NEPAL, PAKISTAN AND SRILANKA ONLY • FOR SALE IN BANGLADESH, BHUTAN, INDIA, MALDIVES, NEPAL, PAKISTAN AND SRILANKA ONLY





EDITION 13

Prosthodontic Treatment for Edentulous Patients

Complete Dentures and Implant-Supported Prostheses

ZARB • HOBKIRK • ECKERT • JACOB

Fenton • Finer • Chang • Koka

Restricted South Asia Edition

This edition is licensed for sale in Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka only.
This edition is not authorized for export outside these territories.
Circulation of this edition outside these territories is unauthorized and illegal.

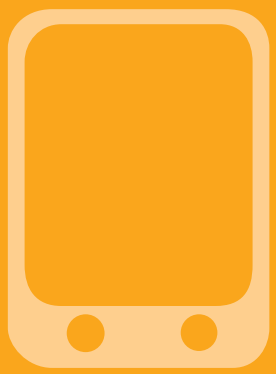
pageburst™

Elsevier Digital Books

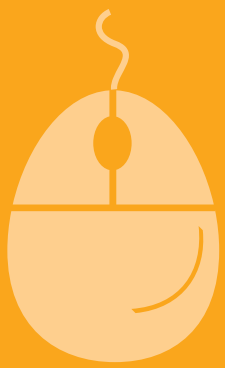
What you need, when you need it, how you want it.



DESKTOP



MOBILE



ONLINE

Access your entire library of Elsevier textbooks from a simple, smart interface. Pageburst integrates Elsevier's trusted content with powerful interactive tools to help you create a more productive, enjoyable learning experience.

- Pageburst offers quick, easy access to the Elsevier content you use and rely on, along with organizational tools to increase your efficiency.
- Pageburst makes it easy to search, take notes, highlight content, and collaborate with classmates or colleagues.

Buy digital books at http://pageburststore.elsevier.com

Prosthodontic Treatment for Edentulous Patients

Complete Dentures and Implant-Supported Prostheses

This page intentionally left blank

Prosthodontic Treatment for Edentulous Patients

Complete Dentures and Implant-Supported Prostheses

Thirteenth Edition

EDITORS

George Zarb, CM, BChD, MS, DDS, MS, FRCD(C), PhD, DSc, MD, LLD (hc)
Emeritus Professor
Faculty of Dentistry
University of Toronto
Toronto, Ontario, Canada

John A. Hobkirk, BDS, PhD, DrMed(hc), FDSRCS(Ed), FDSRCS(Eng)
Emeritus Professor of Prosthetic Dentistry
UCL Eastman Dental Institute
University College London;
Honorary Consultant in Restorative Dentistry
Eastman Dental Hospital
London, United Kingdom

Steven E. Eckert, DDS, MS
Emeritus Professor
Department of Dental Specialties
Mayo Clinic
Rochester, Minnesota

Rhonda F. Jacob, DDS, MS, FACP
Professor
Section of Oncologic and Maxillofacial Prosthetics
Department of Head and Neck Surgery
MD Anderson Cancer Center
University of Texas
Houston, Texas

ASSOCIATE EDITORS

Aaron H. Fenton, DDS, MS, FRCD(C)
Professor in Dentistry
Department of Prosthodontics
Faculty of Dentistry
University of Toronto
Toronto, Ontario, Canada

Yoav Finer, DMD, PhD, MSc (Prosthodontics), FRCD(C)
Associate Professor and Head, Biomaterials
Faculty of Dentistry
University of Toronto
Toronto, Ontario, Canada

Ting-Ling Chang, DDS
Clinical Professor and Chair
Section of Removable Prosthodontics
Division of Advanced Prosthodontics, Biomaterials, and Hospital Dentistry
UCLA School of Dentistry
Los Angeles, California

Sreenivas Koka, DDS, PhD
Professor of Dentistry
Chair, Department of Dental Specialties
Mayo Clinic
Rochester, Minnesota

Prosthodontic Treatment for Edentulous Patients: Complete Dentures and Implant-Supported Prostheses, 13e
Zarb, Hobkirk, Eckert and Jacob

MOSBY
An imprint of Elsevier
3251 Riverport Lane
St. Louis, Missouri 63043

Copyright © 2013 by Mosby, an imprint of Elsevier Inc.

