 51.13)**.
- Open the airway with a head tilt and chin lift **(Fig. 51.14)**.
- Pinch closed the nose of the victim. Take a normal breath, cover the victim's mouth with your lips to create an airtight seal, and then give two, 1 second breaths as you watch for the chest to rise.
- Continue compressions and breaths–30 compressions, two breaths (30:2) – until help arrives. Do not interrrupt the chest compression for more than 10 seconds to provide ventilation.

In a dental clinic, mouth to mouth breathing can be replaced with mouth to mask **(Fig. 51.15)** or Bag-valve-mask device such as Ambu bag **(Fig. 51.16)**. Bag should be squeezed to give two breaths of 1 second each while



Fig. 51.15: Mouth-to-mask ventilation in an unconscious patient



Fig. 51.16: Bag-valve-mask device for positive pressure breathing in case of unconscious patient

watching for chest rise. The person with advanced training can use orotracheal intubation and other supraglottic devices such as laryngeal mask airway for definite securing of the airway.

Use of Automatic External Defibrillator

Automatic external defibrillator is a computerized device to deliver shock to heart **(Fig. 51.3)**. Defibrillation is the term used to describe a controlled electric shock administered to fibrillating heart, which may restore an organized rhythm enabling it to contract effectively. Ventricular fibrillation is the most common cause of cardiac arrest in adult, which can be defibrillated. AED device is programmed to automatically analyze the heart rhythm, determine the need for shock and then deliver it if advised. Every clinic should have an AED because every minute that lapses before defibrillation, the survival rate decreases by approximately 10%.

AED uses voice and visual aid, which prompts to guide the rescuer. The use of AED needs minimal training. One of the AED pads is placed on right side of bare chest just below clavicle and other pad is placed to the side of left nipple with the top edge of pad few inches below armpit. These pads can read the heart rhythm and display it on screen. AED technology does not require ECG rhythm recognition by the operator, therefore, enables the dental staff to attempt defibrillation. The voice prompts warns the rescuers to stand clear of the victim before the delivery of shock. Immediately after delivery of shock, CPR should be resumed and pulse should be checked after 2 minutes of CPR. If AED prompts, no shock is required, then immediately resume CPR. After five cycles of chest compressions and breaths (30:2) AED will prompt you to reanalyze the rhythm and follow prompts.

CPR is continued unless victim regains consciousness or advanced help arrives.

COMMON MEDICAL EMERGENCIES AND THEIR MANAGEMENT

In this section, a brief overview of salient features of commonly encountered medical emergencies are described. The attempt has been made to provide a practical solution for each problem.

Vasovagal Syncope

Syncope is the most commonly encountered medical emergency in dental practice. Syncope is defined as sudden, transient loss of consciousness with spontaneous recovery. Extreme anxiety, fear, and pain are common predisposing factors in a dental setting. There is inadequate supply of blood to the brain due to vagus mediated reflex bradycardia with or without peripheral vasodilatation. The signs and symptoms of syncope include light headedness, dizziness, pallor, nausea, sweating, visual disturbances and fainting. Pulse is slow and feeble due to bradycardia and hypotension.

Stress reduction protocols for managing anxiety, good communication, and reassurance are effective tools to prevent episodes of syncope. The management consists of positioning the patient into supine position with legs



Fig. 51.17: Supine position with legs little raised quickly improves the venous return



Fig. 51.18: Cupped hands in front of face for management of hyperventilation

slightly raised **(Fig. 51.17)**. Aromatic ammonia from the emergency kit may be used as respiratory stimulant. This increases the cerebral perfusion and the patient quickly regains consciousness. Patient's airway should be assessed and other vital signs monitored. Oxygen may be administered through Ventimask® or nasal cannula. Management of nonresolving hypotension associated with syncope has been further discussed in hypotension section.

Hyperventilation

Some patients because of extreme anxiety and fear may start to breathe rapidly and deeply. This conscious overdrive of ventilation is known as hyperventilation. This can lead to excessive washout of carbon dioxide causing decreased partial pressure of arterial carbon dioxide ($PaCO_2$ below 35 mm of Hg). Hypocapnea causes constriction of cerebral blood vessels, thus producing light headedness and dizziness. If the patient continues to hyperventilate, it can lead to respiratory alkalosis with rise of blood pH to 7.55. There is excessive release of catecholamines, which causes palpitations, tachycardia, trembling and sweating. The abnormal feeling coupled with anxiety, makes the patient to hyperventilate more, thus making a vicious cycle. The patient may develop tingling, muscular twitching and carpopedal tetany like features due to hypokalemia and hypocalcemia.

Management of hyperventilation consists of breaking this vicious cycle. The patient should be reassured and asked to breathe slowly and normally. Hyperventilation is the only emergency situation, when oxygen therapy is uncalled for in treatment plan. The old treatment of rebreathing in a paper bag should be avoided as it may lead to dangerously high levels of CO_2. The most effective method of raising $PaCO_2$ is to breathe through cupped hands in front of nose **(Fig. 51.18)** and mouth or breathe through detached oxygen mask which has holes for release of excessive CO_2. In most cases this will terminate the vicious cycle. In certain refractory cases sedation with diazepam or midazolam may be required.

Asthma/Bronchospasm

Asthma is characterized by increased contractile response of smooth muscles of small airways. Asthma may be related to allergy (extrinsic) or nonallergy (intrinsic). In a dental setting, an asthmatic attack may occur in response to anxiety, aerosolized particulate matter or certain drugs such as aspirin and other nonsteroidal anti-inflammatory drugs (NSAIDs). The patient experiences coughing, wheezing, dyspnea and hunger for air. *Asthmatic patients usually carry their bronchodilator medications in the form of inhaler. Known asthmatic patients should be asked to bring their inhaler at the time of appointment and its prophylactic use is advisable.* Bronchodilator inhaler should be readily available at chair side.

In case of an episode of bronchospasm, the patient should be seated upright and oxygen should be administered via mask or nasal cannula. The patient is asked to take puffs from his own inhaler or salbutamol inhaler from the emergency kit. Puffs from inhaler are repeated every minute for 5 minutes or until symptoms improve. The symptoms usually subside with the help of inhaler, because

inhaled medication is as effective as IV medication. In certain cases (status asthmaticus) inhaler medication may not be effective, then one may consider administration of IV salbutamol. 100 mg IV hydrocortisone may be effective in preventing relapse. 0.3 mg of IM epinephrine can be used as last resort or when IV access is not available to relieve bronchospasm. Subcutaneous administration of epinephrine for any condition is no longer thought to be most efficacious. All patients of asthma should be given oxygen at the rate 4–6 L/min with help of face mask. Vital signs and oxygen saturation should be monitored with pulse oximeter and it should be maintained above 90%. Medical help should be sought in case of life-threatening signs such as nonresolving wheezing, cyanosis, bradycardia, slow respiratory rate and deteriorating mental status.

Allergic Reaction/Anaphylaxis

An allergic reaction is antigen and antibody reaction to a substance (allergen) to which the patient has been previously sensitized. There can be various types of allergic reactions ranging from life-threatening type I allergic reaction (anaphylaxis) to type IV (delayed hypersensitivity). It may involve single system or multiple systems producing wide variety of symptoms and presentations. A significant percentage of population is allergic to variety of allergens. The allergy to antibiotics, local anesthetics and latex is not uncommon. Penicillins and its derivatives can produce allergic reactions including true anaphylaxis.

Most common organ involved in allergy is skin resulting in itching, redness and skin rash. There can be severe bronchospasm, when lungs are involved. Laryngeal edema and laryngeal spasm can also occur and it is life-threatening, if not managed adequately. Nausea, vomiting, diarrhea, rhinitis, conjunctivitis and urticaria are other features of allergic reaction. Antigen mediated vasodilatation leads to hypotension and may cause cardiac arrest.

Anaphylaxis is a true emergency and needs to be promptly diagnosed and urgently managed. Drugs required for managing allergic reactions are antihistamines, epinephrine and hydrocortisone. Pheniramine maleate (Avil) is the drug of choice, when allergic reaction is slow in onset and predominantly involves skin. It is given intramuscularly in a dose of 22.5–45 mg. This is followed by oral administration of the drug 25 mg 3–4 times a day for 2 days. When it is given via IV route, the drug should be diluted in 10 mL of distilled water as it can irritate the vein. If primary survey suggests bronchospasm and laryngeal edema, the treatment warrants early use of epinephrine. Epinephrine is the treatment of choice for anaphylaxis as it rapidly resolves the symptoms by reversing the action of histamine and blocks its further release. Adult dose is 0.3 mg IM (1:1,000) or when venous access is available 1–3 ml of diluted 1:10,000 is injected slowly over 5 minutes. The dose is titrated closely, because of potential side effects of epinephrine like severe hypertension and fatal arrhythmias. *Epinephrine is the only drug in emergency kit, which is kept preloaded* because of urgency. Formerly epinephrine was recommended for subcutaneous use, however, absorption and onset are delayed, because subcutaneous vessels contain only alpha receptors. Epinephrine constricts these vessels and delays its own absorption. Whereas, muscle vasculature contains ample amount of beta-2 receptors that dilate the vessels and increase its absorption.

Supportive care, maintenance of airway, monitoring of vital signs and administration of oxygen is simultaneously carried out. Normal saline 25–30 mL/ kg body weight also should be pushed quickly to overcome shifting of body fluid to extravascular compartment. 100 mg of hydrocortisone can also be given once the patient has been stabilized. If there is severe laryngeal edema and laryngospasm, which is not being relieved with any drug, then consideration should be given to cricothyrotomy for securing the airway. It is mandatory that the patient should be made aware of allergen, so that future contact with the allergen may be avoided.

Hypoglycemia and Hyperglycemia

Diabetes mellitus is quite prevalent and these patients are prone to hypoglycemic and hyperglycemic events. In a dental setting, hypoglycemic events are more common than hyperglycemic events. Hypoglycemia can be sudden and more dangerous, whereas hyperglycemic event takes days or weeks to develop. Lack of supply of glucose to brain results in confusion, restlessness, headache or bizarre behavior and ultimately can lead to loss of consciousness.

Loss of consciousness due to hyperglycemia is extremely unlikely occurrence in a dental clinic. However, clinician should be able to differentiate between hyper- and hypoglycemic event. Skin of hyperglycemic patients looks flushed and dry, whereas in hypoglycemia skin is cold and wet. Blood pressure of hyperglycemic patients is low, because of hypovolemia, whereas it may be increased in hypoglycemic patients. Hyperglycemic patients may have fruity sweet odor in their breath, because of ketoacidosis. Monitoring of blood glucose with glucometer in the dental clinic can also confirm the diagnosis.

The most common cause of hypoglycemia is missed meal. Therefore, it can be prevented by making sure, that diabetic patients do not miss their meal before or after dental treatment. If hypoglycemia is evident, it can be readily corrected by giving glucose or sugar source to drink or chew in a conscious patient. In an unconscious patient 25–50 mL of 50% dextrose should be administered IV. Alternately, 1 mg of glucagon can be administered intramuscularly. Protocol of vital sign monitoring and BLS should be followed as in case of any unconscious patient.

Emergency management of hyperglycemic patients in a dental clinic is supportive in nature and patient should be shifted to nearby hospital for definitive management.

Angina/Myocardial Infarction

Angina is feeling of chest pain due to inadequate blood supply to heart. It is because of narrowing or spasm of a coronary artery. Chest pain in angina is directly related to stress, anxiety or exercise. Episode of pain is brief and usually settles within 5 minutes with no permanent damage to the heart.

Acute myocardial infarction is due to development of clot in one of the coronary arteries. There is lack of blood supply to the heart muscle with permanent damage. Ischemic heart is very irritable and susceptible to cardiac arrhythmias. If not recognized and managed adequately, the patient may progress to cardiac arrest.

In both the conditions, patient complains of chest pain, heaviness, shortness of breath, nausea and vomiting. The pain can radiate to shoulders, arm, neck, jaw and upper abdomen.

The goals of management of chest pain are to decrease oxygen requirement of the heart or increase oxygen supply to the heart. This can be achieved by supplying supplemental oxygen via mask or nasal cannula. Nitroglycerin is single most effective vasodilator to relax smooth vascular wall in case of angina pectoris. It can be given in the form of sublingual tablets or spray. 0.4 mg tablet is kept sublingually every 5 minutes with not more than three tablets over 15 minutes. It may cause flushing, pounding in the head and tachycardia and hypotension. Therefore, it is contraindicated when there is concurrent hypotension.

In case of acute myocardial infarction, it is recommended that out of hospital, the patients should receive antifibrinolytic aspirin in a dose of 150–325 mg. Therefore, the patient may be asked to chew four tablets of 75 mg aspirin and swallow. The patient should be shifted under the care of cardiologist as early as possible.

If myocardial infarction progresses to cardiac arrest, then protocol of BLS and CPR is initiated with an attempt to bring back the heart to normal rhythm with the use of AED.

Seizure

Seizure or convulsions is an abnormal electrical activity of brain, resulting in attack involving changes in consciousness, motor activity or altered sensory phenomenon. Most of the patients have epilepsy as a cause for convulsions. Hypoglycemia, hypoxia and local anesthetic overdose can be the other causes for seizure in a dental setting.

In a typical tonic-clonic seizure, major skeletal muscles contract and patient loses consciousness. The patient is apneic, becomes cyanotic and patient may bite the tongue. In clonic phase, muscles relax and contract in waves. Involuntary powerful movements make the patient susceptible to injuries. Most seizures are self-limiting and active seizure usually lasts 1–2 minutes. Postictal phase is accompanied with drowsiness, fatigue and confusion.

In active phase of generalized seizure, never try to restrain the movements or put any object in patient's mouth. This has not been found beneficial, rather it may cause harm to the patient or injury to the healthcare professional. In addition never attempt to ventilate the patient during active phase of seizure. Patients should be turned to their side to protect airway and protective padding may be placed below head to prevent injury. After the seizure, continue to monitor the airway and vital signs. Oxygen can be administered via mask or nasal cannula.

In case of status epilepticus, diazepam 10 mg can be administered intravenously slowly over a 2 minute period to stop the seizure activity. Children are given diazepam in dose of 0.2–0.5 mg/kg intravenously.

The patient should be referred to the treating neurologist for dose adjustment of their anticonvulsant medication.

Drug Overdose Reaction

An excessive dose or inadvertent intravascular injection, or rapid administration of a drug may cause undesirable drug effects. Overdose of local anesthetic drug may be seen in a dental clinic. Clinics where pharmacosedation is used, overdose of opioid and benzodiazepines may happen.

The signs and symptoms of lidocaine toxicity/overdose include restlessness, agitation, confusion, blurred vision, ringing or buzzing in ears. Muscle fasciculations, tremors or seizure activity may be seen. In depressive phase of

lidocaine overdose reaction hypotension, bradycardia, respiratory and cardiac arrest may be seen.

The management of lidocaine overdose consists of maintenance of airway and circulation. Oxygen should be administered and vital signs are monitored. BLS measures are instituted. There is no antidote for lidocaine toxicity; therefore supportive measures should be continued until patient recovers.

Naloxone is antidote for opioid overdose toxicity and is used to reverse the respiratory depressant effect of opioids. It is an opioid receptor antagonist and is available as 0.4 mg/mL formulation in single and multidose vials. Its conventional dose is 0.4 mg (1 mL) by IM or IV route. It can also be given via sublingual injection. Its elimination half-life is 30–90 minutes making its duration of action shorter, than that of most opioids except for fentanyl. Therefore re-sedation is a possibility and patient should be closely monitored.

Flumazenil is an antagonist for benzodiazepines receptors. It is used to reverse the sedative effect of midazolam and diazepam. It is available as 0.1 mg/mL in 5–10 mL multidose vials. Dosage for reversal is 0.2 mg (2 mL) administered IV every 1–2 minutes to a maximum of 1 mg. Its half-life is 40–80 minutes rendering its duration of action shorter than most of the benzodiazepines. It should be used only when benzodiazepines have been given via IV route. It is advisable to observe the patients for 1 hour postreversal.

Choking/Foreign Body Aspiration

There may be accidental slippage of dental instrument, extracted tooth or material into the oropharynx. The object may be swallowed and it will pass to stomach. Rarely the object may pass into the airway. About 90% of the swallowed objects pass through the gut without any complications. In case of swallowed object being sharp, such as reamer or file, a gastroenterologist consultation should be sought urgently.

Glottis is the narrowest part of the airway in adults. In children below 5 years, subglottic area is the narrowest part. Depending on the size of the aspirated object, it may lodge itself into larynx at the level of glottis (in subglottic area in children <5 years) or pass into one of the bronchus via trachea. A foreign body lodged in larynx or bronchus, is an acute emergency as it may cause partial or complete airway obstruction and requires urgent removal. Mild airway obstruction leads to coughing reflex and object may be coughed out by the victim. But severe obstruction leads to weak or ineffective cough and a patient may not able to breathe, speak or cry. *Airway obstruction is one of the leading causes of death in children below 5 years.*

When object can be seen in oropharynx, it can be picked up with the help of Magills forceps or high volume suction apparatus and suction tip. Laryngoscope may be used to improve vision during the procedure. The patient is encouraged to cough and expectorate the object. The AHA recommends certain maneuvers in case of severe airway obstruction, such as Heimlich maneuver **(Fig. 51.19)** and abdominal thrust procedure for expulsion of foreign body. Children less than 1 year of age may require a combination of back slaps and chest thrust, while maintaining the head down position. If these procedures are not successful, then thought should be given to surgical method of securing the airway.

The ASA recommends cricothyrotomy as procedure of choice for establishment of airway patency in an emergency situation, as it is associated with minimal complications as compared to tracheostomy. Cricothyrotomy is a simple procedure, which can be done quickly with minimal equipment and armamentarium.

Cricothyrotomy is the procedure of making an opening in cricothyroid membrane. It is made with help of scalpel blade by giving vertical incision in midline over cricothyroid area. Skin, subcutaneous tissue and deep fascia are incised. There is may be little bleeding from skin margins, which is ignored and can be tackled later. After identification of cricothyroid membrane, a 1–1.5 cm horizontal incision is given over it, in the inferior one-third towards the cricoids cartilage. One may be see bubbling of air, as patient attempts to breathe. A nasal speculum is inserted to enlarge the opening. Alternatively back end of scalpel handle can be inserted and rotated to expand the opening. A number 4–4.5 tracheostomy tube or endotracheal tube is inserted to establish airway. Inserted



Fig. 51.19: Heimlich maneuver for foreign body aspiration



Figs 51.20A and B: (A) Commercially available cricothyrotomy kit; (B) Surgical cricothyrotomy can be quickly done with few basic instruments such as scalpel and nasal speculum

endotracheal tube is attached to oxygen reservoir and patient can be ventilated.

Alternatively a 13 gauge one inch long needle can be used to puncture the cricothyroid membrane. Commercial kits for cricothyrotomy are also available and it is recommended to be kept in emergency kit **(Figs 51.20A and B)**.

Once the patient is stable, medical help is sought from pulmonologist for removal of foreign body. When the object is lodged in one of the bronchus, it is not an acute emergency as patient is breathing and it gives some time for planning the procedure for its removal.

Hypotension

Low blood pressure (systolic pressure below 90 mm of Hg) can lead to inadequate cerebral perfusion and loss of consciousness. Most common cause in dental setting for hypotensive episode is vasovagal syncope. It is associated with bradycardia, usually pulse below 50 beats per minute. By changing the position to supine, with legs elevated usually results in recovery. However, in rare cases the hypotensive episode persists and drugs may be indicated. Hypovolemia is another cause of hypotension, particularly in patients who are fasting. Certain elderly patients may experience an episode of orthostatic hypotension (or also called postural), when they stand up from supine position after prolonged dental appointment. Therefore, chair should be raised slowly and patient should be asked to get up slowly after long dental appointment.

Two medications are useful to manage hypotensive episodes. When hypotension is accompanied with bradycardia such as in case of vasovagal syncope, atropine is a useful drug. It is administered in dose of 0.5 mg IM or IV and can be repeated every 5 minute up to a maximum of 3 mg depending on heart rate and blood pressure readings.

Rapid infusion of normal saline may be warranted to increase the blood pressure. Ephedrine is other drug which is helpful in increasing systolic pressure in a patient with normal heart. It can be given 25 mg via IM or sublingual injection. The dose can be repeated in 5 minutes depending on blood pressure readings.

Phenylnephrine is the other drug which may be used to manage hypotension when patient is having normal heart rate or tachycardia. It is alpha adrenergic agonist and produces vasoconstriction thus improving venous return and systolic pressure. Phenylnephrine is available as 10 mg/mL single dose ampoule and should be diluted to make it 0.1 mg/mL. 0.1–0.2 mg (1–2 mL) increments are given IV slowly with close titration of dose with blood pressure and heart rate.

Hypertension

Transient episodes of hypertension may be encountered in patients with extreme pain or restlessness during lengthy procedure. This rarely requires treatment, other than a time out to calm down. If the episode is accompanied with symptoms like chest pain, headache or visual disturbances then drug intervention to reduce blood pressure may be required. It is important to note that when stroke is being suspected (aphasia, paresthesia and paralysis are suggestive of stroke) then no attempt should be made to lower the blood pressure. Known hypertensive patients who have missed their medications should be given usual dose of their antihypertensive drug.

Esmolol, a selective beta-1 blocker can be used to manage an acute hypertensive event. Esmolol is metabolized rapidly and has brief duration of action (10–30 min). It is available as 10 mg/mL in multidose vial. Its dose is 0.5 mg/kg over 1 minute and can be titrated with 20 mg increments (1–2 mL) every 1–2 minutes. Dose of esmolol should be titrated to repeated measurements of blood pressure and heart rate.

Earlier practice of opening a nifedipine capsule and giving via sublingual route to manage hypertensive emergency is no longer recommended, because it can precipitate myocardial infarction or stroke by excessive lowering of blood pressure. Esmolol is also helpful in managing narrow complex tachycardia and supra ventricular tachycardia.

Cerebrovascular Accident and Transient Ischemic Attacks

Cerebrovascular accident (stroke) and transient ischemic attack (TIA) is caused by interruption of blood supply to brain. Patients are usually elderly with uncontrolled hypertension, diabetes and atherosclerosis. Cerebrovascular event can be as a result of ischemic or hemorrhagic event. The signs and symptoms in case of TIA are for short duration and recover spontaneously usually within 24 hours. Symptoms of TIA vary from episodes of slurred speech, to temporary numbness or paralysis of face arm or leg. There can be monocular diplopia, loss of balance and coordination. TIA is a warning of a major ischemic cerebrovascular event and patients should be immediately referred to a neurologist.

The signs and symptoms of stroke include altered consciousness, headache, nausea, vomiting, inability to speak, facial paralysis, paraesthesia, and hemipalsy. The management consists of recognition and urgent shifting to nearby hospital. An early management is crucial for favorable outcome in certain types of stroke. While transport is being arranged, institution of BLS measures such as positioning to prevent aspiration, suctioning to maintain airway, monitoring of vital signs and oxygen therapy are important.

CONCLUSION

Medical emergencies in a dental clinic do happen. Most of the emergencies can be prevented by thorough history taking, physical examination and adequate modification of treatment plan. Meticulous attention in preparation of emergency kit and equipment for handling medical emergencies is required. Thorough knowledge and training in using the drugs and equipment is required. Frequent mock drills with the support staff should be carried out and each member should know its exact role in the emergency team. One should retain its calm and composure during handling of emergency and there should be no element of panic for successful outcome. Periodic training, updating skills, knowledge and regular practice are keys to successful outcome. With these measures, dental staff would be able to handle any medical emergency with utmost confidence.

Points to Remember

- Recognition of patient at risk
- Drugs and resuscitation equipment
- Basic life support
- Common medical emergencies and their management.

Syncope	Angina/ Myocardial infarction	Choking
Hyperventilation	Hyperglycaemia/ Hypoglycaemia	
Hypotension		
Asthma	Seizure	
Hypertension		
Allergy/anaphylaxis	Drug overdose reaction	Stroke

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CHAPTER 52 Cardiopulmonary Resuscitation

INTRODUCTION

Cardiac arrest is the most serious complication faced by the medical personnel. A prompt diagnosis and immediate cardiopulmonary resuscitation (CPR) can prevent many deaths.

Cardiopulmonary resuscitation, is an emergency procedure performed in an effort to manually preserve intact brain function until further measures are taken to restore spontaneous blood circulation and breathing in a person who is in cardiac arrest. It is indicated in those who are unresponsive with no breathing or abnormal breathing. In general, CPR is continued until the person has a return of spontaneous circulation (ROSC) or is declared dead .CPR serves as the foundation of successful cardiopulmonary resuscitation, preserving the body for defibrillation and advanced life support. Studies have shown that immediate CPR followed by defibrillation within 3–5 minutes of sudden VF cardiac arrest dramatically improves survival rate.

PATHOPHYSIOLOGY

CPR is used on people in cardiac arrest in order to oxygenate the blood and maintain a cardiac output to keep vital organs alive. Blood circulation and oxygenation are required to transport oxygen to the tissues. The physiology of CPR involves generating a pressure gradient between the arterial and venous vascular beds; CPR achieves this via multiple mechanisms.The brain may sustain damage after blood flow has been stopped for about four minutes and irreversible damage after about seven minutes. Typically if blood flow ceases for one to two hours, then body cells die. Therefore, in general CPR is effective only if performed within seven minutes of the stoppage of blood flow. The heart also rapidly loses the ability to maintain a normal rhythm. Low body temperatures, as sometimes seen in near-drownings, prolong the time the brain survives. Following cardiac arrest, effective CPR enables enough oxygen to reach the brain to delay brain stem death, and allows the heart to remain responsive to defibrillation attempts.

CARDIAC ARREST AND ITS TREATMENT

In cardiac arrest, circulation ceases or stops and vital organs are deprived of oxygen. It can be broadly defined as "inability of the heart to sustain an effective output."

Etiology

Causes of cardiac arrest are varied and many.

- **Cardiac disease:** Coronary artery disease, valvular lesion, cardiomyopathies, heart blocks.
- **Hypoxia:** Due to respiratory obstruction or disease.
- **Hypotension:** Due to massive blood loss.
- **Hypoglycemia:** In diabetic patients or in children/ adults due to preoperative conditions.
- **Fainting:** Most common during anesthesia in dental chair.
- **Effect of drugs:** Intravascular injection of adrenaline, sensitivity to local anesthetic agent.
- **Electrolytic changes:** Intravenous administration of calcium, rise of serum potassium in diabetic acidosis or renal failure.
- **Vagal reflex mechanism:** During intubation, surgical stimuli provoking bradycardia.
- **Terminal stages of any disease:** Diabetic coma, malignancy, etc.

Diagnosis of Cardiac Arrest

- **Pulse**: Absence of pulse in major vessels like carotid or femoral.
- **Respiration:** Cessation of respiration, absence of breath sounds.

- **Auscultation of the heart:** Absence of heart sounds.
- **Pupils:** Pupils may be dilated with a sluggish or no reaction to light.
- **Skin color:** There may be pallor or cyanosis.
- **General condition:** An unconscious person not responding to stimuli.

Treatment of Cardiac Arrest

Cardiac pulmonary resuscitation is most effective, when started immediately and should be initiated by any person present at the time of cardiac arrest/when the patient collapses.

Management of CPR depends on whether the arrest has occurred in the hospital or outside the hospital and on the availability of a single or double rescuer.

Outside the hospital, it is the *basic life support* (BLS). Inside the hospital it *is BLS plus advanced care life support* (ACLS) and *postresuscitation life support, in short called as cardiac pulmonary cerebral resuscitation (CPCR).*

BASIC LIFE SUPPORT

Aim: The major objective of BLS is to maintain oxygenation in lungs, brain and heart with rescue breathing and cardiac compression by which oxygen is transported to tissues before the ACLS.

Procedure: The three parts sequence [airway-breathing-circulation (ABC)].

Maintain:

- Airway
- Breathing
- Circulation

Each part of ABC begins with an assessment phase to determine patient's response, presence of pulse and state of respiration.

Airway

When the victim is unresponsive, one has to first position the patient and assess the airway.

Position of the victim: The victim must be made to lie supine, on a firm flat surface. If the head is higher than the feet, then the blood flow to the brain may be reduced and also the airway management is easier, when the patient is supine.

Position of the rescuer: The rescuer should be at the victim's side at a distance equal to the width of the victim's body and at the level of the victim's shoulder.

Triple maneuver:

1. Open the mouth—clear the airway
2. Head tilt and chin lift
3. Jaw thrust.

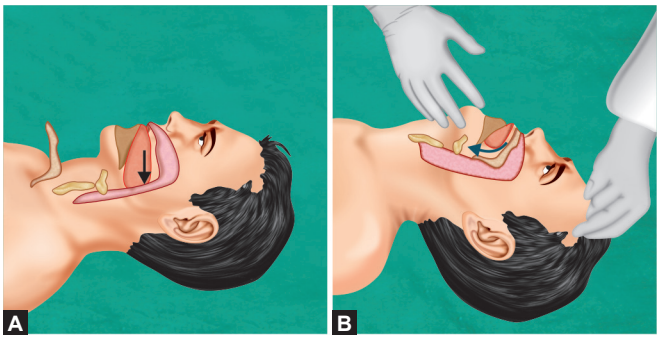
Opening the airway: In an unconscious patient, muscle tone is often impaired resulting in obstruction of the pharynx, by base of the tongue and soft tissue of the pharynx. Since the tongue is attached to the lower jaw, moving the lower jaw forward will lift the tongue away and open the airway.

Head tilt and chin lift (Figs 52.1A and B)

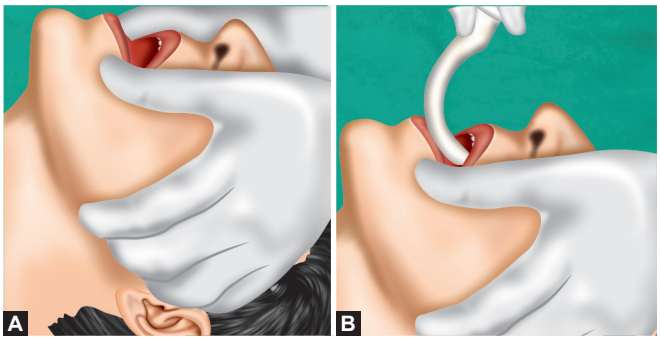
- Place one hand on the victim's forehead and apply firm backward pressure to tilt the head back.
- Place the fingers of the other hand under the bony part of the chin.
- Lift the chin forward and support the jaw.

Jaw thrust (Figs 52.2A and B)

- Grasp the angle of the victim's lower jaw and lift with both hands, one on each side, displacing the mandible forward, while tilting the head backward.
- If there is a foreign material or vomitus in the victim's mouth, it should be removed quickly.



Figs 52.1A and B: Opening the airway with chin lift and head tilt: (A) Airway obstruction due to tongue fall in supine position, (B) Obstruction relieved with chin lift and head tilt



Figs 52.2A and B: Opening the airway by jaw thrust: (A) Jaw thrust, (B) Insertion of oral airway

- One should be careful about loose dentures, which may pose a serious problem in mouth-to-mouth breathing.
- A Guedel's or Safar's airway, laryngeal mask airway, esophageal gastric tube, if available may be used.

Foreign Body Airway Obstruction

Back blows: It should be given on the middle of the back of the patient (4 times). This produces the cough impulse.
Heimlich maneuver: Consists of manual thrust with the patient breathing, rescuer behind the patient and compressing the patient's chest 6–10 times.

Finger sweep method: For unconscious patient, with foreign body, this can be used both in adults and children.

Breathing

One must first determine the presence or absence of breathing by,

- Placing the ear near the victim's mouth or nose
- Looking for chest wall movement
- Auscultation of chest for breath sounds.

Expired air resuscitation

- Mouth-to-mouth breathing
- Mouth-to-nose breathing
- Mouth to airway breathing.

Mouth to mouth breathing (Fig. 52.3): A quick and effective way to provide oxygen to the victim. The rescuer uses his expired air oxygen to supply to the victim.



Fig. 52.3: Mouth-to-mouth rescuer breathing

- Open the airway with triple maneuver.
- Close the victim's nostrils with the thumb and index finger.
- Take a deep breath and form a seal with lips around the victim's mouth before exhaling.
- Two slow breaths (of 1/2 to 2 seconds per puff) are given to provide good chest expansion, decreasing the possibility of gastric distension at the same time.

Mouth to nose breathing: When mouth to mouth breathing is not possible, because of difficulty in opening the mouth or a seal cannot be formed.

- Tilt the victim's head back with one hand over the victim's forehead.
- Close the victim's mouth.
- Lift the victim's lower jaw with the other hand.
- Take a deep breath, form a seal with lips around victim's nose and blow.
- Victim is then allowed to exhale.

Mouth to airway breathing: Open the airway with the triple maneuver.

- Close the victim's nostrils with the thumb and index finger.
- Take a deep breath and form a seal with the lips around the victim's mouth before exhaling.
- Two slow breaths (of 1/2 to 2 seconds per puff) are given to provide good chest expansion, decreasing the possibility of gastric distention at the same time.

Mouth to Barrier Device

Some rescuers may prefer to use a barrier device, during expired air resuscitation. Two such devices available are masks and face shields. Most masks have a one-way valve, so that exhaled air does not enter rescuer's mouth. A barrier device ideally should have low resistance for gas flow or the user may get tired from excessive respiratory effort.

If rescue breathing is necessary, position the barrier device over the victim's mouth and nose ensuring adequate air seal. The breaths are given in the same sequence at the same rate as described earlier.

Mouth to Mask Breathing

This device includes a transparent mask with a one-way valve mouthpiece. Some devices have an oxygen adapter that permits the administration of supplemented oxygen.

Mouth to mask breathing is reliable form of ventilation, since it allows the rescuer to use two hands to create a seal.

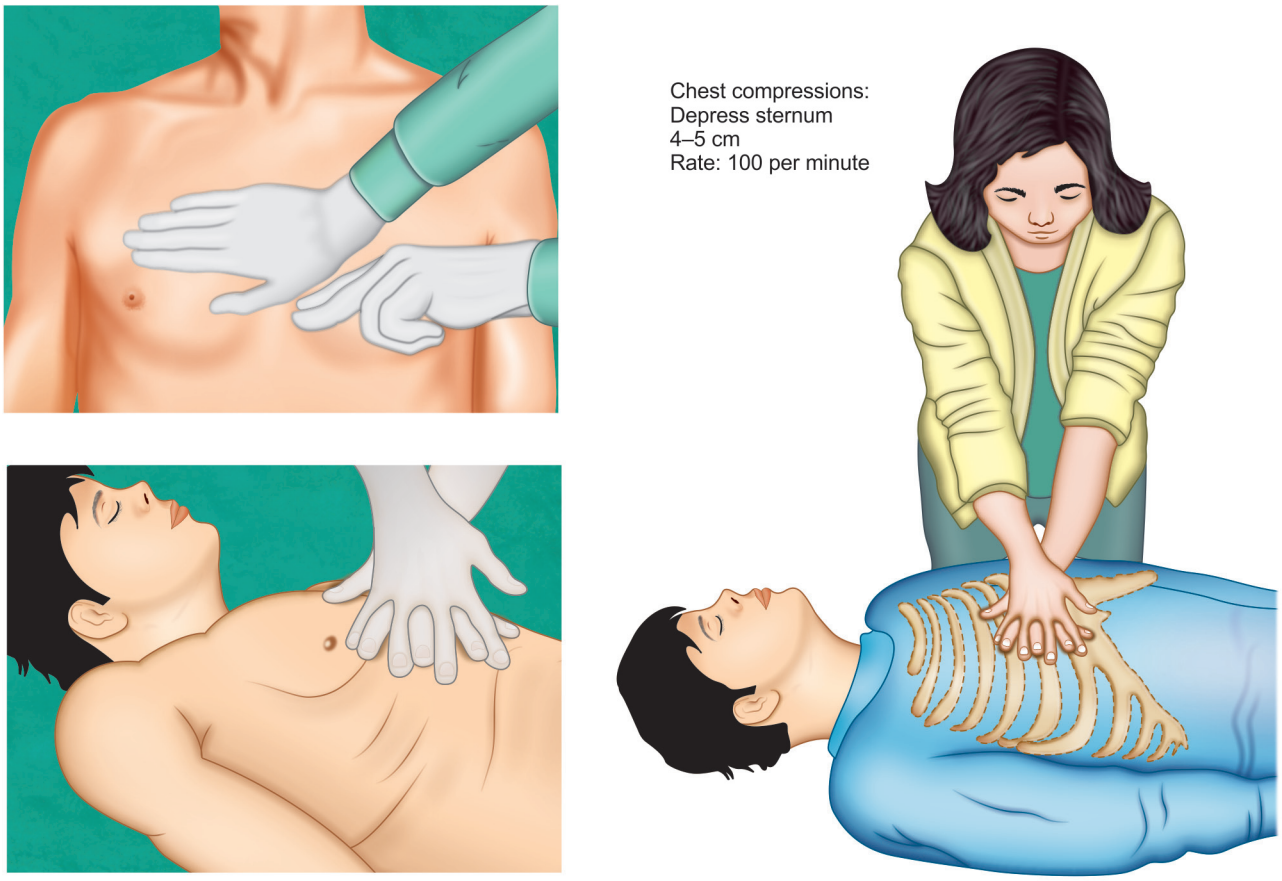


Fig. 52.4: External cardiac massage—Diagrammatic representation

Technique

- Place the mask around the patient's mouth and nose. Positioning of the mask should be proper so that an airtight seal can be obtained.
- Seal the mask by placing the heal and thumb of each hand along the border of the mask and compress firmly to provide a tight seal around the victim's mouth and nose.
- Place the remaining mask along the bony margin of the jaw.
- Lift the jaw while performing a head tilt.
- Follow the same sequence as for mouth to mouth breathing.

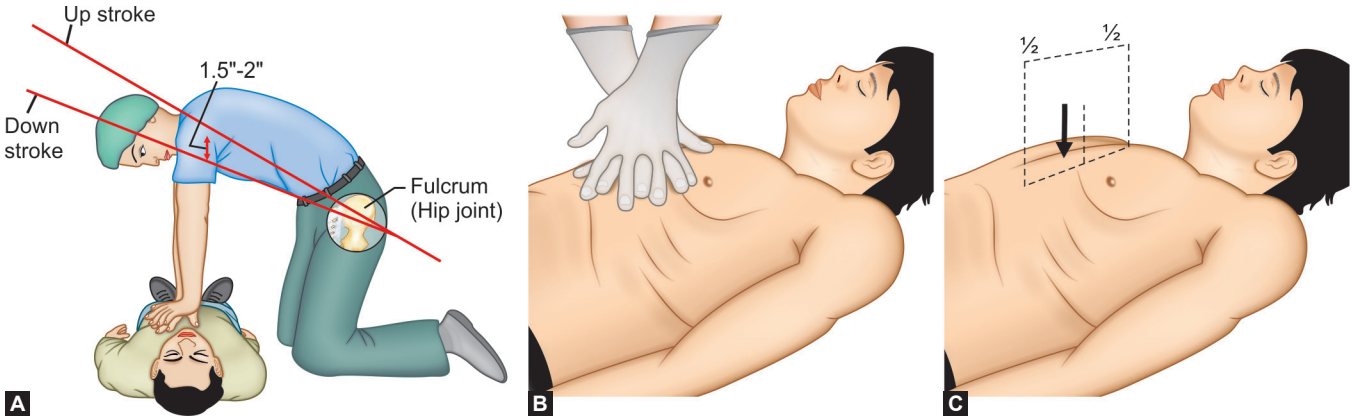
Circulation Check

The carotid artery is the most easily palpable in a groove between the trachea and large strap muscles of the neck. The carotid pulsations are felt, while all other pulses may not be palpable. If no pulse is palpated one should start external cardiac compression to establish circulation.

External Cardiac Compression (Fig. 52.4)

In this technique the rescuer applies pressure over the lower half of the sternum, at the rate of 100–200 per minute. These compressions provide circulation as a result of a generalized increase in intrathoracic pressure, due to direct compression of the heart between the sternum and the vertebrae. When the compressions are accomplished by rescue breathing, the blood supplied to the organ is likely to carry oxygen.

- Position the victim, supine on a firm surface.
- Locate the lower margin of the victim's rib cage.
- Locate the lower part of the sternum, by moving the fingers along the notch, where the rib meets the sternum in the center of the chest wall.
- Place the heel of one hand, on the lower half of the sternum, with the other hand on top of the first hand,



Figs 52.5A to C: External cardiac massage: Chest compression showing the proper position of the rescuer (with shoulder over the victim's sternum and elbows locked)

in such a way that the long axis of the rescuer's hand is placed on the long axis of the sternum. This helps in keeping the force of compression on the sternum **(Figs 52.5A to C)**.

- The fingers are kept interlocked at the chest.
- The rescuer's elbow should be locked into a position, such that the arms are straightened and shoulders are placed directly over the hand, so that the thrust of each compression is straight down on the sternum.
- For the normal sized adult, the sternum should be depressed approximately 2 to 2.4 inches by the force provided by the rescuer's body weight.
- Optimal sternal compression is the one, which can generate an adequate carotid pulse.
- The rescuer should release the pressure, after each compression to allow blood to flow into the chest and heart.
- Duration of each compression should be 50% of the compression release cycle with a chest compression rate of 80–100 per minute.

Assessment of the Patient During CPR

Inspection:

- Chest rise
- Depth of compression
- Position of rescuer's hands.

Palpation:

- Check for return pulse
- Assess peripheral pulse.

Auscultation:

- Breath sounds
- Heart sounds.

Standard approach to unconscious patient in one rescuer CPR

- Determine unconscious position of the victim's spine
- Open the airway and deliver slow air breaths
- Perform 18 compressions at the rate of two ventilations
- After 5 cycles of compression re-evaluate the patient
- Check for return of the carotid pulse
- If absent, resume CPR

With two-rescuer CPR, the ratio of compression and ventilation is maintained at 5:1.

ADVANCED CARDIAC LIFE SUPPORT

The emergency care provided by BLS helps to restore circulation; ACLS helps to evaluate and restore the spontaneous circulatory function. In addition to BLS skills, ACLS includes use of adjunctive equipment and techniques available in a hospital set-up assisting ventilation and circulation, such as electrocardiogram (ECG) monitoring with arrhythmia recognition and defibrillation **(Figs 52.6A and B)**, establishment of IV access and drug therapy.

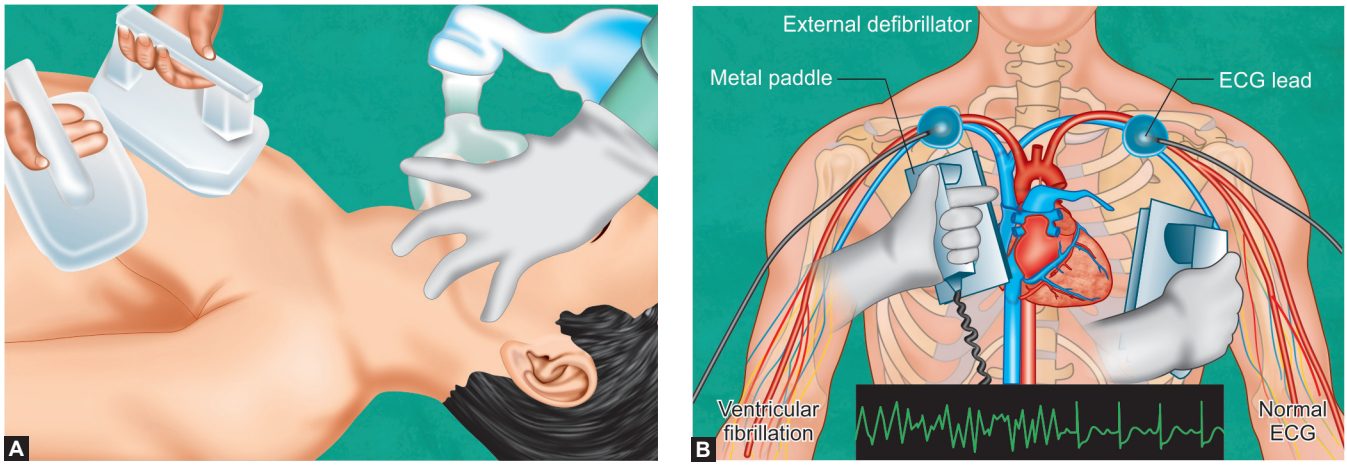
Key Points

ACLS Primary Survey

Continue ABC of BLS and defibrillate first.

First ABCD of ACLS:

- A—airway
- B—breathing
- C—circulation
- D—defibrillation.