Copyright © 2004, 1997, 1990, 1985, 1980, 1975, 1970, 1964, 1959, 1953, 1947, 1940 by Mosby, Inc., an affiliate of Elsevier Inc.

All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopy, recording, or any information retrieval system, without written permission from the publisher.

Original ISBN: **978-0-323-07844-3**

This edition of **Prosthodontic Treatment for Edentulous Patients: Complete Dentures and Implant-Supported Prostheses, 13e** by George Zarb, CM, BChD, MS, DDS, MS, FRCD(C), PhD, DSc, MD, LLD (hc) ; John A. Hobkirk, BDS, PhD, DrMed(hc), FDSRCS(Ed), FDSRCS(Eng); Steven E. Eckert, DDS, MS and Rhonda F. Jacob, DDS, MS, FACP is published by an arrangement with Elsevier Inc.

Indian Reprint ISBN: 978-81-312- 3346-7
First Reprinted in India 2012
Reprinted 2014, 2015

Restricted South Asia Edition

This edition is licensed for sale in Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka only.
This edition is not authorized for export outside these territories.
Circulation of this edition outside these territories is unauthorized and illegal.

Notice

Medical Knowledge is constantly changing. Standard safety precautions must be followed, but as new research and clinical experience broaden our knowledge, changes in treatment and drug therapy may become necessary or appropriate. Readers are advised to check the most current product information provided by the manufacturer of each drug to be administered, to verify the recommended dose, the method and the duration of administration, and the contraindications. It is the responsibility of the practitioner, relying on their own experience and knowledge of the patient, to determine dosages and the best treatment for each individual patient. Neither the Publisher nor the Authors assume any liability for any injury and/or damage to persons or property arising from this publication.

The Publisher

Published by Elsevier, a division of Reed Elsevier India Private Limited.

Registered Office: 818, 8th Floor, Indraprakash Building, 21, Barakhamba Road, New Delhi-110001
Corporate Office: 14th Floor, Building No. 10B, DLF Cyber City, Phase-II, Gurgaon-122 002, Haryana, India.

Printed and bound in India at : EIH Limited-Unit Printing Press, IMT Manesar. Gurgaon

This text is dedicated to the memory of Carl O. Boucher and Judson Hickey,
as well as to Gunnar E. Carlsson and Charles L. Bolender.
We remain grateful to these exceptional scholars, mentors, and friends
for their legacy of clinical scholarship in all its aspects—education, research, and service.

This page intentionally left blank

Contributors

Tomas Albrektsson, MD, PhD, RCPSG
Professor and Head
Department of Biomaterials
Institute of Clinical Sciences
University of Göteborg
Göteborg, Sweden

James D. Anderson, BSc, DDS, MScD
Emeritus Professor of Prosthodontics
Faculty of Dentistry
University of Toronto
Toronto, Ontario, Canada;
Director (retired), Craniofacial Prosthetic Unit
Toronto Sunnybrook Regional Cancer Centre
Toronto, Ontario, Canada

Nikolai Attard, BChD, MSc, PhD
Dean and Head
Department of Restorative Dentistry
Faculty of Dental Surgery
University of Malta
Malta

Mario A. Brondani, DDS, MSc, PhD
Assistant Professor
Department of Oral Health Sciences
Division of Community Dentistry and Prosthodontics and Dental Geriatrics
Faculty of Dentistry
University of British Columbia
Vancouver, British Columbia, Canada