Figs 52.6A and B: External defibrillation: (A and B) Diagrammatic representation

Second ABCD of ACLS:

- A—perform endotracheal intubation
- B—assist ventilation
- C—circulatory support, gain IV access, attach monitor, identify rhythm, measure blood pressure, and provide appropriate medication
- D—differential diagnosis, find and treat the cause.

Drug Therapy

During cardiac arrest, drug therapy is secondary management to the more fundamental interventions. Airway management, ventilation, chest compression and defibrillation, if appropriate, should take precedence over medication.

Drugs used are as follows:

- Adrenaline
- Atropine
- Xylocaine
- Calcium
- Sodium bicarbonate.

Adrenaline

Only vasopressor drugs are accepted uniformly for CPR since 1940. It is still the drug of choice even today.

Action: Alpha-adrenergic properties increase peripheral resistance, which leads to increase in aortic diastolic pressure causing increase in coronary pressure and myocardial blood flow.

Dose: Empirical dose is 10 mcg/kg body weight repeated every 5 minutes.

Atropine Sulfate

Action: Enhances sinus node automaticity and atrioventrical condition by the vagolytic effect. Atropine is indicated in asystole and when bradycardia coexists with hypotension.

Dose: Adults, 0.5 mg IV every 3–5 minutes up to a total of 0.4 mg per kg. Children, 0.2 mg per kg, minimum of 0.1 mg per kg to a maximum of 0.5 mg per kg body weight.

Lignocaine or Xylocaine

Indications:

- Ventricular tachycardia (VT)
- Ventricular premature contraction (VPC).

Dose: 1 mg/kg body weight followed by 0.5 mg/kg body weight, followed by infusion (maximum 3 mg/kg body weight).

Calcium

Indicated in hypocalcemia, hypercalcemia, Ca-channel blocker overdose, etc.

Dose: 10 mg/kg body weight.

Sodium Bicarbonate

Specific indications:

- Metabolic acidosis
- Prolonged duration of arrest
- Hyperkalemia

Side effects:

- Hyperosmolarity
- Hypernatremia
- Hypercapnea
- Paradoxical intracellular acidosis.

Dose: 1 mg/kg body weight initially, half dose repeated every 10 minutes. If blood gases are known, dose can be calculated as 0.3 × base deficit × weight in kg (where × means multiplied by).

Other Drugs Used in CPR

Drugs	*Dose*
• Dopamine	: 5–10 μg/kg body weight
• Dobutamine	: 2–5 μg/kg body weight
• Calcium chloride	: 5–10 μg/kg body weight
• Amrinone	: 0.75 μg/kg body weight.

Vasopressors

- Norepinephrine: Infusion—0.1 μg/kg body weight
- Phenylephrine: 50–200 μg/kg body weight.

Vasodilators

- Nitroglycerine: Infusion 0.25–0.5 μg/kg body weight
- Sodium nitroprusside: 0.25–0.5 μg/kg body weight.

Postcardiac Arrest Complications

- Complications of CPR:
  Rib fractures, gastric laceration or rupture, splenic rupture, pneumothorax.
- Ischemic injury
  - Renal
  - Cerebral
  - Hepatic and others.

Outcomes of Resuscitation

- Depends on many factors like age of the patient, the cause line factor witnessed or unwitnessed, the rhythm and the ischemia time, etc.
- Neurological recovery is 50%.
  - If the arrest time is less than 6 minutes, and CPR time is less than 15 minutes—the outcome is satisfactory.
  - If arrest time exceeds 6 minutes and CPR time exceeds 15 minutes chances of survival are almost nil.

Points to Remember

- Cardiac arrest and its treatment
- Basic life support
- Advanced cardiac life support.

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Section 18

Recent Advances in Oral and Maxillofacial Surgery

53. Recent Advances in Oral and Maxillofacial Surgery

CHAPTER 53 Recent Advances in Oral and Maxillofacial Surgery

INTRODUCTION

Innovations and discoveries in the field of science are happening rapidly. The emerging technologies are rapidly changing the nature of dental, medical, and surgical practice. As clinicians involved in direct patient care, it is our fundamental duty to keep abreast with latest advances in the field of medical sciences and use these technologies judiciously for the benefit of the patients. On the other hand, clinician must be prudent enough to adopt the new technology, and should not put the patients to increased risk, in the name of advanced technology. This chapter will cover the latest trends and changes in the field of oral and maxillofacial surgery.

ADVANCES IN THE FIELD OF RADIOLOGY AND IMAGING

Over the last 2 decades, there have been tremendous improvements in the field radiology and imaging. There are faster and powerful computed tomography (CT) and magnetic resonance imaging (MRI) machines backed by advanced softwares and graphics, which have given the capability to capture images of any part of the body in great detail. With the use of digital radiography it is possible to see images instantaneously with decreased dose of ionizing radiation. The images can be stored, manipulated, and retrieved easily.

CT scan has become an invaluable tool in assessment of craniofacial morphology. It gives better details of bone as compared to the soft tissues. With advanced multislice scanners it is possible to capture images in great detail in all the three planes in a few seconds. CT angiograms give accurate pictures of vascular anatomy in vascular lesions. Further, data generated by CT in the form of "digital imaging and communication in medicine (DICOM)" files can be used to construct actual three-dimensional (3D) models.

Advances in the field of MRI technology have produced faster machines with no need to lie in closed chambers for long time. MRI is an important tool in the diagnosis of head and neck pathologies. Major advantage is that it does not use ionizing radiations and gives excellent soft tissue details. It is useful in evaluation of head and neck malignancies, temporomandibular joint (TMJ) pathologies and vascular lesions. MRI angiograms are helpful in differentiation between high flow and low flow vascular malformation. DICOM data generated from MRI can also be used for production of stereolithographic models.

Positron Emission Tomography and PET/CT

Advent of positron emission tomography (PET) and combined PET/CT is a promising development. These modalities have the potential to help in staging, identifying responses to nonsurgical therapy and allowing early detection of recurrence of patients with head and neck cancer. The PET is used to study *in vivo* metabolic processes by using physiologically active compounds labeled with short-acting positron emitting isotopes. Positron emitting tracers, e.g. oxygen-15, nitrogen-13, and fluorine-18 can bound to a variety of molecules, which are used in the human metabolic pathways. Fluorodeoxyglucose (FDG) is the most widely used tracer with PET imaging. When administered intravenously, FDG is trapped as 2-deoxyglucose-6-phosphate within cells. The unstable photon rich fluoronucleus rids itself of excessive charge with emission of a positively charged electron, becoming a more stable nucleus. These positrons travel a millimeter or less in the tissues before interacting with electron resulting in an annihilation reaction, which results in release of two photons at approximately 180° to one another (gamma photons). Detection of these photons by detectors is used to build-up three dimensional

representations of these events. The data are displayed in a manner similar to conventional sectional imaging. These images produced reflect glucose uptake within various tissues.

The application of PET-FDG in detection of malignancy arises because of the hallmark of the malignant cells, which is increased glucose metabolism. One of the disadvantages of PET is that the areas of abnormality on PET imaging cannot be perfectly correlated with the anatomy. To overcome this problem PET scans are increasingly read alongside CT or MRI scans, the combination giving both anatomic and metabolic information. The fusion of PET and CT technology (PET/CT) taken on a single device offers excellent localization and improved detection of head and neck pathologies.

One of the main advantages of PET/CT is that, it can pick-up the lesions in early stage before these are morphological evident, which leads to earlier diagnosis of tumors. It is helpful in head and neck malignancy to detect metastatic or recurrent disease and occult primary unknown cancer. In addition, it can demarcate tumor margins at sites, where it is difficult to evaluate the tumor clinically. It is particularly helpful in areas, where it is difficult to separate recurrence from changes resulting from previous treatment, such as surgery and radiotherapy. It can establish whether enlarged lymph nodes contain tumor or are reactive and it can detect small foci of disease **(Fig. 53.1)** and assess the whole body in one step with a much lower dose of radiation than whole body CT. Other use of PET/CT is in evaluating growth abnormalities of the TMJ such as condylar hyperplasia **(Fig. 53.2)**.

Many benign causes and several artifacts can simulate physiologic or pathologic FDG uptake in the head and neck, e.g. tuberculous cervical lymph nodes may mimic malignancy on PET. Therefore, interpreting radiologists and nuclear medicine physicians must be familiar with the patterns of FDG uptake in the head and neck to avoid misinterpretation or misdiagnosis.

Stereophotogrammetry and Laser Surface Scanning

These are the two most commonly used techniques to capture the three dimensional surface images of face. Stereophotogrammetry uses two or three cameras configured to a computer to capture a stereo image of face by means of triangulation. In laser surface scanning the light and camera technology is used to capture the image exact position of surface point on the object. Then computer software is used to synchronize the data and generate a 3D image. These images can be used for diagnosis, treatment planning and comparison of surgical outcome, as these images are highly accurate (up to 0.5 mm accuracy). The maxillofacial applications of these 3D cameras are growing, especially in orthognathic surgery, orthodontics and evaluation of craniofacial deformities. It is possible to superimpose photographic soft tissue data over the bony data set obtained from CT or cone beam computed tomography (CBCT). This fusion of hard tissue images and

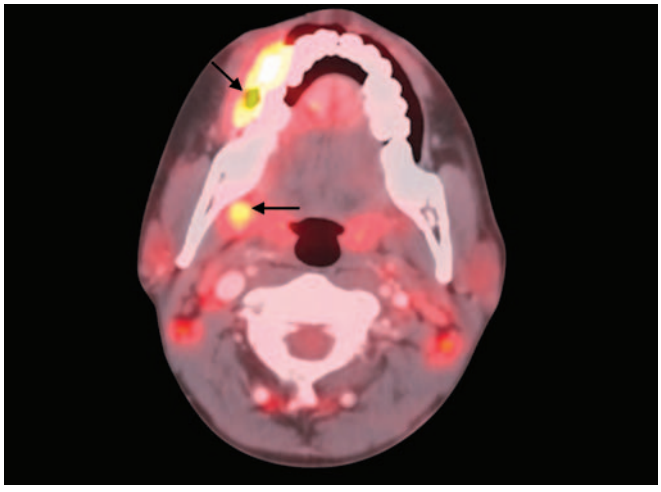


Fig. 53.1: Positron emission tomography-computed tomography (PET/CT) fusion image in a patient with oral squamous cell carcinoma of buccal mucosa, showing metastasis to ipsilateral submandibular lymph nodes

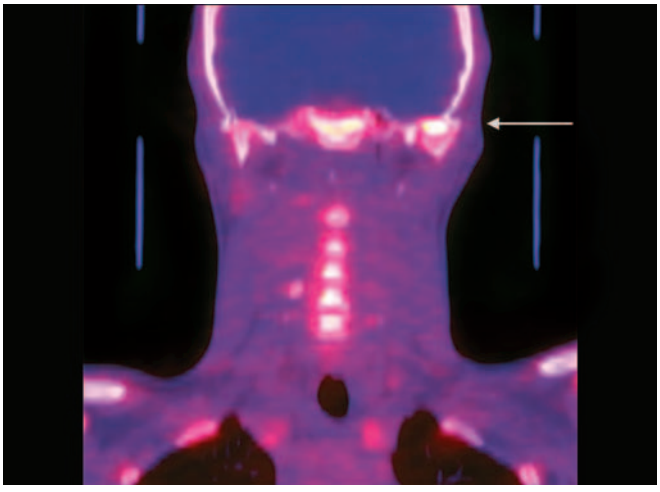
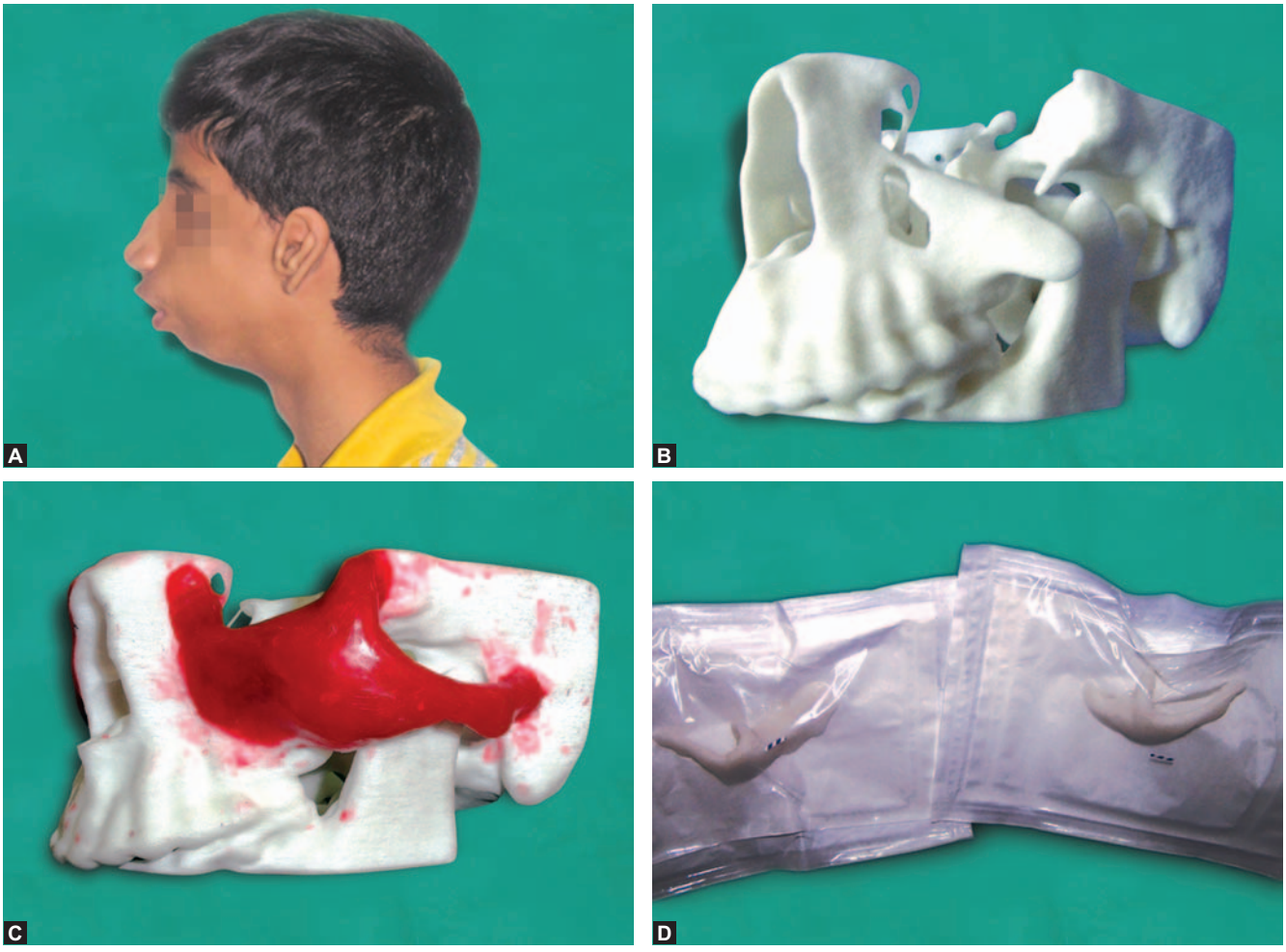


Fig. 53.2: Positron emission tomography-computed tomography (PET/CT) fusion image showing hyperactivity (hot spot) in left temporomandibular joint (TMJ) in a case of condylar hyperplasia

surface images of face provides opportunities for diagnosis and planning corrective surgeries and postoperative comparisons. 3D cephalometric measurements can be done on these images.

Rapid Prototyping and Stereolithography

Rapid prototyping is the process of creation of physical models from medical scan data. The physical model is built in a layered manner and it reproduces internal and external anatomy accurately. Medical scan data can be obtained from CT, CBCT or MRI. There are many technologies for manufacturing of medical models. All of these technologies were basically developed for industrial purposes and later on adopted for production of medical models. These include stereolithography, selective laser sintering, 3D printing, fused deposition modeling, digital light processing and polyjet modeling. Stereolithography is the most commonly used technology and involves selectively solidifying an ultraviolet sensitive liquid medical resin using laser beam. Stereolithographic models **(Figs 53.3A to D)** can be used for diagnosis, surgical planning, teaching, custom made implants and prosthetic devices. The models allow for wax replacement of avulsed structures or generation of mirror-image structures, prebending of osteosynthesis bone plates, fabrication of templates, choosing of stock alloplasts. These technologies are also used for making surgical guides **(Fig. 53.4)**, and scaffolds for tissue engineering.



Figs 53.3A to D: (A) Profile of a patient suffering from Treacher Collins syndrome, (B) Stereolithographic model of the patient suffering from Treacher Collins syndrome. Model was generated from scanned computed tomography (CT) data; (C) Wax-up was done on this model for planned malar reconstruction with customized porous polyethylene implant; (D) Customized implant for correction of missing malar prominence was manufactured by the company Biopore (Nobel guide implant planning software was used)

Surgical Guides and Custom made Implants

Special interactive computer softwares are available for maxillofacial surgery and oral implant planning **(Figs 53.5 and 53.6)**.

Scanned data from CT or CBCT is converted into virtual 3D models. These virtual models can be used for surgical planning in cases of orthognathic surgery, distraction osteogenesis and dental implant placement. This virtual planning can be used for production of surgical guides, stents or customized implants. With the help of surgical guides, operation can be performed exactly according to the plan with reduced operating time. Surgical guides are quite popular for dental implant placement **(Fig. 53.4)**. In implantology, surgery is no longer restricted to the imagination of operator, but can be visualized in 3D. Template systems designed to transfer a preoperative desired implant position on to the surgical site are reported to produce accuracy, eliminate errors in manual insertion and complications like damage to inferior alveolar nerve canal can be avoided.

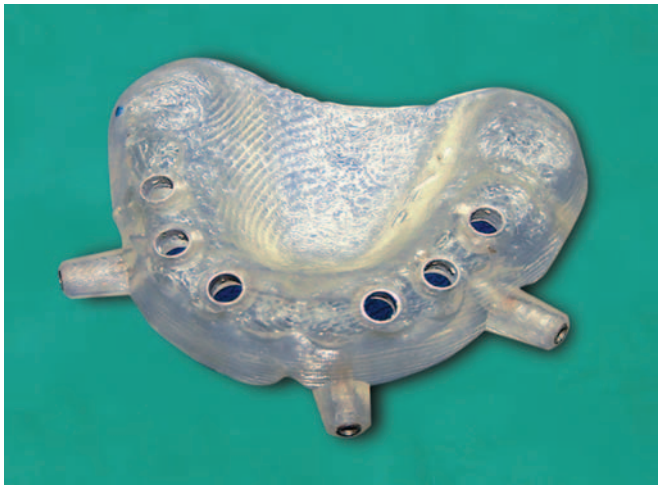


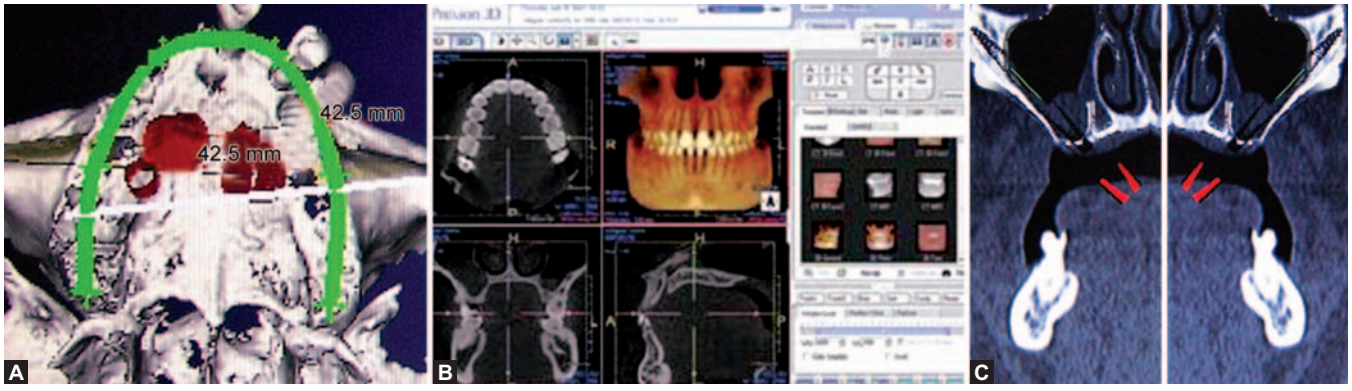
Fig. 53.4: Custom-made surgical guide for dental implant placement manufactured through rapid prototyping. Planning was done on interactive implant planning software (Nobel Biocare)

Its applications for osteotomy guide, distractor placement guide and occlusal wafer guide for orthognathic surgery are increasing. Surgical guides have been shown to provide an accurate reliable physical alternative to computer guided navigation.

Softwares can also be used to capture the anatomy of normal side and produce mirror image to be used as guide for reconstruction on the abnormal side. Rapid prototyping techniques can be used to construct customized implants. These customized implants reproduce the exact details as needed by the patient **(Fig. 53.3)**.

INTRAOPERATIVE NAVIGATION AND ROBOTIC SURGERY

Surgery in the cranial area includes complex anatomic situations with high-risk vital structures and high demands for functional and esthetic results. Conventional surgery requires that the surgeon transfers complex anatomic and surgical planning information, using spatial sense and experience. The surgical procedure depends entirely on the manual skills of the operator. The development of image-guided surgery provides new revolutionary



Figs 53.5A to C: (A) Nobel guide implant planning software. Virtual 3D model generated from scanned computed tomography (CT) data is being used for placement of zygoma implants. Surgery was done as per the planning; (B) Different softwares for construction of 3D models; (C) Zygomatic bone supported (R) and (L) implants placement planning

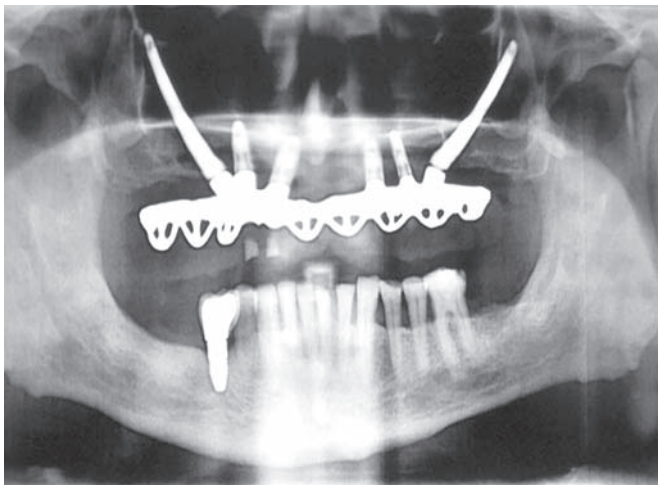


Fig. 53.6: Final orthopantomogram (OPG) of zygomatic bone supported (R) and (L) implants

opportunities by integrating presurgical 3D imaging and intraoperative manipulation.

Integration of imaging with surgical field allows visualization of different types of images and simultaneously shows structures that are normally visible intraoperatively and permit navigation in areas of anatomical sensitivity. This enables preoperative surgical planning to be incorporated directly into the procedure. Clinical benefits of image guided surgery include use of smaller incisions, direct access to targeted areas and consequently less invasive procedures.

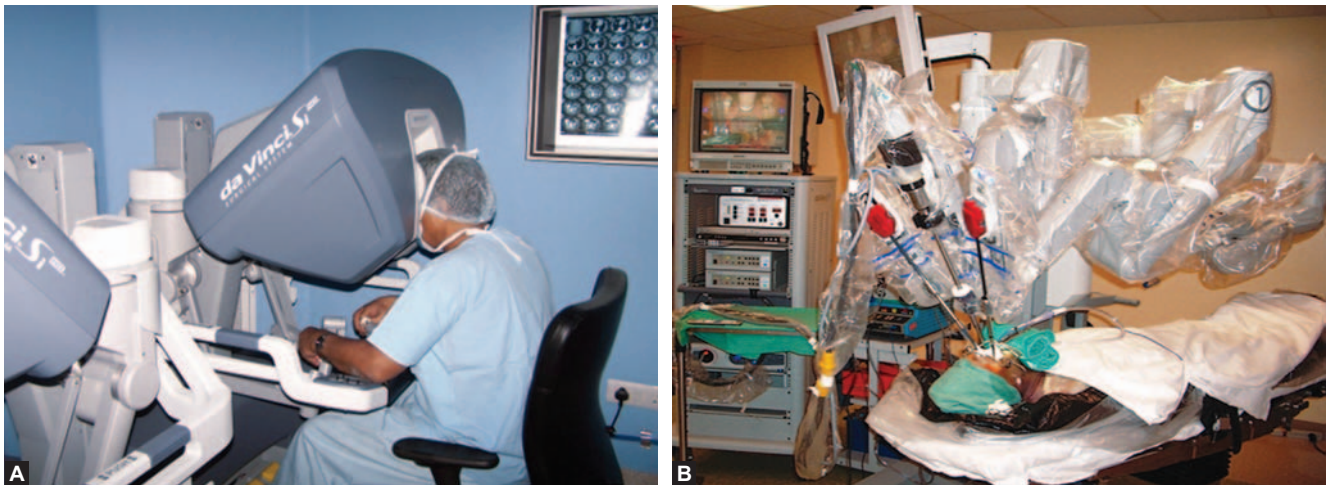
Computer-aided surgery systems are commonly used in neurosurgery, endoscopic sinus surgery, and some orthopedic procedures. Because of the complex nature of maxillofacial reconstruction procedures, these systems are now being used for maxillofacial surgery. Intraoperative navigation gives the surgeon control in difficult access areas and complex procedures, thus reducing the chances of human error.

In computer-aided surgical systems a virtual patient is generated from the preoperative scans. Certain stable landmarks are identified on both the virtual patient and actual patient. In technical language, these markers are known as "Fiducial markers". These markers serve as a guide for tracking of the patient and surgical instrument in space. Tracking is mainly done with the help of transmitters, which uses an optical source or electromagnetic source. There are two transmitters, one to be placed on the patient and other to be placed on surgical instrument. Computer with the help of fiducial markers integrates the information from the actual patient with the virtual patient to precisely locate the patient and surgical instrument in space.

Further step in the advancement with fusion of these technologies is robotic surgery. In robotic surgery, a robotic arm controlled by the surgeon, sitting far away from the operation table, actually performs the procedure. Surgery with great precision in difficult areas through minimal access is possible with the help of robotic arm. Many advanced hospitals in the world have robotic surgery suites to perform difficult surgeries in head and neck with the help of robotic arm [Trans-oral robotic system (TORS) based on da Vinci robotic arm] **(Figs 53.7A and B)**. TORS has the benefits of being less invasive, with fewer complications and shorter hospital stays. There is less blood loss, little scarring, and fewer temporary and permanent side effects, such as loss of speech or swallowing ability. Surgeons operate with greater precision and control using the TORS approach, minimizing the pain, and reducing the risk of possible nerve and tissue damage linked to large incisions.

Minimal Invasive Surgery and Role of Endoscopes in Oral and Maxillofacial Region

Minimally invasive surgery, with the use of the endoscope has improved in recent years, because of technological advancements in optics and associated instrumentation. Flexible endoscopes have revolutionized many fields of surgery including maxillofacial surgery. First application of endoscopic surgery was in sinus surgery and functional endoscopic sinus surgery has become a standard of care. Endoscopic surgery has been applied to many areas of craniomaxillofacial surgery, which includes correction of cranial synostosis, esthetic procedures like brow lift, forehead contouring, frontal sinus fracture repair, orbital decompression, various osteotomies and fracture repair including mandibular condyle fractures. Trauma, orthognathic, sialoendoscopy, and TMJ surgery are commonly performed with the assistance of the endoscope. From an educational standpoint, surgical anatomy and various other principles can easily be taught to trainees with the assistance of the endoscope. The operating surgeon can visualize an area via the endoscope, and instruct regarding the surgical maneuvers on the monitor, without obstructions to view. This technique also allows others in and out of the room to view the image. Endoscopically assisted surgery is gaining popularity and is becoming a tool frequently used by surgeons to assist in and simplify some of the more difficult techniques that often require more extensive surgical exposure for visualization. In this way, difficult deeply located areas can be accessed easily through small incisions, thus reducing morbidity and hospital stay. Flexible endoscope



Figs 53.7A and B: (A) Robotic surgery—da Vinci operation suite for performing robotic surgery (Facility at PGI, Chandigarh); (B) Transoral robotic surgery with the help of robotic arm in a head and neck cancer patient

is especially available for TMJ arthroscopy, and salivary gland endoscopy. Endoscopically assisted approaches have been advocated for open reduction and internal fixation of condylar fractures **(Fig. 53.8)**. This approach allows fracture treatment with limited transoral incision. In conjunction with transoral approach, scars are invisible and risk of facial nerve damage is minimal.

With the advent of sialoendoscope **(Figs 53.9A to C)** \nonsurgical removal of stones has become possible. Sialoendoscopy has been used for obstructive sialadenitis. Its use is recommended in all cases where stone has not been visualized radiologically. It is also useful for balloon dilation of ductal strictures, basket retrieval of stones and washing of mucosal plugs.

Fiberoptic assisted intubation for general anesthesia also has made the job of anesthetist easy in difficult airway cases.

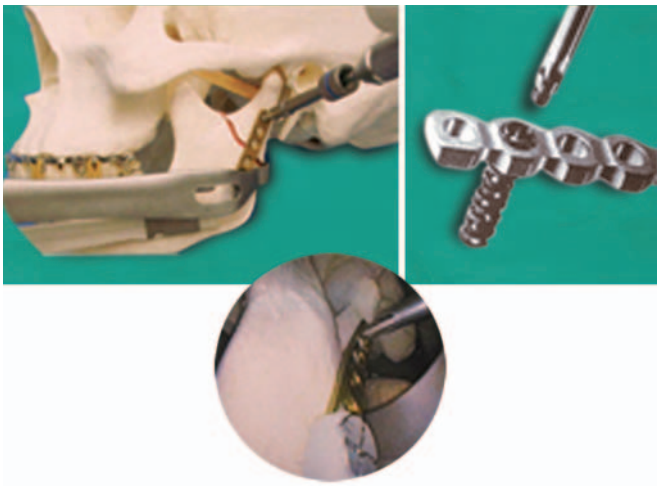
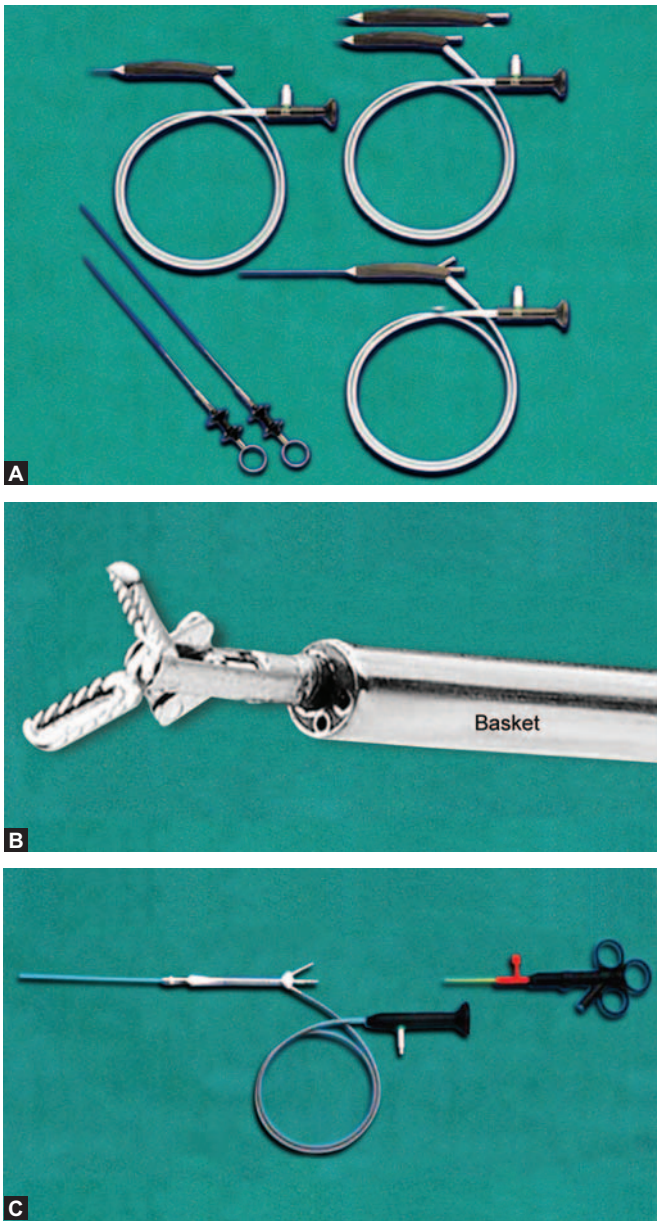


Fig. 53.8: Instrumentation and technique for endoscopic assisted reduction and fixation of condylar fracture

Tissue Regeneration/Engineering in Oral and Maxillofacial Surgery

An oral and maxillofacial surgeon is constantly facing the difficult task of reconstruction of missing tissues as a result of ablative surgery, post-traumatic or congenital defects. Each different anatomic area offers a different challenge in terms of specific need for bone reconstruction in terms of esthetics, form and function. Autogenous bone grafting, regional or free microvascular flaps have been the main stay for reconstruction, but this causes possible donor and recipient site morbidity. The development of effective reconstructive procedures using tissue engineering techniques without the need for conventional tissue transplantation procedures can have a tremendous impact on surgery of head and neck area.

Tissue engineering is an interdisciplinary field comprising of cell biologists, biochemists, material scientists, engineers, and clinicians, and an understanding of the complex role of the various components with the aim to create limitless and readily available supply of off-the-shelf tissue regenerates. Tissue engineering involves the vital collaboration between the three key components, stem cells, resorbable scaffolds and bioactive molecules such as growth factors. The combination of scaffolds and cells is often referred to as a construct. Constructs may be fashioned *ex vivo*, and then implanted into an individual.



Figs 53.9A to C: Sialendoscope—1.3 mm diameter sialendoscope

Approaches to Tissue Engineering

- **Growth factors/bone morphogenetic proteins (BMPs):** BMPs are the group of osteoinductive sequentially arranged amino acids and polypeptides that are capable of stimulating adult mesenchymal cells to become osteoblasts and form bone. Adult mesenchymal cells are supplied by periosteum and paraperiosteal connective tissue. Recombinant human BMP-2 (rh-BMP-2) (infuse, meditronics) was approved as an alternative to autogenous bone graft for sinus augmentations and for localized alveolar ridge defects associated with extraction sockets. It has been used for reconstruction of mandibular continuity defects as well. Tissue engineered osteoinductive grafts may someday eliminate the need for harvesting corticocancellous grafts. At present rh-BMP-2 is very costly. However, there is no need to harvest autologous bone graft, the cost of surgery and duration of hospital stay is less, thereby reducing the cost difference with non-BMP cases.
- **Stem cells:** Stem cells can dedifferentiate in the correct setting into simple, unspecified forms. They, then have the ability to form new structures based on the stimulus and chemical factors that are present in the matrix. There are two types of stem cells—(1) adult stem cells and (2) embryonic stem cells. Human embryonic stem cells are pluripotent stem cells isolated from the inner mass of human blastocysts. At this time, embryonic stem cells are not usually used in the clinical setting and are used for only research purpose in some countries. Embryonic stem cells have great potential because of their capacity for differentiation. However, before human embryonic stem cells can be used clinically for tissue engineering, problems, such as culturing them without exposure to animal proteins as well as avoiding teratoma formation and immune rejection by the recipient's host, must be solved.

The source of cells for tissue engineering depends on the structure to be replaced. Currently, adult stem cells used in clinical setting are autologous cells. For the tissue engineering of bone, cells from the bone marrow and adipose tissue have been used as autologous cells. These have the ability to dedifferentiate from mesenchymal cells to osteoblasts and then to osteocytes, which have the ability to lay bone in a laminated form. Harvesting adipose tissue or bone marrow is not morbid. These cells are then used to seed a resorbable scaffold made with CAD/CAM technology to the precise dimensions of a missing segment of bone. The seeded cells can be stimulated physically with magnetic or galvanic stimulation, ultrasound, hypoxic or hyperoxic gradients, growth factors such as transforming growth factor beta-1 (TGFB-1), BMPs or vascular endothelial growth factor (VEGF), to guide the differentiation and growth of the cells.

Despite some success in areas of bone tissue engineering, limitation of these techniques, methods and strategies are evident in the clinical arena. The central issue is how to generate a blood supply within any bone

construct such that new bone functions as normal bone. Blood supply allows bone to fight infection and to receive nutrition that aid in its incorporation and remodeling at the site of implantation. Without a method of generating an adequate blood supply, bone regeneration cannot become the method of choice. Although use of tissue engineering for reconstruction of mandible has been reported at present, the technology is very expensive and at experimental stage.

Stem cells from dental pulp from developing teeth, shed deciduous teeth and dental follicle provide other source of adult epithelial and mesenchymal stem cells **(Fig. 53.10)**.

Third molar removal also presents some opportunity for harvesting follicular cells, cementoblast-like cells and dental pulp stem cells, which have been cultured and studied. The receptors of these cells can be characterized, an important first step in understanding these cells and their potential future use.

There is a hope to create synthetic form of bone, skin, cartilage and muscle that can function as well as normal tissues depends on ability to effectively integrate multiple technologies and components that are capable of meeting the complex demands of reconstruction in head and neck area. No single scientific field can generate the ideal method of engineering tissues. However, through collaboration and expansion of progression in tissue engineering the right combination of materials, cells and growth factors may be found, so as to make taking tissues from other sites of body a thing of past.

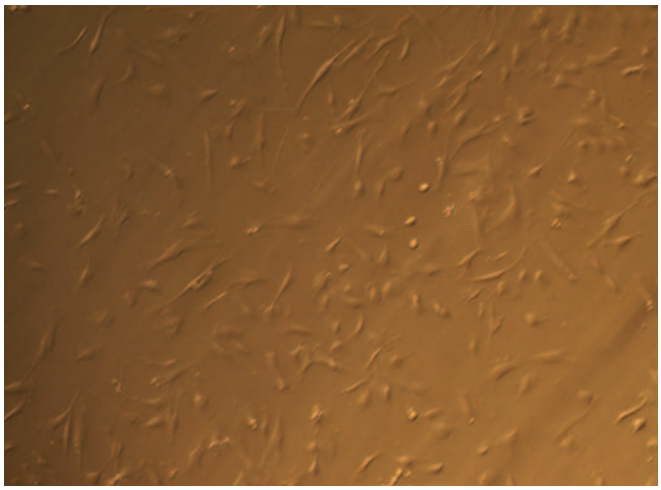


Fig. 53.10: Stem cell cultured from dental pulp at Department of Regenerative Medicine, Postgraduate Institute of Medical Education and Research, Chandigarh, India

ADVANCES IN LOCAL ANESTHETICS

In oral surgery, local pain management is the most critical aspect of patient care. Improvement in local anesthetic agents and their delivery system are the most significant advances that have occurred in last decade. Today's anesthetics are safe, effective and can be reversed and are associated with minimal risk of allergic reactions.

Articaine

It is a new aminoamide class of local anesthetic, approved by US Food and Drug Administration (FDA) in 2000 for clinical use. It is available in 4% strength with 1:100,000 or 1:200,000 epinephrine. It has thiopentone ring instead of benzene ring, which makes it more lipid soluble. Therefore, it has got better tissue penetration and diffusion than the lidocaine. Because of better bone penetration and diffusion it can anesthetize palatal side and anterior lingual sides with buccal infiltration only. Because of the presence of additional ester group it can undergo biotransformation in plasma as well as in liver. Its lower systemic toxicity and wide therapeutic range allows its use for in higher concentration than other amide type local anesthetic. The maximum dose of 4% articaine should not exceed 7 mg/kg body weight. 4% articaine is as efficient as 2% lidocaine in achieving anesthesia for various dental and oral surgical procedures.

Reversing Effects of Local Anesthesia

Soft tissue anesthesia after local anesthetic infiltration or block may linger on for several hours. This may not be desirable in certain case especially in children. In 2009, FDA approved phentolamine mesylate (OraVerse®, Novalar Pharmaceuticals Inc., USA) for the reversal of the local anesthetic. This can be used both in adults and children, but not recommended below 6 years of age or weight less than 15 kg. Phentolamine is an alpha-adrenergic antagonist, it acts by providing vasodilatation, thus allowing the faster diffusion of local anesthetic into vascular system. It is injected in same volume as the local anesthetic and it accelerates the reversal of soft tissue anesthesia.

Local Anesthesia Delivery Devices

Fear of needle prick and pain during injection of local anesthetic are the main problems of local anesthesia delivery. Newer local anesthetic delivery devices not only provide reduction in pain on injection and failure rates, but also produce more precise anesthetized area. Vibrotactile,

VibraJect, DentalVibe, Accupal, CompuDent are the few local anesthetic delivery devices which uses vibration technology to decrease the pain on injection.

Advances in TMJ Arthroscopy and One Point Arthroscopy

The improvements in optics and lens technology have advanced the ability to diagnose and treat various pathologic conditions of TMJ through arthroscopy. The TMJ arthroscope is a small, tube like camera that projects the image of the joint onto a monitor, allowing the surgeon to view the inside the joint without making any large incisions. Over the last decade TMJ arthroscopy and arthrocentesis have gained popularity because of its minimal invasive nature and low complication rates. Now, it is possible to use lasers instead of conventional cutting instruments through the arthroscope. This allows the surgeon to cut and ablate tissues without causing iatrogenic tissue damage.

Standard TMJ arthroscopy involves two arthroscopy portal punctures over the TMJ. One is for the arthroscope and other for the blunt probe, which is used for lysis and lavage. Recently, one puncture arthroscope has been introduced for visualization of TMJ. The OnPoint™ 1.2 mm Scope System (Biomet Microfixation, USA) is an innovative breakthrough that provides minimally invasive visualization of the TMJ in the comfort and convenience of an office based setting. It uses disposable 1.2 mm fiberoptic scope **(Fig. 53.11)**. With a scope diameter no larger than an 18 gauge needle, this state-of-the-art imaging system allows for an accurate and less invasive procedure.



Fig. 53.11: Single port 1.2 mm flexible temporomandibular (TMJ) arthroscope (OnPoint™)

Buccal Pad of Fat in TMJ Reconstruction

This technique has been invented by V Rattan, in year 2004. In this technique dead space created after gap arthroplasty is blocked with the help of buccal pad of fat. Buccal pad of fat is harvested through the same preauricular approach as used for TMJ surgery. Blunt dissection is done anteromedial to the coronoid process, where buccal pad of fat is located and it is transposed to TMJ area **(Fig. 53.12)**. This fat can completely block the dead space as compared to any other tissue, because of its fluidity. This prevents formation of blood clot, which is primary factor for heterotopic bone formation and reankylosis of TMJ. Long-term viability of this flap has been established by the author in a MRI study. This technique has totally eliminated chances of reankylosis of TMJ. In a follow-up of 60 cases, ranging from 1 year to 7 years, treated by this technique, none of the patients had reankylosis.

RECENT ADVANCES IN MAXILLOFACIAL TRAUMA MANAGEMENT

High velocity trauma leads to badly comminuted and displaced fractures. To manage these complex fractures, there have been improvements in techniques of fracture fixation and reduction. Other advances in the field of surgery are also applicable to trauma management. This includes improved diagnostic imaging, minimal access surgery and endoscopic surgery, biomaterial advances, intraoperative imaging, rapid prototyping techniques, computer-assisted surgery, and customized implants.

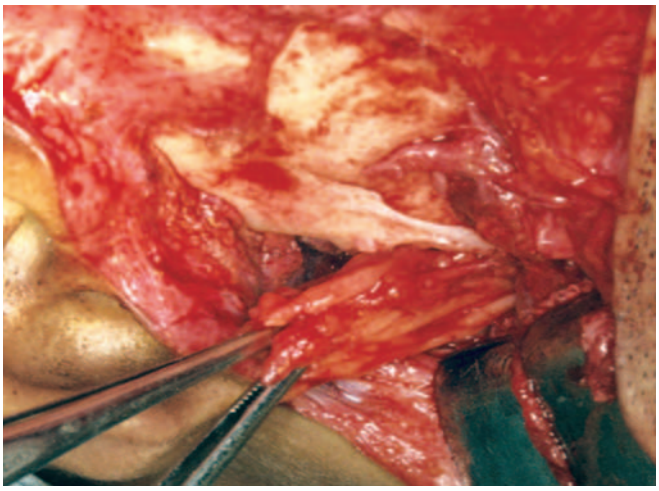


Fig. 53.12: Buccal pad of fat flap can easily reach temporo-mandibular (TMJ) for blocking the dead space and prevents heterotopic bone formation (technique developed by Dr Vidya Rattan)

Intermaxillary Fixation Screws

Special screws for intermaxillary fixation (IMF) are available, which have a hole for passage of wire below the screw head. The screws are inserted above the root apices in maxilla and mandible, and wire is passed through the holes to close the mouth in occlusion **(Fig. 53.13)**. These are temporary fixation devices and once the fractures are fixed screws can be removed intraoperatively or a later date under local anesthesia. Screws are quick to place, maintain better oral hygiene, and there is no risk of prick injury, as compared to fixation with arch bars and wires. There is risk of injury to tooth roots,- so these should be placed away from roots of teeth.

Rapid Intermaxillary Fixation

Rapid IMF (Synthes, Switzerland) is an adjustable flexible plastic band that wraps around the tooth to create an anchorage point for temporary maxillomandibular fixation and immobilization. These have been developed to reduce the risk of needle-stick injury. IMF is done with the help of elastic chain **(Fig. 53.14)**. These anchorage points can retain IMF up to 3 weeks.

A recent and significant advancement has been the development of resorbable implants. Drawbacks of currently used titanium implants may include soft tissue irritation and cold intolerance, creation of distortion artifact on CT and MRI, weakening of bone from excessively rigid fixation, "stress shielding" possible interference with facial growth, implant migration over time, and the possible need for subsequent implant removal. Resorbable plates provide initial osseous fixation strength for direct bone healing and then they disappear over a period of time leaving behind no foreign body.

Resorbable plates and screws typically feature one or a combination of the esters of polylactic acid (PLA) or polyglycolic acid (PGA). PLA occurs in the stereoisomer polylevolactic acid (PLLA) and the stereocopolymer polydextrolactic acid (PLDA). The strength of plates depends on the biomechanical properties of polymer used. PLLA is the strongest with least tissue reaction and bulk, although not as resorbable. PLLA plates have 50% yield strength required to break a titanium miniplate—champy type. PLDA is the weaker polymer that degrades rapidly. The alloy of PLLA and PLDA can achieve a balance between strength, lack of bulkiness, crystallinity and optimal resorption rate. The manufacturing process technique is also important for optimization of biomechanical properties of the plates.

PLA and PGA are degraded by hydrolytic destruction of the polymer via citric acid cycle in the liver followed by metabolism of single lactic or glycolic acid molecules through corresponding biochemical pathways and elimination primarily through respiration. The rate of degradation depends upon blended composition of the PLA and PGA components. Complete resorption may take 12–24 months depending on the composition.

Potential problems of biodegradable plating systems include decreased strength; screws require tapping, water bath for heating to aid adaptation, and increased bulk as compared to titanium. These plates are costly than titanium plates. These materials have been successfully used for fixation of fractured and osteotomized segments in craniomaxillofacial region.



Fig. 53.13: Intermaxillary fixation with the help of screws (Synthes)

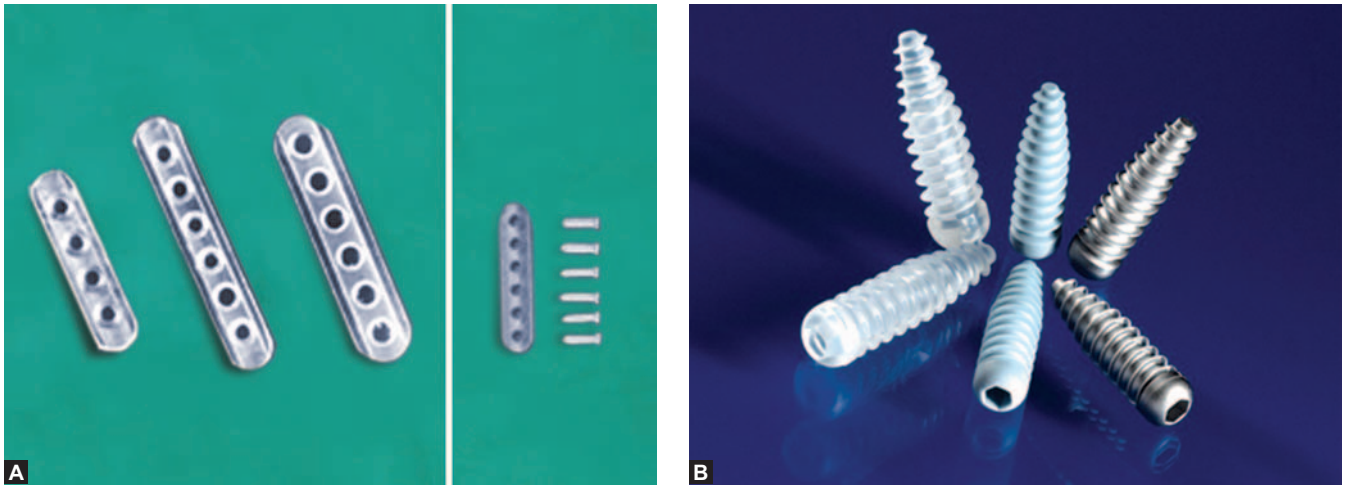


Fig. 53.14: Rapid intermaxillary fixation (IMF) technique (Synthes)

The strength of these plates has been improved by self-reinforcing technique in which polymeric fibers of same material are added to the binding matrix of the plates and screws. These (BioSorb FXs, Conmed Linvatec, Finland) plates can be bent at room temperature and do not require heat to become malleable **(Fig. 53.15)**.

SonicWeld Treatment

The SonicWeld Rx (KLS® Martin, USA) system is a further improvement to overcome the limitations of resorbable screw. The SonicWeld Rx process takes advantage of polymer characteristics instead of adapting titanium screw designs. A completely resorbable SonicPin Rx® is inserted into a predrilled hole. The user activates the SonicWelder, creating ultrasound vibration while driving the pin into the pilot hole **(Fig. 53.16)**. The SonicPin penetrates into all bone cavities and welds to the resorbable plate. The SonicPin is allowed to return to a solid, and then the process is complete. The result is a three dimensionally stable construct. Implant insertion takes only a few seconds and there is minimal possibility of stripping in the hone or shearing of the pin as with screw fixation. SonicPin is comprised of the same material as PDLLA implants (Resorb-X). Resorb-X implants are a homogeneous blend of D and L isomers of PLA and are an inherently amorphous, totally noncrystalline polymer.



Figs 53.15A and B: (A) Bioresorbable plates and screws; (B) Bioresorbable screws

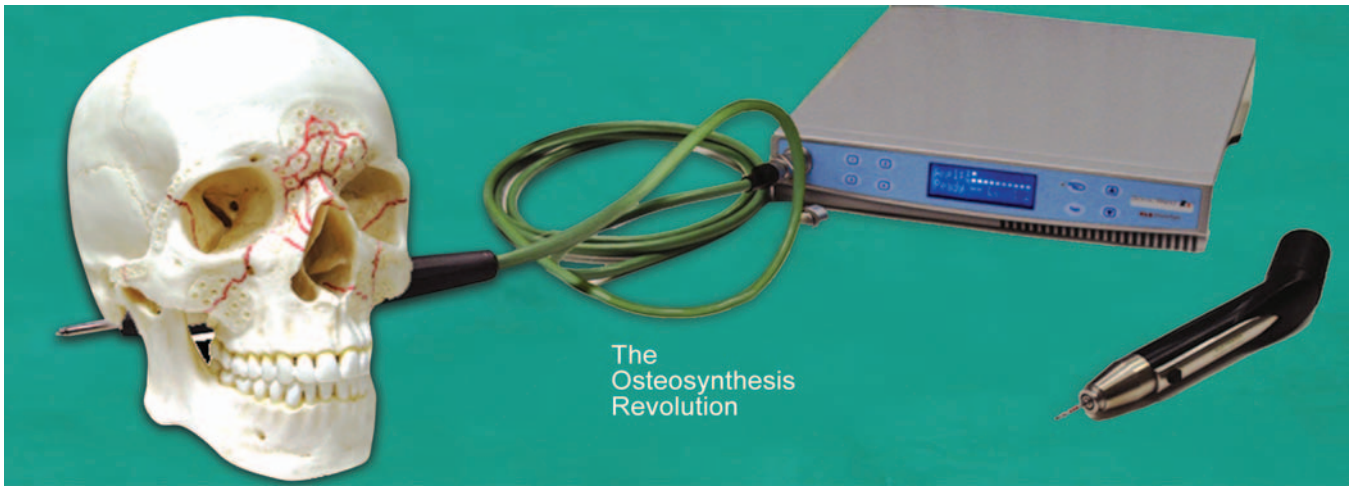


Fig. 53.16: SonicWeld treatment concept (KLS Martin)

Biological, mechanical and histological testing and clinical validation have proven the biocompatibility of SonicWeld Rx® implants. It maintains its strength for approximately 10 weeks, and safely degrades through hydrolysis and the metabolic process. SonicWeld Rx® is not indicated for fully load bearing situations or for patients with conditions including blood supply limitations, insufficient quantity or quality of bone, or latent infections.

Self-drilling, Self-tapping Screws

The self-drilling principle has the advantage of avoiding the necessity to drill a hole, thus shortening the process of osteosynthesis and requiring less instrumentation. Preclinical investigations at the AO center utilizing cadaver cortical bone in 1–3 mm thickness as well as cancellous bone block have demonstrated that in thin bone, (1–3 mm thickness), pull out strength of the self-drilling, self-tapping screws was similar to conventional self-tapping screws. With cancellous bone blocks, the self-drilling screws had a threefold increase in retentiveness, when compared to the self-tapping variety. Thus the self-drilling, self-tapping screws were essentially equal to the retentiveness of self-tapping screws in thin bone, but were much superior in cancellous bone. This is presumably due to self-drilling screws compressing rather than cutting the cancellous bone around the threads of the screws. The clinical implication is that self-drilling, self-tapping screws are much superior when fixing screws into a cancellous bone graft. It should be noted that self-drilling screws may be difficult to apply in extremely dense bone such as the mandible.

Locking Plates and Screws System

In locking plates, the screw locks not only to the bone, but to the bone plate as well. This is accomplished by having a screw with a double thread. One thread will engage the bone, another will engage a threaded area of the bone plate **(Fig. 53.17)**. The result is a locking plate system, which in effect provides a mini internal fixator. This avoids problem of loosening of one or more screws during the convalescent period following miniplate osteosynthesis.

Since the plate locks to the screw rather than gaining its rigidity by being compressed against the bone, it also avoids the cortical necrosis, which is sometimes seen under a plate, which is compressed against the bone.

Locking plate and screw systems have several advantages over the conventional screw systems. It becomes unnecessary for the plate to intimately contact

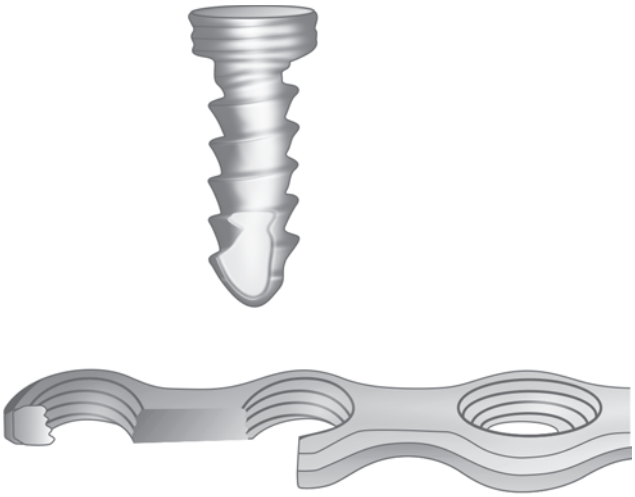


Fig. 53.17: Locking plate and screw concept (AO)

the underlying bone in all areas. Conventional plate/screw systems require precise adaptation of the plate to the underlying bone. Without this intimate contact, tightening of the screws will draw the bone segments towards the plate, resulting in alterations in the position of the osseous segments and the occlusal relationship. As the screws are tightened, they "lock" to the plate, thus stabilizing the segments without the need to compress the bone to the plate. This makes it impossible for the screw insertion to alter the reduction. Another possible advantage to this property of a locking plate/screw system is a decreased incidence of inflammatory complications from loosening of the hardware. It is known that loose hardware propagates an inflammatory response and promotes infection. Locking plate/screw systems have been shown to provide more stable fixation than conventional nonlocking plate/screw systems. The locking screws need to be in alignment to the threads on plate meaning that axis of insertion need to be guided with the help of a guiding sleeve.

Another advancement in locking technology is multidirectional fixation. TriLock technology (Medartis, Basel, Switzerland) represents a significant step forward in multidirectional and angular stable fixation. The spherical three-point wedge-locking creates a connection between the head of the screw and the plate hole which is stable in angle and axial plane **(Fig. 53.18)**. The locking can be adjusted up to three times within ± 15° without loss of stability.

However, locking plates are not without problems. The locking plates can fatigue or fail in long unsupported sections or if it is stressed too much at one level. Locking

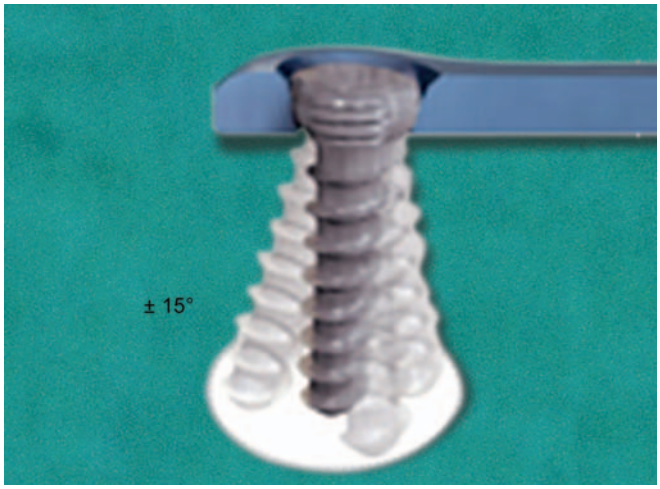


Fig. 53.18: TriLock locking screw concept (Medartis)

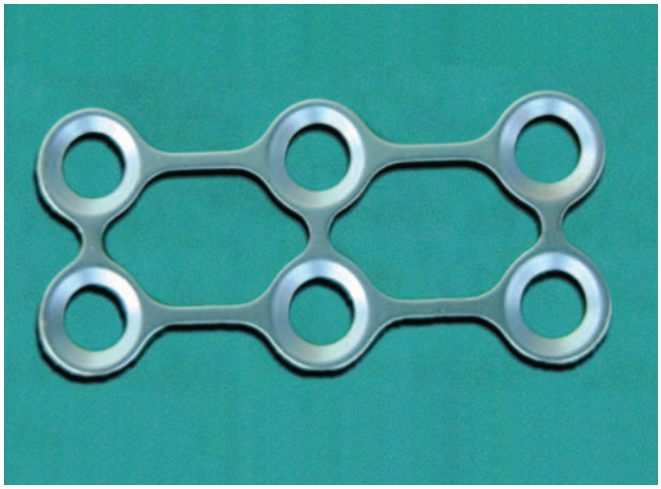


Fig. 53.19: 3D plate concept

plate failures can be mechanical—bending stresses on the plate, the screw-to-plate junction or biological—the screw-to-bone interface, bone quality.

3D Plates

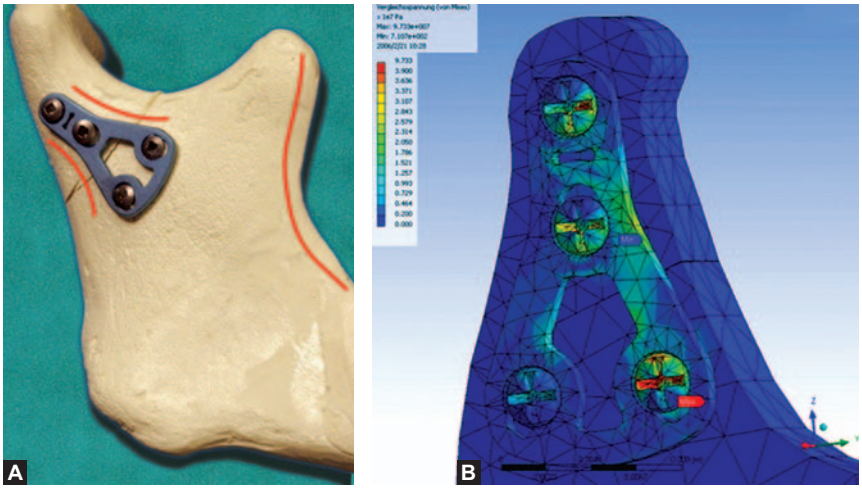
In 1992, Farmand developed 3D plate with quadrangular design formed by joining two miniplates with interconnecting crossbars. In 3D plates, whose stability, unlike traditional plates, do not depend on the thickness of the plate, but depends on its format. The stabilization of plates with monocortical screws forms a cuboid that gives to the system tridimensional stability **(Fig. 53.19)**. This stability is shown in biomechanical studies. These plates can be inserted through intraoral techniques and have shown low complication rates. Because of smaller size, these are easy to handle and adjust. To overcome the disadvantages of loosening of hardware and need of perfect adaptation of miniplates, a new internal mini-locking-3D system was developed in collaboration with the AO/Association for the Study of Internal Fixation (ASIF) Institute.

Trapezoidal Condylar Plates

These plates are especially designed on the concepts of Christopher Meyer and colleagues from France, who did experimental studies on photoelastic analysis of bone deformation in the region of the mandibular condyle during mastication. They consistently found compressive stress patterns along the posterior border of the ramus and tensile stress patterns along the anterior border of the ramus and in the zone situated below the sigmoid notch. Therefore, there is need of osteosynthesis plates in the condylar region, close to the tensile strain lines, as has been recommended also for other parts of the mandible when applying semirigid internal fixation. Trapezoidal condylar plates (TCPs) fulfill these biomechanically required principles of functionally stable osteosynthesis **(Figs 53.20A and B)**. The primary stability achieved by TCPs is superior to that obtained by single plating techniques, by axial lag-screw osteosynthesis, and by rectangular plates in the sagittal plane. This is due both to the 3D concept and to the trapezoidal shape itself.

Delta Plate Fixation for Condylar Fractures

The design of the new delta-shaped miniplate (Modus Trauma 2.0 Condylus Fragment Plate; Medartis, Basel, Switzerland) takes into account previous *in vitro* analysis on load, strain, and bone deformation at the condylar neck region, as well as finite-element analysis. Tensile strains occur mainly at the anterior and lateral borders of the condyle; compressive strains, at the posterior and medial borders. The plate is 1 mm thick, 20 mm long and 5 mm wide at the top and 12 mm wide at the base. Each side of the plate has a cross-section of 1 × 2.5 mm, considerably greater than that of an adaptation miniplate. The plate has the base oriented toward the angle of the mandible; thus, the lines of tensile and compressive stress distribution run parallel to both sides of the plate. At the top of the plate is an arm with two longitudinally arranged holes, the lower of which has a gliding design. Two more gliding holes form the two corners of the base of the plate. The design of the plate allows for treatment of even high condylar neck fractures **(Fig. 53.21)**. The plate's delta



Figs 53.20A and B: Trapezoidal plate for fixation of condylar fracture, based on the Meyer's concept. Red lines show tensile forces during chewing. Osteosynthesis plates should be placed on these lines to counteract functional forces

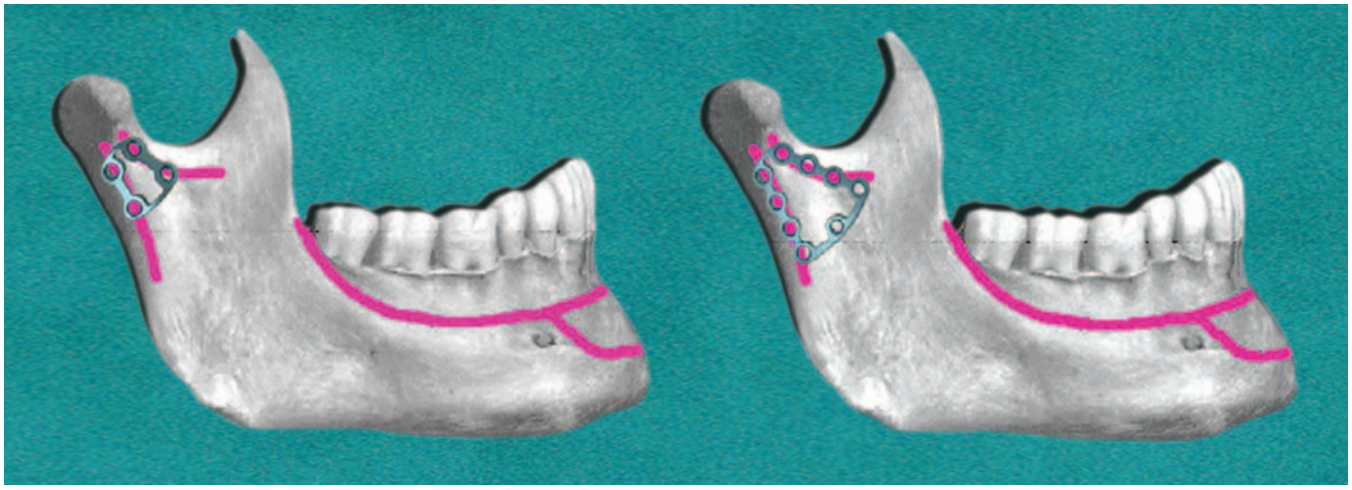
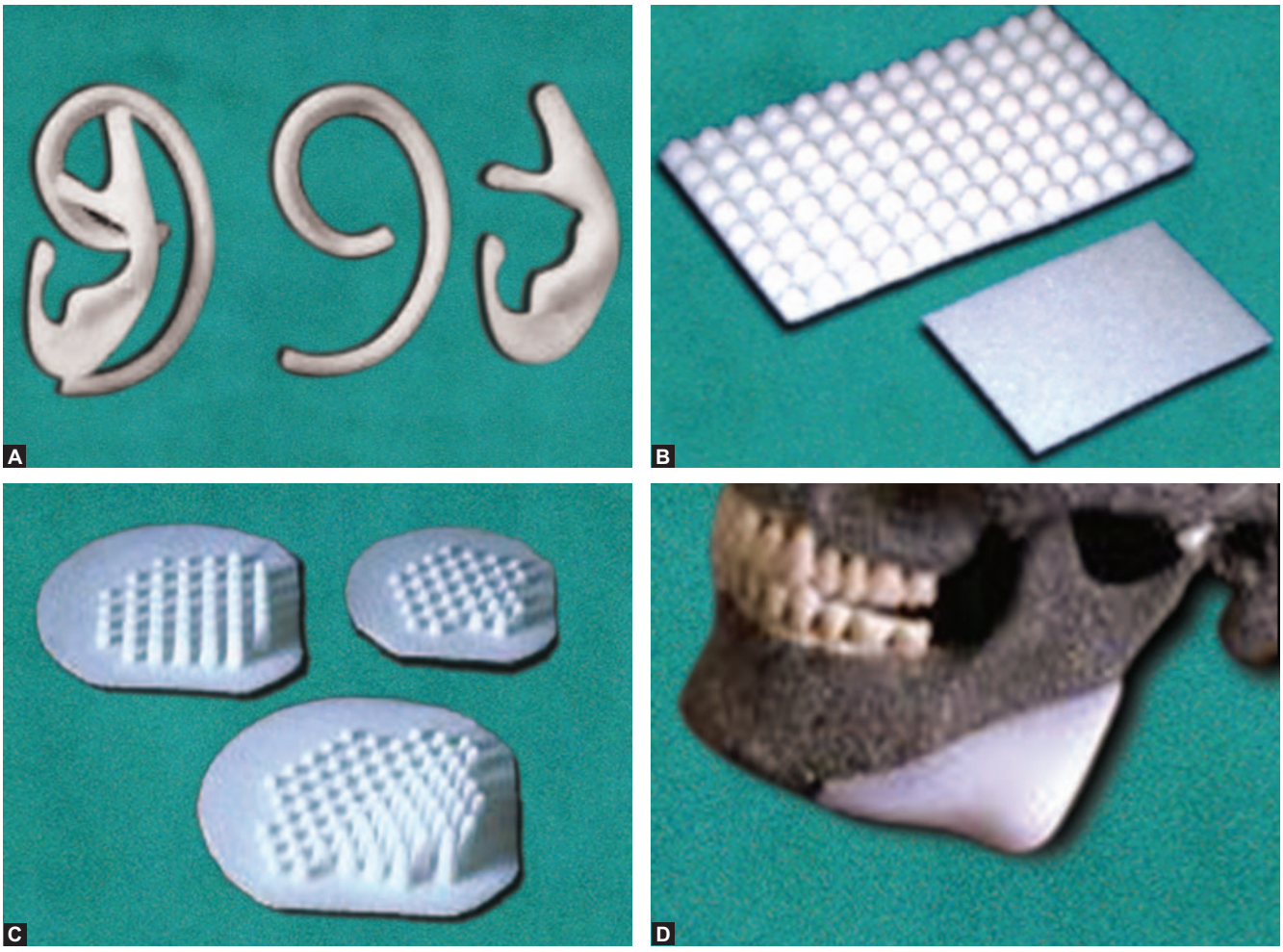


Fig. 53.21: Delta plate for fixation of condylar fracture (Medartis)

shape can handle changing loads, with the highest tensile strain occurring at the anterior and lateral surfaces and the highest compressive strains on the posterior surface. The plate can be easily placed in the confined space at the condylar neck. In cases, when it is desired to avoid visible scars on the face and neck, endoscopic-assisted transoral fracture reduction and stabilization using the delta-shaped miniplate can be done. Taking into account the advantages in biomechanics and handling of the locking miniplate system and the advantages of the delta-plate for fixation of condylar neck and subcondylar fractures, a locking delta-plate has been developed, i.e. the TriLock delta condyle trauma plate (Medartis, Switzerland). These plates are made of pure 1.3 mm thick titanium and are fixed with 2.0 mm TriLock titanium monocortical screws.

Porous Polyethylene Implants (Figs 53.22A to D)

This carbon base polymer is a linear high density polyethylene sintered synthetic alloplastic implant. It has become one of the most popular alloplastic material (MEDPOR, Porex, Biopore, SynPOR) for facial augmentation, for correcting contour deformities, orbital floor repair and enophthalmos correction. The implants are manufactured from an inert, nonabsorbable polymer, formulated to contain a network of open and interconnecting pores



Figs 53.22A to D: (A) MEDPOR® prefabricated implant for ear reconstruction; (B and C) MEDPOR® sheets and blocks; (D) MEDPOR® for angle reconstruction

approximately 100–250 μm in size. The large pore size allows for fibrovascular ingrowth, thus substantially decreasing chances of extrusion and rejection.

Various preformed implants of various standard shapes and sizes are readily available.

Orbital floor implants are available with channel for miniplate or titanium orbital mesh aiding in fixation and stability **(Fig. 53.23)**. One side of the implant facing orbital floor can be made smooth to decrease the risk of orbital soft tissue adhesion. In complex deformities customized implants can be made to order by utilizing rapid prototyping techniques.

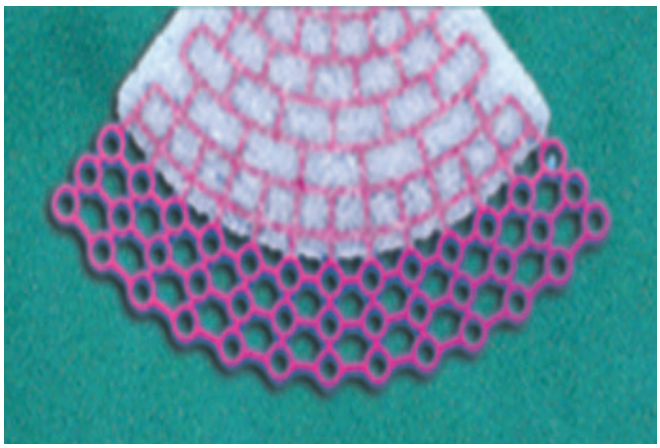


Fig. 53.23: Porous polypropylene with titanium mesh for orbital floor repair (SynPOR, Synthes)

Advances in Topical Hemostatic Agents

Hemostatic agents provide control of bleeding by enhancing or accelerating the natural clotting process.

Although pressure, ligation of vessels and use of electrocautery are the main techniques to control bleeding, the role of hemostatic agents may be secondary, but of great importance in certain cases. Hemostatic agents can facilitate clot formation through enzymatic reactions with host factors, mechanical compression, or a combination of the two. Tissue sealants and bioadhesives act through polymerization between themselves and adjacent tissues. Many new products have been introduced as hemostatic agents. These will be discussed in this section.

Ostene

Ostene (Baxter, USA) is a Wax-like and malleable sterile mixture of water-soluble alkylene oxide copolymers developed as an affordable, easy-to-handle synthetic bone hemostasis material, that reduces the overall risk of postsurgical infections. It is a replacement for bone wax which remains indefinitely at the site of application, inhibits bone healing and increases inflammation and infection. In contrast, ostene is water soluble, gets dissolved within 48 hours, and reduces bacterial adhesion. The material is used in cardiac, orthopedic, oral and maxillofacial, and neurosurgery. Other applications under development include the use of Ostene as a safe, soluble delivery vehicle for a variety of therapeutic agents, from antibiotics to bone growth factors.

ActCel

ActCel hemostatic gauze (Coreva health sciences, USA) is a collagen-like natural substance, created from chemically treated cellulose. ActCel hemostatic gauze is hypoallergenic and contains no chemical additives, thrombin or collagen. When hemostatic gauze contacts blood and other body fluids, it expands three to four times, the original size. ActCel gauze will convert to a gel that self dissolves into glucose and saline over a 1–2 week period, if not removed. ActCel effectively reduces clotting time by accelerating the formation of fibrin cross-linkages, while increasing blood viscosity. This biological reaction promotes the aggregation of red blood cells acting as a clotting agent. ActCel hemostatic gauze may be easily removed from a wound, if necessary, by simply applying water to the gauze; the dressing will dissolve immediately.

Gelitacel

Gelitacel (Gelita Medical, Netherlands) is a fast working oxidized resorbable cellulose hemostatic gauze of natural origin made from highest alpha grade selected cotton. Gelitacel is absorbed in 96 hours, thus reducing risk of encapsulation. It is approved for dental use in Europe. It can be cut to the desired size and adapts easily to anatomical structures. Specifically when soaked with blood, gelitacel is easy to use. It can be sutured to ensure position. It does not stick to the instruments or to the surgical gloves. It can be removed easily to check the bleeding, without falling apart. Gelitacel maintains its original consistency as gauze and does not immediately change into an amorphous mass during the surgical procedure. Extensive tests on gelitacel have proven that the gauze has outstanding strength in longitudinal direction, under both dry as well under fluid/blood saturated conditions.

Chitosan Products

Chitosan is a naturally occurring positively charged polysaccharide derivative of deacetylated chitin. Chitin can be obtained from a variety of sources including the exoskeletal structure of Crustaceans (crabs, shrimps, diatoms, etc.). Chitosan is derived from chitin, using various processes of sodium hydroxide washing to obtain the desired degree of deacetylation and molecular weight. The positive charge attracts the negatively charged red blood cells forming a coagulum that seals the bleeding vessel. It is able to act as a hemostatic independent of coagulation factors. It does not have toxicity and side effects to the human body except for very low-risk of allergic reaction. The biological functions of chitosan are antibiosis and bacteriostasis, hemostasis, and promoting wound healing. It is available in sponge, bandages (e.g. Hemcon), and granular form for use on external wounds, nasal packing and dental use.

HemoStase

HemoStase (Cryolife, USA) is a natural hemostatic product used for the control of surgical bleeding. It is a plant based powder that rapidly dehydrates blood and promotes clotting on contact by controlling the clotting factors. The HemoStase got FDA premarket approval in 2006. It is available in a convenient ready-to-use applicator. HemoStase rapidly absorbs fluids from the blood and accelerates the natural, physiologic clotting process for both diffuse and profuse bleeding, and in the presence of anticoagulants. HemoStase, unlike many hemostatic agents, does not require additional operating room preparation or special storage conditions. In addition, preclinical studies have shown that HemoStase does not promote infection and absorbs within 24–48 hours of

application at the wound site, compared to other surgical hemostats which can take 3–8 weeks or more to fully break down.

QuikClot

QuikClot (Z-medica, USA) is a granular hemostatic agent that saves lives by rapidly stopping severe bleeding. It is being promoted as prehospital hemostatic agent. It is composed of an inert mineral derivative of volcanic rock with active substance *Koline*. It meets a variety of medical needs and application is nonallergenic. It is applied on the wound and then pressure dressing is given to achieve hemostasis. It acts by activating the intrinsic pathway of coagulation by way of activating factor XI and XII.

Floseal

Floseal basically consists of bovine thrombin plus cross-linked gelatin granules mixed together. The bovine thrombin directly activates fibrinogen and converts it into fibrin monomers. It works on the common pathway bypassing all of the other necessary clotting factors. Only requirement is to have functional fibrinogen in order for it to work. The product floseal itself is a little bit different from just using topical thrombin plus Gelfoam, because the gelatin granules are cross linked in such a way, that they do not swell to nearly the same extent. It is absorbed in approximately 6–8 weeks. Because it is Gelfoam beads it can cause arterial embolization, if it is used near a larger vessel. It contains bovine antigens; therefore, it can lead to antibody formation.

Fibrin Sealants

Fibrin sealant [Tisseal (Baxter) and hemaseel (Angiotech Inc. Canada), crosseal (Omrix Biopharmaceuticals)] is a natural or synthetic combination of hemostatic and tissue adhesive. It is available in two separate tubes/vials and these need to be mixed before application. The basic idea is that pure human fibrinogen is combined with bovine thrombin and aprotinin. The bovine thrombin converts exogenous human fibrinogen to fibrin monomers. The patient's own factor XIII and calcium, then converts it into fibrin polymer. There are two vials and these need to be prepared by mixing, just before application. Fibrin sealants are absorbed within 10–14 days and need a relatively dry field in order to work. Some of the fibrin sealants use pooled human fibrinogen, in which there is always the potential for transmission of infectious agents. There is, risks of arterial embolization and antibody formation, when used near large torn vessels. The fibrin sealants are expensive and most efficacious, of all the topical hemostatics.

Artiss

Artiss (Baxter) is a human fibrin sealant, which is used to cause blood clotting during surgery or due to trauma when natural blood clotting processes are deficient. Artiss is the only premixed, ready-to-use fibrin sealant specifically indicated for tissue adherence in face-lift and burn surgeries. It was first approved by the FDA in 2008, to adhere autologous skin grafts to surgically prepared wound beds resulting from burns in adult and pediatric populations of 1 year of age or older.

Feracrylum

Feracrylum (e.g. Sepagard, Themis Medicare, India) is a biocompatible, biodegradable water-soluble polymer of polyacrylic acid. This polymer is hygroscopic in nature, soluble in water, nonabsorbable in the system. Its mode of action is via activation of thrombin, which subsequently causes conversion of fibrinogen to fibrin and thus clots formation. Feracrylum has a high molecular weight of 500,000 to 800,000 Daltons, thus has no adverse systemic effects. On coming in contact with serum proteins, it forms a thin film, thus acting as a mechanical barrier preventing exogenous contamination. The unique inherent antimicrobial property of these synthetic polyacrylates simultaneously prevents bacterial growth on and near the wound site. It is available in gel form and 1% solution. Solution can be irrigated or sprayed onto tissues or applied soaked in a gauze over the wound.

Advances in Dental Extraction Techniques: Atraumatic Extractions

In an attempt to place dental implants in immediate extraction sockets newer techniques and instruments have been developed to make exodontia fast, predictable, and atraumatic. The main aim is to extract the tooth with minimal trauma to the alveolus with maximum preservation of the surrounding bone. Basically all techniques are taking advantage of efficient Class I lever principles, as well as biomechanical properties that result in the release of the tooth from the socket while conserving bone and soft tissue.

Luxators

Luxators are the special set of elevators with a thin tapering blade and varying angulations that compresses the alveolar

bone and cuts the periodontal ligament fibers **(Fig. 53.24)**. Force is applied with hand in apical direction parallel to long axis of tooth to gently ease the tooth from its socket. The operation is performed with the minimum of tissue damage, healing is quicker and it is less distressing for the patient and the surgical team alike.

Manual Periotome

These are thin tipped blades made of good quality steel or titanium which are inserted into periodontal ligament space to act as periodontal ligament knife **(Fig. 53.25)**. These work on the wedge principle and cause severing of periodontal ligament. Handle of the instrument is gently tapped with hammer along the long axis of root to be extracted. This is done in an incremental manner restricting to 2–3 mm each time. The instrument is placed in proximal areas and not on buccal side as bone on buccal side is thin and weakest. It is best suited for extraction of single rooted teeth. In case of multirooted teeth, the tooth can be sectioned and each root is removed separately with the help of periotome. Once the tooth gets luxated, it is picked up with extraction forceps gently.

Powered Periotome

The powered periotome (Powertome 100S, WestPort Medical, Salem, USA) is an electric unit that has a handpiece with a periotome blade that is controlled by a foot switch **(Fig. 53.26)**. The automated periotome blade is controlled by a solenoid within the handpiece. Power output to the handpiece is regulated by the controller box and may be adjusted to 10 different power settings. The Periotome is operated by selecting a power setting on the controller unit and inserting the blade into the PDL space. User experience indicates that it is often easiest to begin interproximally. After inserting the blade into the PDL space, the Powertome is activated via the foot switch. Keeping the blade parallel to the long axis of the tooth, the blade should follow the contours of the tooth in a sweeping motion, advancing apically in 2–4 mm increments. During activation of the unit, the Periotome blade advances easily with minimal hand pressure yielding much faster and less fatiguing results than traditional periotomes. Following use of the Periotome the tooth in question should be gently removed with forceps in a rotational fashion. Multirooted teeth, on the other hand, may require surgical sectioning to convert the tooth into multiple rooted teeth. In some instances, especially in the cases of fused or convergent roots, multirooted teeth may be removed without the need for sectioning. If the roots are flared, however, sectioning

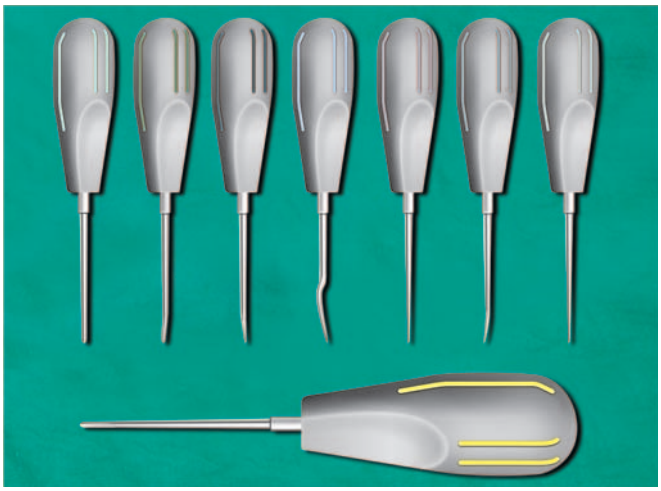


Fig. 53.24: Different Luxators available in the market

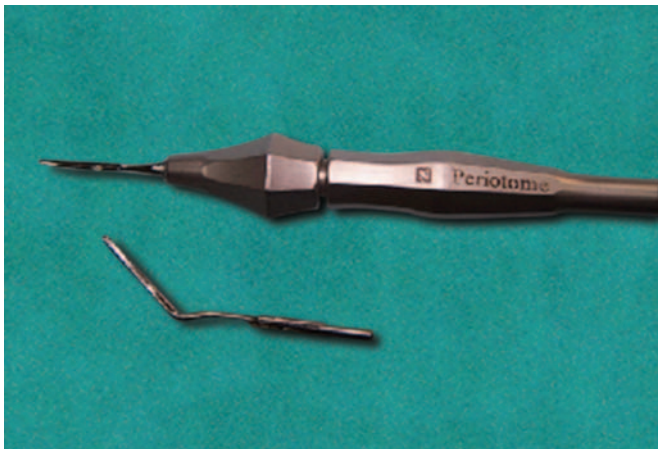


Fig. 53.25: Manual periotome handle and the tip

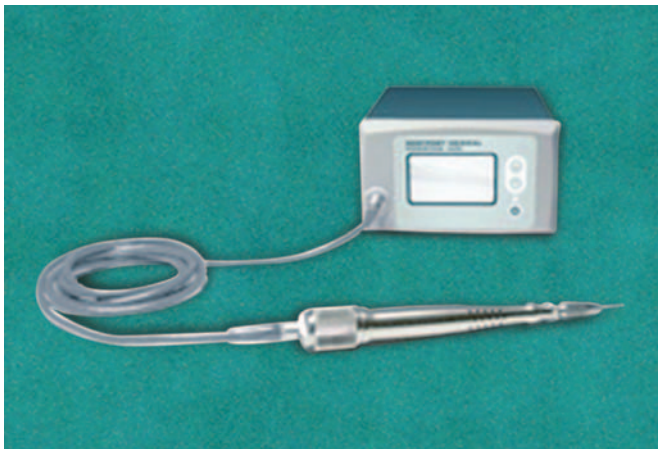


Fig. 53.26: Powered periotome motor and handpiece with periotome tip

the tooth into multiple single rooted teeth will reduce potential for damage to adjacent bone.

Piezotome

This works on the same principle of cutting periodontal ligament fibers with a thin tip applied to handpiece of piezosurgery unit **(Fig. 53.27)**.

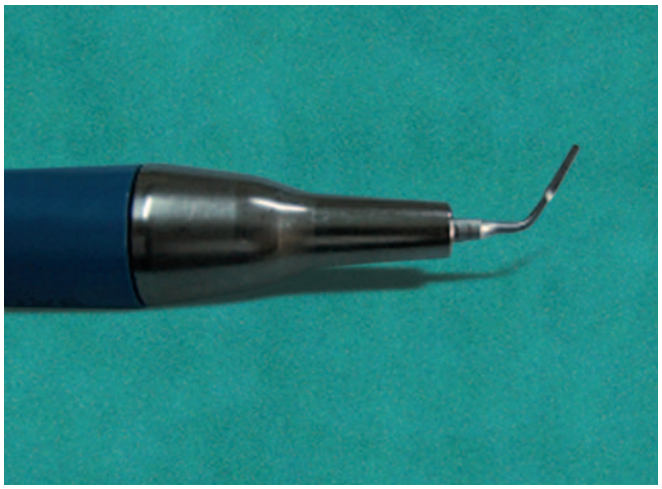


Fig. 53.27: Piezotome for cutting periodontal ligament fibers

Easy X-TRAC Technique

According to the manufacturer the Easy X-TRAC technique allows to *execute an atraumatic extraction with no rotary movements,* zero bone loss, and no post-traumatic swelling. This instrument utilizes sort of a cork-screw mechanism to pull the tooth out of the socket, leaving much of the cortical plates intact **(Fig. 53.28)**. An endodontic post like screw is hammered into single rooted tooth and with a special lever, force is applied onto this nailed screw to extract tooth out of its socket. This technique cannot be used for severely mutilated teeth or teeth already having post. Instrument is expensive and each screw can be used three times maximum.



Fig. 53.28: Easy X-TRAC kit

Physics Forceps

The designers of the Physics Forceps (Golden-Misch) incorporated the concept of first class lever mechanism into the design of their instruments. One handle of the forceps is connected to a "bumper" which acts as a fulcrum point and placed on facial side over mucogingival junction. The other beak of forceps is placed on lingual or palatal side of the tooth **(Fig. 53.29)**. For better understanding of the mechanism of this forceps, first mechanism of traditional forceps should be understood.

Traditional exodontia is analogous to removing a nail from a board with a pair of pliers. Trying to do so places the operator at a mechanical disadvantage, one that worsens with the length of the nail embedded in the board, and worsens even more if the embedded portion is bent. Attempting this inevitably takes more time and creates more damage. Traditional extraction forceps are like the pliers, the location of the force application and the fulcrum are the same. An excessive amount of force is required, and the risk of something breaking is increased. The traditional elevator is a somewhat better class I lever than the traditional forceps in that there is some distance between the force of application and the fulcrum. A more effective class I lever is created when one uses a claw hammer to remove the nail. In this case, the force applied to the object (nail) is farther away from the fulcrum (the base of the hammer), creating a greater moment or

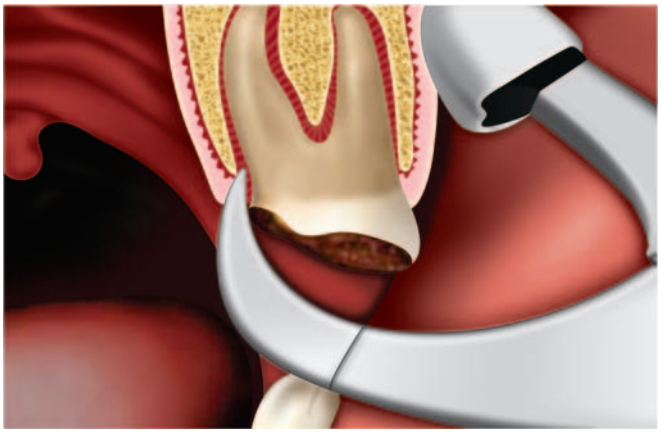


Fig. 53.29: Dental extraction with physics forceps

mechanical advantage, resulting in more efficient removal of the nail.

There are four standard instruments (upper anterior, upper right, upper left, lower universal), and four 2nd/3rd molar instruments (upper right, upper left, lower right, lower left). The bumper cushions the light pressure placed on the alveolar mucosa. After placing the beaks a light, constant, rotational pressure around the axis of the tooth is applied. Within a short period of time, movement of the tooth laterally and/or occlusally will be noticed. This will continue until the tooth is mobile enough to remove with a Rongeur or traditional forceps. The Physics Forceps is not meant to completely remove the tooth from the socket, but to sever the attachment to the socket so that it can be easily removed. This prevents fracture of the buccal plate of bone.

Advances in Tissue Dissection Technology during Surgery

Ultrasonic Cutting and Coagulating Devices

Ultrasonic cutting and coagulating devices [Harmonic Scalpel, Ethicon **(Fig. 53.30)**] utilize ultrasonic energy in the form of sharp blade vibrating at 25 kHz–55 kHz over a distance of 100 micrometers. These vibrations break the hydrogen bond and produce frictional heat during tissue cutting. The vibrating blade is used for dissection of tissues with simultaneous cutting and coagulating. The heat generated is much less as compared to electrocautery and lasers, therefore, causing less thermal injury to tissues. There is improved visibility during tissue cutting due to simultaneous coagulation of vessels.

Plasma Tissue Management System and Coagulator

In this radiofrequency energy is utilized to generate plasma field of highly ionized particles of normal saline (Mechan ENT plasma ablation system, **Fig. 53.31**). These ionized particles are used to disrupt the organic molecular bond of tissues for tissue dissection during surgery. Plasma field is generated between the two beaks of the instrument and it works on bipolar mode. Therefore, current is not passed through whole body as in monopolar mode. Absence of return current removes the risk of burns and cardiac pacemaker problems. Tissue temperature is in range of 40–70°C which is sufficient for cutting and coagulation of tissues and there is no collateral damage. Due to simultaneous coagulation during cutting dissection field is bloodless.



Fig. 53.30: Ultrasonic cutting and coagulating devices



Fig. 53.31: Plasma tissue management system and coagulator

Advances in Sterilization Techniques

Hydrogen Peroxide Gas Plasma Sterilizer (Sterrad, Johnson and Johnson)

In this gas plasma is generated in enclosed chamber under deep vacuum. Electrical field in form of high radiofrequency energy is used to excite the gas molecules to produce charged particles many of which are free radicals. Free radicals are the atoms with unpaired electron which are highly reactive. The free radicals derived from hydrogen peroxide are hydroxyl and hydroperoxyl. These free radicals within plasma field interact with the cell components of microorganisms including spores and cause destruction of cell metabolism. This highly microbicidal activity can be achieved at a relatively low temperature of 37–44°C. Therefore, material that cannot tolerate high temperature and humidity such as plastics and electrical devices can



Fig. 53.32: Hydrogen peroxide gas plasma sterilizer

be sterilized by plasma sterilizers. Whole cycle of plasma sterilization takes around 55–75 minutes. The byproducts of sterilization cycle are oxygen and water vapor. Therefore, the process is environment friendly and sterilized products are available for immediate use and do not require aeration as in case of ethylene oxide sterilization. The plasma sterilizers can be used to sterilize about 95% medical items including narrow lumen endoscopes, fiberoptic instruments, micromotors along with cables, dental handpieces and polymer based instrument and materials **(Fig. 53.32)**. The plasma sterilizers are not suitable for sterilizing cotton, linen and paper.

Points to Remember

- Advances in the field of radiology and imaging
- Intraoperative navigation and robotic surgery
- Advances in local anesthesia
- Recent advances in maxillofacial trauma management
- Advances in topical hemostatic agents
- Advances in dental extraction techniques-atraumatic extractions
- Advances in sterilization techniques.

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Appendices

Appendix 1 Complications following minor oral surgical procedures

Appendix 2 Complications following the use of local anesthetic solution in dentistry

Appendices

Appendix 1: Complications following minor oral surgical procedures

Sl. No.	*Complications*	*Causes*	*Prevention*	*Management*
A.	**Intraoperative complications**			
a.	**Soft-tissue injuries**			
1.	Mucosal tears	i. Improper surgical technique: (Inadequate size of flap) ii. Improper handling of instruments: (careless retraction) iii. Use of excessive and uncontrolled forces	i. Proper surgical technique (Proper designing of flap) ii. Proper handling of instruments iii. Use of controlled force	Closure of tear after completion of surgical procedure
2.	Punctures (Elevator slipping off)	Uncontrolled force (elevator) *Common areas:* i. Upper—posterior palate ii. Lower—tongue and floor of the mouth	i. Use of controlled force ii. Supporting the alveolus from lingual and palatal sides with fingers iii. Proper grip of instruments (Elevators should always be used with an index finger, as a guide, down to the shank of handle towards the tip, to act as a "stop", in case the instrument slips)	*Depends upon size:* i. *Small:* Closure not required; allowed to heal with 2° intention ii. *Large:* Closure indicated; and allowed to heal with 1° intention *Deep punctures:* Suturing may block drainage from depth of wound. Therefore, wound is left open for drainage; and allowed to heal with 2° intention
3.	Inadvertent incisions	Lack of attention *Common sites:* lips and cheeks	Surgeon should be constantly alert, while taking the blade; from tray back to tray; or from staff back to staff	Depends upon the length of incision i. *Small:* No need for suturing ii. *Large:* Requires suturing
4.	Thermal injuries	It may leave a thick ugly scar i. Using hot instruments directly from autoclave Instruments that feel warm with gloves on; are sufficient to cause tissue damage ii. Overheating of rotary instruments (handpieces) iii. *Predisposition (Common sites):* Lips, cheeks and angles of the mouth	i. Allow instruments to cool down ii. *For speed-cooling:* immerse in normal saline iii. Regular maintenance of rotary instruments iv. Proper retraction to protect lips and cheeks, etc.	It can leave ugly, thick scars. i. Application of vaseline ii. Scar-revision, if present; at a later date

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Sl. No. Complications	Causes	Prevention	Management
5. Abrasion and avulsion injuries	Use of rotary instruments with long shanks of burs/drills; rubbing onto soft tissues *Predisposition:* (Common sites): Lips, cheeks and corners of mouth	i. Surgeons should be alert/attentive; while using rotary instruments ii. Adequate retraction or protection of soft tissues, while using these instruments	*Depends upon size and site:* Palliative ii. Area-covered with vaseline iii. Revision of scar, at a later stage
6. *Crush injuries:* Gingival tissues lacerated by blades of forceps	i. Carelessness ii. *Common occurrence:* Upper and lower lips getting entangled with forceps while extracting molars *Maxillary tooth:* Patient will inform of pain *Mandibular tooth:* Severe crush injury, as the area is anesthetized	i. Surgeon should remain alert and attentive ii. Careful retraction of soft-tissues, especially the lips	Palliative
7. Ecchymosis	Secondary bleeding internally (a) mild and (b) severe	Atraumatic surgical technique	a. Mild: Reassurance to the patient b. Treat with cold or hot packs depending upon when the patient is seen c. Use of proteolytic enzymes (serratiopeptidase 20 mg/day)
8. *Surgical emphysema:* Air pushed in tissue spaces	It follows the use of air-driven turbine for bone/tooth sectioning. It develops rapidly with a crackling feeling	Avoid using air-driven instruments for oral surgical procedures.	Absorption is spontaneous, within 1–2 weeks i. Observe signs and symptoms ii. Control of infection
b. Injuries to hard tissues: (teeth and bone)			
B. Teeth			
a. Injuries to tooth being extracted			
1. Fractures of teeth/roots	a. *Major cause:* Improper surgical technique: (i) Improper or no elevation prior to application of forceps. (ii) Inappropriate/excessive application of force applied over forceps during extraction b. *Other causes:* Presence of following factors increase the likelihood of fracture of teeth/roots: i. Tooth weakened by carious process or large restoration ii. *Hasty extraction:* Impatient at the time of extraction iii. *Abnormal root morphology:* Ankylosed roots, devitalized roots, divergent roots, dilacerated roots and slender roots iv. Dense alveolar bone	a. Preoperative assessment of root morphology, and carious lesions b. Planning surgical removal c. *Good surgical technique:* i. Proper selection of instruments ii. Proper use of instruments iii. Proper application of elevators iv. Proper application of forceps and v. Use of controlled force	Ideally, all roots should be removed. Some apical fragments are difficult or hazardous to remove; because of proximity to inferior alveolar nerve, or the antral floor. Such root fragments are best left *in situ* Generally, the removal or a root fragment depends upon (i) vitality of the tooth, (ii) length of the root, (iii) whether the root was infected or not, (iv) whether the tooth was luxated or not, and (v) whether the patient is immunocompromised or not. Root fragments lesser than the apical third, or 5 mm, with a vital pulp in a healthy patient can be left alone; while those greater than 5 mm, with necrotic pulps and with periapical radiolucent areas should be removed; unless the risks of so doing outweighs potential gain. Both the retention of root apex and information given to the patient should be recorded

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Sl. No. Complications	Causes	Prevention	Management
2. Displacement of teeth/ roots			
a. Displacement of teeth/ roots in soft-tissues			
i. Displacement under the mucoperiosteal flap	i. Thin cortical plate, ii. Uncontrolled force, and iii. Fenestration in cortical plates	Use controlled force, and support the alveolus during extraction	Exploration and removal Sometimes radiographs may be required. i. Attempt should be made for its retrieval; Manipulation or pushing the root piece back into its socket should be tried
ii. Displacement in the lingual pouch, and	i. Thin lingual cortical plate in region of mandibular third molar		
iii. Displacement through the lingual cortex of bone in submandibular space	ii. Fenestrations of bone; where roots are in direct communication with submandibular space (In case of fenestration, it is unpreventable) iii. Breaking of lingual cortex due to fusion with the tooth/root	Support of one finger over lingual cortical plate; in order to prevent tooth being pushed into submandibular fossa	ii. Suitable medications should be prescribed (antibiotics, analgesics) iii. If unsuccessful, or beyond the capabilities of the operator, refer to oral and maxillofacial surgeon
iv. Teeth/roots displaced in pterygopalatine fossa	i. Highly placed, unerupted maxillary third molars with conical fused roots ii. Inadequate access, and iii. Careless technique	i. Preoperative assessment (suitable radiographs) ii. Careful surgical technique iii. Sometimes unpredictable	i. Take appropriate radiographs ii. Referral to oral and maxillofacial surgeon.
v. Teeth/roots displaced into maxillary sinus	Predisposition: i. Maxillary posterior teeth are in close proximity with floor of maxillary sinus Teeth commonly involved; second premolars, and molars, especially teeth having conical roots, and partially erupted maxillary third molars *Commonly involved root:* Palatal root of maxillary first molar ii. Large antral cavity close to the apices of posterior teeth iii. *With advancing age, there is increase in pneumatization:* The teeth appear to be protruding into the antral cavity in a radiograph. In three dimensions, the bone of the antral floor may be very thin; and at times the root apices may contact with antral lining iv. Solitary molar tooth in atrophic maxillary alveolus v. Molar roots with large splayed roots close to antral floor	i. Preoperative assessment (proximity of roots of molars with floor of maxillary sinus, especially third molar) ii. Use of controlled force iii. Support the alveolus iv. Leave the apical third of maxillary molar palatal roots; unless there is an indication for their removal *NB:* Patient should be informed of such a possibility before extraction	*Confirmation:* 1. Inspection of extraction socket 2. *Nose-blowing test:* Patient is instructed to gently blow through the nose, against closed nostrils. There is passage of air through the socket, due to increase in the intra-antral pressure. The expelled air produces bubbling with blood in the socket; or if socket is empty, a fine wisp of cotton wool is held near the extraction socket. It will be deflected by the stream of air. It is essential to use gentle pressure to identify oro-antral communication (OAC). Overenthusiastic blowing may actually produce a breach in continuity of antral floor 3. Instruments, such as, suction tips and probes through the socket into the antrum in an attempt to confirm the defect. This maneuver could create a communication, if not existed.

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Sl. No.	Complications	Causes	Prevention	Management
				Treatment is delayed for (a) further radiographic evaluation and confirmation. The ideal way to manage oroantral communication (OAC), is to close immediately before the passage of saliva through the defect which may cause sinusitis (b) Defect less than 2 mm: Blood clot gets organized. (c) Defect greater than 2 mm: Hemostatic agents are inserted in the socket and the socket is sutured. (d) If failure; then surgical closure is undertaken: (i) Raise the three-sided buccal mucoperiosteal flap, and advance it over the socket. (ii) Release the periosteum at the base of flap well beyond the reflection of sulcus. (iii) Achieve complete closure. (iv) Closure assisted by reducing the height of socket wall. (v) Refer to oral and maxillofacial surgeon for sinus exploration and retrieval of the roots. (vi) Information and assurance to the patient. (vii) Details notified in the record. (viii) *Sinus regimen:* Avoid blowing nose for 10–14 days. Broad spectrum antibiotics taken for seven days. Regular use of nasal drops and decongestants. (ix) If immediate closure of oroantral communication (OAC) is not possible, the patient should be referred to oral and maxillofacial surgeon
b.	Aspiration of teeth/roots in tracheobronchial tree	Careless technique	Careful technique	Refer to chest surgeon (Bronchoscopy and exploration)
c.	Swallowing of teeth/roots in gastrointestinal tract	i. Careless technique ii. Uncooperative patient iii. Mentally challenged patients	Careful technique	Refer to gastroenterologist (gastroendoscopy)

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Sl. No.	Complications	Causes	Prevention	Management
C.	**Injuries to adjacent teeth**			
1.	Subluxation/luxation/ fracture	i. *Improper surgical technique:* Placement of elevator, and use of inappropriate forceps, uncontrolled force, and application of force directly over the adjacent tooth, ii. Injudicious use of mouth props, laryngoscopes, oro-endotracheal tubes, airways, especially during extraction under GA	i. Proper surgical technique (Proper placement of elevators, and use of proper forceps) ii. Use of controlled force iii. Force to be applied on the tooth to be extracted unless the adjacent tooth is also to be extracted	a. *Subluxation:* Tooth is stabilized with wire or acrylic splint b. *Luxation:* i. Reimplanted immediately and stabilized with splints ii. Endodontic therapy—planned *NB:* During the period of stabilization, the tooth is kept free of occlusion
2.	Fracture of cusps, incisal edges, restorations, and artificial crowns, etc.	i. Large carious lesions ii. Poorly condensed amalgam restoration iii. Poor retention of restoration iv. Application of excessive force	i. Preoperative assessment (clinical and radiological) ii. Avoid placing instruments against fillings, (avoid putting heavy leverage against fillings) iii. Use—Proper instruments *NB:* Necessary to warn patient in advance	i. Application of temporary filling after procedure ii. Plan—permanent restoration subsequently *NB:* Care taken not to allow filling material to fall in the socket (foreign body reaction)
3.	Extraction of a wrong tooth	i. Carelessness ii. Improper communication (Referred patients, particularly by orthodontists)	i. Careful extraction ii. Referred cases; check the charts iii. In doubt, communicate and confirm with referring specialist iv. Mark the tooth with indelible pencil	i. Replace tooth as soon as possible; and stabilize with wire or splint/arch bar Plan for endodontic treatment ii. Inform orthodontist (referring specialist) iii. (Revise—Treatment plan and accommodate the mistake) iv. Inform the patient
C.	**Fractures**			
a.	Fracture of maxillary alveolus	i. Improper placement of instruments ii. Uncontrolled force (excessive force can lead to fracture of tooth or root) iii. Inadequate support to alveolus iv. Fusion of alveolar bone with the tooth, (common in maxillary second and third molar regions) v. Thinness of alveolar cortical bone	i. Preoperative assessment (Maxillary sinus and tuberosity) ii. Use of controlled force iii. Adequate support to alveolus during extraction iv. Remove tooth surgically (Removal of buccal bone/sectioning of teeth)	a. Bone completely detached from periosteum: i. Completely detached bone cannot be replaced.Often it remains attached to the tooth and is removed with it ii. Reposition the flap and obtain complete closure. If the fragment cannot be removed from the tooth, the mucoperiosteum should be carefully separated from the bone using an instrument such as a periosteal elevator, or Mitchell's trimmer; to avoid tearing of the gingiva/mucoperiosteum. Sometimes, the bone fragments can be detached from the tooth with a fine fissure bur or a Coupland's chisel. This is done when the bone has mucoperiosteum attached to it. Such bone can be retained

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Sl. No. Complications	Causes	Prevention	Management
			b. Bone attached to soft-tissues (periosteum) i. Bone retained ii. Achieve complete closure
b. Fracture of maxillary tuberosity: It is a type of alveolar fracture	a. *Predisposition:* Common sites: (i) Isolated, overerupted maxillary 2nd and 3rd molars, (ii) Presence of a large antrum weakens the maxillary alveolus b. Application of excessive/uncontrolled force c. Large splayed root mass of maxillary second and third molars d. Fusion of unerupted maxillary third molar to roots of second molar	i. Preoperative assessment (radiographs: maxillary sinus and tuberosity) Good surgical technique ii. Support alveolar bone during extraction, use of controlled force iii. Perform extraction surgically (remove locking buccal bone, sectioning of teeth)	a. *Small fragment:* Examine the fractured portion of tuberosity adherent to the tooth. Separate the periosteum from the bone, and the bone is removed along with the tooth. Section and remove the tooth leaving bone segment attached to periosteum b. *Large fragment:* (i) Stop/abandon the extraction. Equilibrate the tooth (ii) If partially extracted: (1) Remove the tooth surgically; and leave the bone fragment attached to the periosteum; or (2) Section the crown; leave roots *in situ*. Roots can be removed later, when tuberosity is more stable (approximately 6–8 weeks) (3) Splint the tooth; if necessary (4) If sinus is involved, (Large segment involving bone forming floor of the antrum. It may result into oro-antral communication) (5) Antibiotics and analgesics (6) *Sinus regimen:* nasal drops and decongestants (7) Refer to oral and maxillofacial surgeon
c. Fracture of mandible	a. Predisposition: (i) Common situation: vertically impacted mandibular third molar, (ii) atrophic mandible b. *Poor surgical technique:* Carelessness, and excessive force with elevators c. Other situations are examples of pathological fractures: (i) Large cysts, (ii) Tumors, (iii) Generalized osteoporosis, (iv) Paget's disease, (v) Osteogenesis imperfecta, (vi) Hyperparathyroidism, (vii) Osteomyelitis, previous therapeutic irradiation (Osteodystrophies: osteitis deformans, fibrous dysplasia, fragilitas ossium).	*Prevention:* (i) Preoperative assessment: Surgery should be carried out only after proper preoperative assessment. Good history, clinical and radiological examination, construction of splints preoperatively; and planning to do such cases in a proper environment. Careful elevation ii. Use of controlled force iii. *NB:* Difference between simple extraction and extraction of mandibular third molar	If fracture occurs during the course of extraction; the procedure should be stopped, appropriate radiographs are taken. Explanation should be given to the patient's and relatives. Prescribe antibiotics and analgesics. Liquid diet i. Fracture: Reduction and fixation ii. Patient should be warned about the possibility of fracture, before the operation iii. Refer to oral and maxillofacial surgeon

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S. No. Complications	Causes	Prevention	Management
D. Other complications			
1. Breakage of instruments (Elevator tips, burs/drills)	i. *Excessive force:* Straight elevators, inadequate torque ii. Fault in manufacturing iii. Old overused instruments	i. Use controlled force ii. Use good quality instruments	i. Debridement ii. Attempt to remove the broken piece iii. Radiographs iv. If failure, refer to oral and maxillofacial surgeon
2. TM joint injury a. Trauma to the capsule	Stretching of capsule of TM joint Forceps applied during extraction are transmitted during extraction to TM joint Postoperative pain and limitation of movement	Adequate stability to TM joint during extraction i. Adequate manual support of lower jaw during extraction ii. Support alveolus iii. *Difficult extraction:* Resort to surgical extraction	Conservative management: Rest to the joint. (Soft diet, hot water fomentation external over joint, analgesics, and restriction of mouth opening)
b. Dislocation of condyles	i. Application of excessive force ii. Failure to support the mandible; with extracting a difficult tooth. Mandible should be adequately supported The dental forces applied to the teeth cause larger displacing forces than the left hand can provide as a support iii. More likely to occur under GA, when masticatory muscles are relaxed, particularly it happens due to injudicious use of mouth prop/gag or jaw stretche	i. History of previous dislocation ii. Use of controlled force iii. Support the jaw Additional support can be obtained by asking the patient to bite on the mouth props. These transfer part of the displacing forces to maxillary teeth	Correction to be done immediately a. Standing in front of the patient b. Standing behind the patient i. Reduction is done, with the thumbs wrapped with gauze or a bandage, to avoid injury by teeth, and placed on the occlusal surfaces of mandibular posterior teeth, and fingers under use of mouth gags, to force open the jaws the mandible. Mandible is then pushed down-wards, backwards, rotating the chin upwards. With this maneuver, the condyles are moved downwards and backwards over the articular eminences of temporal bone. Subsequently, upwards to regain its position in the glenoid fossa ii. Patient should be warned not to open his mouth too widely or to yawn for a few days postoperatively. Patient is instructed to support the jaw during yawning iii. Extraoral bandage support for the joint is applied, and worn until tenderness in the affected joint subsides iv. Failure to reduce dislocation—reduction can be attempted under 5–10 mg of IV/IM valium

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Sl. No. Complications	Causes	Prevention	Management
			v. Failure to reduce the dislocation; or if there is resistance encountered, LA solution is injected high in the buccal sulcus, bilaterally adjacent to maxillary third molar region, similar to the technique of posterior superior alveolar nerve block. This helps in paralyzing lateral pterygoid muscles and overcoming muscular spasm. Under GA, it is easy to reduce dislocation. It is valuable to check the occlusion, at the end of any extraction or surgical procedure
3. Involvement of maxillary sinus: Oroantral fistula (OAF)	*Predisposition:* Maxillary sinus closely related to roots of the teeth Oroantral communication (OAC)/ oroantral fistula (OAF); frequently produced in cases of roots with close proximity to antral floor	*Preoperative assessment:* of relationship of sinus floor to roots of teeth (radiographs)	Depends upon the size of defect a. *Small opening:* (<2 mm) Surgical closure: Not necessary. Blood clot is organized and retained b. *Large opening:* Large (>2 mm) Surgical closure is required. Flap is designed and the defect is closed c. *Sinus regimen:* To prevent sinusitis: Antibiotics, nasal drops and nasal decongestants (to keep nasal cavity and the ostium patent; encourage drainage from sinus) d. In case of an established oroantral fistula (OAF), refer patient to oral and maxillofacial surgeon.
4. *Hemorrhage:* Primary hemorrhage: a. Hemorrhage at the time of surgery Reactionary hemorrhage: b. Hemorrhage within few hours after surgery, when vasoconstriction of damaged blood vessels has ceased Secondary hemorrhage: c. Hemorrhage up to 14 days postoperatively, as a result of infection	(A) Local and (B) General A. Local: i. Bleeding from arteriole or vessel ii. Granulation tissue iii. Crush injury B. General: (1) Natural and (2) Acquired (a) Natural: i. Hemophilia A ii. Hemophilia B (b) Acquired: 1. Anemia (Severe) 2. Hypertension (uncontrolled) 3. Vitamin K deficiency 4. Vitamin C deficiency 5. Anticoagulation therapy 6. Liver diseases 7. Idiopathic thrombocytopenia	1. *Preoperative assessment:* a. Good medical history (personal and family history of blood relatives; of bleeding tendency) b. History of previous relevant episodes; particularly following tooth extraction (with full details) c. *Appropriate investigations:* Prothrombin time (PT), Plasma thromboplastin time (PTT), Bleeding time (BT), Platelet count (PC), and International normalized ratio (INR) d. *Suspected cases:* Refer the patient to hematologist for necessary investigations e. Good surgical technique	1. Must have a good suction apparatus, and have a clear vision of operative field a. Control the hemorrhage from soft tissues: (a) Methods of controlling hemorrhage i. Mechanical pressure in the form of finger/thumb pressure ii. Electric cauterization iii. Injection of local anesthetic containing a vasoconstrictor (adrenaline), for relief of pain as well as for vasoconstriction iv. *Suturing*; particularly, figure-of-eight type, across the margins of the socket v. Acrylic splint; immediate denture

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Sl. No.	Complications	Causes	Prevention	Management
		8. Hemorrhagic disorders 9. Under GA, if oxygenation is insufficient	i. Careful handling of tissues to avoid unnecessary trauma ii. Placing a gauze pack over the socket for at least ten minutes; with application of biting pressure; to allow blood clot to form inside the socket iii. Remove all granulation tissue iv. Avoid crushing of tissue v. Good knowledge of anatomy of surgical area vi Instructions to patient; not to disturb clot by avoiding vigorous mouth rinsing or chewing, or putting external agents (tongue, fingers) 2. *Observation:* At the completion of procedure, observe the patient in the office for 15 minutes; then change the pack just prior to patient's departure	vi. Clamping of bleeding vessel and ligation with 3/0 or 4/0 ligature, or coagulation with diathermy b. Methods of controlling hemorrhage from bone: Bone bleeding is controlled in the following ways: i. Packing the socket with gauze under pressure ii. Crushing or burnishing the bone. It is done with a hemostat or any other blunt instrument. This is applicable to small areas. It crushes the bony channels iii. Application of hemostatic substances: absorbable sponges: gelatin foam (gelfoam), surgical or fibrin foam, etc. These substances are placed in the socket in small amount. These control bleeding by providing a clotting matrix and stabilization of the clot iv. Application/smearing of bone wax into relevant spaces in bone marrow with the help of an instruments such as burnisher or Mitchell's trimmer. It is rarely used, and is effective in stopping extensive bleeding from extraction sockets, especially, if inferior alveolar artery/vein is damaged *Drawback:* It is poorly absorbed and may contribute to postoperative infection v. A block of impression compound is moulded over the area to offer compression or special acrylic splint constructed

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Sl. No.	Complications	Causes	Prevention	Management
5.	Late supine hypotensive syndrome (LSHS) of pregnancy	*Predisposition:* Usually occurs in late pregnancy; 10% as per American literature Patient complains of faints. *Mechanism:* Pressure of fetus over inferior vena cava (IVC). There is decrease in venous return (VR), hence less cardiac output (CO); hence less blood pressure (BP); and hence cerebral ischemia; that leads to feeling of faint	i. Put the patient in upright position ii. Treatment sessions should be of short durations iii. Avoid recumbent position	i. Turn the patient on one side ii. Treatment sessions of short durations mechanism: venous return (VR) is increased, cardiac output (CO) is restored, blood pressure (BP) is increased. Cerebral flow to brain is restored
E.	**Postoperative complications**			
1.	Bony spicules	Improper debridement	Proper debridement—surgical procedure	Removal and/or filing of bone.
2.	Hemorrhage	Poor surgical technique	a. Postoperative instructions: i. Avoid violent exercises, stimulants, very hot food or drinks, for the rest of the day ii. Avoid vigorous or repeated mouth rinsing or chewing; it disturbs the clot and promotes bleeding iii. *Observation:* At the completion of procedure, observe the patient in the office for 15 minutes; then change the pack just prior to patient's departure	i. Examination of the mouth: in order to determine the site and amount of hemorrhage ii. Clean the area off the blood clots iii. Application of a gauze pack over the site of hemorrhage. Patient is asked to hold it under biting pressure. Application of tannic acid on the portion of the pack relation to the site of hemorrhage. It helps to arrest hemorrhage iv. In case of tear in gingiva, it is advisable to apply suture under LA. When hemorrhage is found to be in the gingiva surrounding a tooth socket, figure-of-eight type of suturing across the socket *Advantages:* (i) Causes tension in mucoperiosteum; which helps in arresting hemorrhage, coming from soft tissues, (ii) It protects the blood clot from disintegration, (iii) Hemorrhage from bone: as described earlier, (iv) If these measures fail, refer the patient to nearest hospital, for further management

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Sl. No. Complications	Causes	Prevention	Management
3. *Fibrinolytic alveolitis:* (Dry socket, alveolar osteitis, localized osteitis alveolalgia, alveolar osteomyelitis). It involves part or whole of the walls of socket; or the lamina dura. Geoffrey Howe, defined it as well recognized, but ill understood complication of extraction of teeth. Characteristics: The condition is characterized by acute pain, bony walls of the socket are denuded of blood clot	*Etiology:* Not clear/obscure. Trauma and infection; together. They cause inflammation of marrow spaces of alveolar bone. That liberates tissue activators which convert plasminogen in blood clot to plasmin. This dissolves blood clot and releases kinins from kininogen; which is present in blood clot. The final result is of dissolution of blood clot and severe pain *Predisposing factors:* i. Infection of socket occurring either before, during or after the extraction—may be an exciting factor ii. *Trauma:* It is true that the condition may follow the use of excessive force during extraction. However, it is not always the case; and complications may occur after very easy extractions iii. *Vasoconstrictors:* Many authorities feel that vasoconstrictors used in LA solution may predispose to dry socket, by interfering with blood supply of bone, and they point out that the condition occurs more frequently under LA than GA. Thus, vasoconstrictors cannot be the basic cause of the condition, but may well be a contributing factor iv. Mandibular teeth show higher incidence of dry sockets than maxillary teeth. Mandible has much more dense bone and is less vascular than maxilla. However, anatomical studies	Following measures should be employed i. Scaling of the teeth; any gingival inflammation should be treated prior to extraction ii. Minimum amount of local anesthetic solution necessary for producing analgesia should be administered iii. Teeth should be removed in the least traumatic manner possible iv. Prophylatic use of antibiotics especially metronidazole from the day of extraction for 3–4 days reduces the incidence of dry socket significantly. It also has been shown to provide prompt relief from pain; if given in large doses for 5 days v. Wound debridement vi. Nerve blocks—preferred to LA infiltration	Not a progressive disease *Aim:* (i) Relief of pain, and (ii) Speed of resolution (a) *Procedure:* i. Irrigation of debris and debridement: Socket is irrigated with warm normal saline and all degenerating blood clots are removed. Sharp bony margins should be either excised with rongeur forceps or smoothened with a bone file ii. or a drill Medicated dressing/Iodoform gauze or composed of zinc oxide eugenol on cotton wool should be packed loosely and not tightly; as it may set hard and be difficult to remove. The dressing is composed of: Eugenol, Balsam of Peru, Chlorobutanol, and Benzocaine Dressing—first 24 hours; then every alternate day; then every 3–4 days for more than 2 weeks iii. Broad-spectrum antibiotics (b) *Other measures:* Analgesics, and hot saline mouth baths

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Sl. No.	Complications	Causes	Prevention	Management
		revealed that the blood supply to alveolus in lower molar region is not poorer than that of the other regions of the jaw. Lower teeth usually are more difficult to extract than upper teeth v. *Gravity:* Mandibular sockets become contaminated with food debris. vi. Existence of systemic etiological factor. There is with a insufficient evidence to support this concept. However, increased titer of fibrinolytic substances as has been demonstrated in alveolar bone of patients afflicted with dry socket vii. *Bacteriological origin:* A number of bacteria are known to possess fibrinolytic activity. It has been recently postulated that *Treponema denticola* may have an etiological role in the genesis of dry socket viii. Pregnant women and those taking oral contraceptives appear to be more susceptible than others		c. Regular follow-ups d. If pain persists; it may require chemical cauterization of exposed bare painful bone *Procedure:* i. Isolation and drying of dry socket ii. Application of small quantity of carbolized resin on the bony walls of the socket iii. Zinc oxide eugenol cotton wool dressing is inserted over the caustic and left *in situ* for 3 days. The dressing relieves pain, but delays healing. Alternatively, Whitehead's varnish on a piece of ribbon gauze can also be used and left *in situ* for 2–3 weeks. It is not very effective in controlling pain. At the time of removal of the pack the socket will be seen granulating
4.	*Nerve injuries:* i. Nerve injuries without significance: Naso-palatine and buccal nerves ii. Nerves posing problems: Inferior alveolar, mental, and lingual nerves			The anesthesia/paresthesia lasts for periods lasting from a few days to many months, depending upon the amount of damage sustained by the involved nerves. Such patients should be seen at regular intervals until sensation returns to normal. The nature and extent of sensory loss should be carefully elicited and recorded at each visit; so that the rate of recovery is determined; and necessary supportive treatment is instituted

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Sl. No. Complications	Causes	Prevention	Management
a. Inferior alveolar nerve	i. Close proximity of mandibular third molar roots to inferior alveolar nerve ii. *Careless surgical technique:* Movements of roots likely to cause damage; especially, when the roots are curved around the canal, or grooved by it	a. Preoperative assessment: (radiographs). Sometimes roots of third molar are grooved, notched, or perforated by the contents of inferior alveolar neurovascular bundle b. During procedure: Careful surgical technique: (i) while cutting the teeth, and (ii) while using a bur/currette	a. Replace the severed portions of nerve; within the canal. Allow proximal end to regenerate. Regeneration usually takes 2–6 months and sometimes years b. Decompression is required; if there is nerve impingement or entrapment c. Microvascular surgery is required for anastomosis and grafting d. Referral to oral and maxillofacial surgeon e. Patient should be warned of such consequences
b. Lingual nerve	*Predisposition:* Lingual nerve is in close proximity to roots of mandibular third molar i. Risk of damage while taking incision, and during elevation of lingual periosteum ii. While manipulation of lingual mucoperiosteal flap iii. Risk of direct trauma from burs or chisels used for removal of bone, or sectioning of the tooth iv. Injury during injection is rare	i. Good knowledge of anatomy ii. *Careful surgical technique:* (proper placement of incision, careful bone removal, retraction and less manipulation of lingual flap)	i. Refer to oral and maxillofacial surgeon ii. Patient should be warned preoperatively about the possible consequences and the probable outcome
c. Mental nerve	Surgery in the area of mental nerve i. Overextension of relieving incision in the depth of mucobuccal fold, in premolar region ii. Removal of bone encroaching on mental foramen just below and between premolar root apices iii. Careless retraction of the flap in the vicinity of mental foramen iv. Incision and drainage of abscesses situated in the region of premolars	a. Good knowledge of anatomy b. Good surgical technique: (i) Proper planning of incision, and (ii) Careful reflection of mucoperiosteal flap, (iii) Incision and drainage of abscesses be done by Hilton's method, in order to minimize risk of damaging mental nerve, and (iv) Protection of mental nerve with a retractor	i. Assurance to the patient ii. Refer to oral and maxillofacial surgeon
5. *Injury to TM joint:* Postoperative traumatic arthritis	(i) Difficult extractions, (ii) Prolonged surgical procedures on unsupported mandible.	(i) Difficult extractions may be done surgically, (ii) Support mandible during surgical procedures	a. Rest to joint b. Analgesics and anti-inflammatory agents

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Sl. No.	Complications	Causes	Prevention	Management
6.	Acute osteomyelitis (OML)	*Predisposing factors:* Traumatic extraction of lower molars under LA, in the presence of acute gingivitis, periodontitis, or pericoronitis	*Precautions:* The following measures to be undertaken prior to undertaking any surgical intervention: (i) To do prophylactic scaling of teeth, whenever indicated. (ii) To treat acute conditions first, and control the infections	For details of management, refer to the chapter on "Osteomyelitis"
7.	Infection/suppuration at the site	Lack of aseptic technique: inadequate preparation of the site, inadequate sterilization of instruments, etc.	i. Use of aseptic technique, and ii. Use of atraumatic technique	i. Use of antibiotics, and ii. May be incision and drainage
8.	Failure to complete the operation	a. Inadequacy of anesthesia: It includes: (i) faulty technique, and (ii) insufficient dosage of LA agent b. Lack of cooperation from the patient c. Lack of facilities d. Lack of skills	i. Careful preoperative assessment, and ii. Careful treatment planning	i. Plan to do the procedure in a place with proper facilities, and with proper anesthesia ii. Dental surgeon should be calm, courteous, and confident iii. *Nervous patients:* Use premedication

Appendix 2: Complications following the use of local anesthetic solution in dentistry

Sl. No	*Complications*	*Causes*	*Prevention*	*Management*
A.	**Complications arising from drugs or chemicals used**			
1.	Soft-tissue injury	Self-inflicted trauma (lips and cheeks) Common in children, and mentally and physically challenged adults	Warn the patient's parents or guardians against biting lips or tongue	*Symptomatic:* Comprises of analgesics, antibiotics and topical anesthetic gel for relief of pain
2.	Sloughing of tissues (tissue ischemia and necrosis) i. Epithelial desquamation, ii. Sterile abscess iii. Necrosis	i. *Predisposition:* Commonly seen in hard palate, as in the region of nasopalatine, and greater palatine nerves, because the mucoperiosteum is tightly attached to the bone It occurs at the site of injection Necrosis leads to painful ulceration ii. Related to volume of solution injected iii. Application of topical LA agent for prolonged period iv. Use of vasoconstrictors (usually epinephrine), resulting in tissue ischemia and necrosis (Guinta 1975)	i. Use LA agent with short duration action. ii. Use less amount of LA agent (minimal effective dose) iii. Warn the patient against application of hot items	Depends upon injury *Symptomatic:* Consists of analgesics, topical anesthetics, and bland diet, etc. Usually resolves within 1–2 weeks An established abscess may require incision and drainage
B.	**Complications arising from injection techniques**			
1.	Needle stick injuries	Careless technique	Careful of sharp instruments Prophylactic vaccination of HBV infection to be taken and maintained	If injury involves a patient with AIDS, then i. The concerned authority should be informed ii. Postexposure prophylaxis PEP to be considered
2.	Needle breakage	1°: Sudden unexpected movements by patient 2°: (i) Size of needle. Breakage is common in thin (smaller diameter or of larger gauge) needles, (ii) Previously bent needles, (iii) Redirection of needles inside the tissues, (iv) Defect in manufacturing. Nicking of blood vessels during injection of LA agent	Inform the patient of the technique and the procedure Use of proper gauge of needle (for nerve blocks; 25 gauge needles) Insertion of needle, few mm away from the hub Do not redirect the needle once completely in the tissues. Always use needles of good quality	Remain calm. Do not panic If needle is visible, and is outside the soft-tissue, catch it with a hemostat and remove it If not visible, refer the patient to oral and maxillofacial surgeon
3.	Hematoma		Good knowledge of anatomy. Use short needle for posterior superior alveolar nerve block Minimize the number of needle penetrations	a. Immediate; If the area is accessible, application of pressure for 2–3 minutes Observe the patient at least 12 hours b. Delayed: (i) Assurance to the patient (ii) External ice application (iii) Symptomatic treatment: consisting of analgesic; muscle relaxant, and (iv) Prophylactic antibiotic cover

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Sl. No. Complications	Causes	Prevention	Management
4. Infection	i. Contamination of needles ii. Improper preparation of site iii. Needle passing through an area of infection iv. LA solution deposited under pressure; as in intraligamental injection (deposit bacteria)	i. Preparation of site prior to penetration ii. Careful handling of needles (avoid touching nonsterile surface) iii. Avoid multiple injections with same needle iv. Use disposable needles v. Proper handling of dental cartridges (a) Store cartridges with a cover or a container (b) Clean the diaphragm with antiseptic prior to its use (c) Use cartridge only once	i. Analgesics ii. Antibiotics iii. Physiotherapy iv. Muscle relaxants v. Incision and drainage, if necessary
5. Failure to obtain local analgesia	a. Faulty technique: i. Deposition of LA agent far away from nerve ii. Accidental intravascular administration b. Anatomical aberrations i. Abnormal innervation ii. Additional innervation c. Abnormal reaction to effect of LA agent d. Injecting in an infected area	i. Good knowledge of anatomy ii. Good surgical technique	Not required i. Repeat the injections ii. Consider anesthetizing additional nerve supply iii. In the presence of infection select higher block techniques
6. Postinjection herpetic lesions	Reactivation of dormant herpes virus particles by trauma of injection. Usually, seen in patients with history of recurrent herpes labialis, particularly, in the terminal distribution of trigeminal nerve (Inferior alveolar nerve, superior labial branch of infraorbital nerve) in a previously anesthetized nerve	i. Preanesthetic assessment: history of recurrent herpes infections ii. Delay surgical intervention in the active stage	Symptomatic
C. Complication arising from both			
1. Pain on injection	i. Careless injection ii. Blunt needles iii. Rapid deposition of LA solution iv. Needles with barbs (pain while withdrawal) v. High temperature of LA solution	i. Use sharp needles ii. Proper technique iii. Use sterile LA solution iv. Use topical LA agent prior to injection v. Inject LA solution slowly vi. Temperature of the solution should be approximately the same as room temperature, i.e. avoid using refrigerated cartridges	Not required

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Sl. No.	Complications	Causes	Prevention	Management
2.	Burning on injection	i. Rapidity of injection ii. Contamination of LA cartridge (alcohol, or cold–sterilizing solutions iii. High temperature of LA solution iv. Altered pH of solution	i. Slow injection ii. Cartridges to be stored at room temperature	Not required
3.	Trismus	i. Trauma to muscles, and blood vessels in infratemporal and pterygomandibular fossae ii. Solution containing alcohol or cold sterilizing solutions (contamination due to storage) iii. LA agents are mild myotoxic iv. Hemorrhage leads to irritation of muscles v. Low-grade infection	i. Use sharp, sterile and disposable needles ii. Proper handling of needles iii. Avoid contamination of needles iv. Avoid multiple injections into the same area v. Use minimum effective volumes of LA agent vi. Aspiration before injection	*Symptomatic: and consists of:* i. Physiotherapy with jaw stretcher (Heister) ii. Heat therapy iii. Warm saline rinse iv. Analgesics v. Muscle relaxants vi. Brisement force under sedation
4.	Edema	i. Trauma during injection ii. Infection iii. Allergy (angioedema) iv. Hemorrhage v. Injection of irritating solutions such as cold-sterilizing solutions vi. Proper storage of cartridges	i. Preoperative assessment (history) ii. Careful handling of LA armamentarium iii. Atraumatic technique	*Find out the cause:* Allergy; antihistaminic, breathing compromised; then basic life support (BLS) is instituted (Airway, breathing, and circulation; ABC). Administration of epinephrine, antihistaminics, and corticosteroids. Refer to oral and maxillofacial surgeon
5.	Blanching of skin	i. Trauma to blood vessel by needle ii. Intravascular administration	Use of aspiration technique, and avoid intra-arterial administration of local anesthetic agents	Usually, a transient phenomenon. No treatment is required
6.	Persistent paresthesia or anesthesia	i. Injection of LA solution near a nerve with contaminated LA solution with cold sterilizing solution ii. Trauma to nerve sheath iii. Hemorrhage in and around nerve sheath	i. Strict adherence to injection protocol ii. Careful surgical technique iii. Proper handling of dental cartridges	Reassurance to the patient (Tincture of time) Prescribe B_1, B_6, B_{12} vitamin tabs. Observe the patient for two months; if no improvement, refer the patient to oral and maxillofacial surgeon Most paresthesias resolve within 8 weeks

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Sl. No.	Complications	Causes	Prevention	Management
7.	Facial nerve paresis/ paralysis	i. Injection of LA solution in the capsule, or the deeper lobe of parotid gland ii. Injection superficially, into muscles of facial expression	i. Good knowledge of anatomy ii. Follow the standard protocol for LA technique	Explanation and assurance to the patient Unilateral loss of motor function. It is transient and lasts for few hours, depending upon agent used, and its volume injected Inability to voluntarily close the eye. Eye-dressing is given. Contact lenses should be removed
8.	Persistent (prolonged) pain	i. *Poor surgical technique:* Subperiosteal injection of local anesthetic agent, and tearing of periosteum by tip of the needle ii. Needle tip with barbs iii. Ischemic necrosis (use of vasocons: trictors: excess amount, less dilution)	i. Good surgical technique; avoid subperiosteal injection, and tearing of periosteum. Infiltration anesthesia should be given paraperiosteally, and not subperiosteally ii. Avoid needles with barbs iii. Use vasoconstrictors with maximum dilution	Symptomatic

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