David Chvartszaid, DDS, MSc (Prostho), MSc (Perio), FRCD(C)
Assistant Professor
Department of Periodontics
Faculty of Dentistry
University of Toronto
Toronto, Ontario, Canada

Randa Diwan, BDS (Cairo University, Egypt), PhD (Manchester University, England)
Assistant Professor
Department of Prosthodontics
Faculty of Dentistry
University of Toronto
Toronto, Ontario, Canada

Emad S. Elsubeihi, BDS, MSc, Dip Prosth, PhD
Prosthodontist
Tawam Hospital
United Arab Emirates;
Assistant Professor of Prosthodontics
Faculty of Dentistry
University of Garyounis
Benghazi, Libya

Leslie P. Laing, BSc, BEd, MSc, PhD, DDS, MSc, FRCD(C)
Assistant Professor
Department of Prosthodontics
Faculty of Dentistry
University of Toronto
Toronto, Ontario, Canada

Li-Deh Lin, DDS, PhD
Associate Professor
Department of Dentistry
School of Dentistry
National Taiwan University
Taipei, Taiwan

Michael I. MacEntee, LDS(I), Dip Prosth, FRCD(C)
Professor
Department of Oral Health Sciences
University of British Columbia
Vancouver, British Columbia, Canada

C. Peter Owen, BDS, MScDent, MChD
Professor and Head
Department of Prosthodontics
University of the Witwatersrand
Johannesburg, South Africa

Alan G.T. Payne, BDS, MDent, FCD (SA)
Prosthodontist
Private Practice
Dunedin, New Zealand

Thomas J. Salinas, DDS
Professor
Department of Dental Specialties
Mayo Clinic
Rochester, Minnesota

Ann Wennerberg, LDS, PhD
Professor
Department of Prosthodontics
Faculty of Odontology
Malmö University
Malmö, Sweden

John P. Zarb, BA, DDS, MSc, FRCD(C)
Staff Prosthodontist
Mt. Sinai Hospital
Toronto, Ontario, Canada;
Private Practice
Barrie, Ontario, Canada

Preface

The 13th edition of **Prosthodontic Treatment for Edentulous Patients** seeks to maintain our commitment to guiding dental students, dentists, and prosthodontists to make the best-informed clinical decisions while optimally managing the needs of edentulous patients. As practicing dentists and clinical educators, we continue to seek educational formats that reconcile established clinical protocols with research developments, while never losing sight of the ultimate beneficiaries of our professional skills—our patients. The latter have become increasingly aware of their right to receive efficacious and effective dental therapies, and hence a text that brings context and understanding to a participatory partnership between patient and dentist.

Choosing an eclectic approach to our synthesis of optimal care knowledge for caring for this special patient cohort, we invited leading international educators and scholars to join us in articulating the strongest case possible for understanding the edentulous predicament and its management. We are confident that the end result reflects an approach that never loses sight of the biological underpinnings of each patient's unique situation. Moreover, the best current management of the edentulous predicament is now seen in a far broader and more rational context than past descriptions. This is because the educational and research focus in prosthodontics has continued to grow and evolve in the past near-decade since we published the 12th edition. Advances in dental materials and increased objectivity in the understanding of limitations of mechanical analogues for the masticatory system had already facilitated significant progress in the discipline. However, the single most compelling catalyst for change has been the technique of osseointegration. This ushered in an exciting new therapeutic era, especially for prosthetically maladaptive patients. As a result, compromised denture stability and retention are now being confidently addressed in a far more versatile and predictable manner.

An entirely new implant-related protocol can now be employed to address the edentulous predicament, given the spectrum of changes that have been catalyzed by commercially pure titanium implants combined with traditional surgical protocols employing delayed loading. Three decades of clinical experience and research have demonstrated the potential of different biomaterials with roughened surfaces, immediate loading, and various surgical techniques for host site improvement. Time and even better research in patient-mediated concerns—particularly economic benefits—will ultimately determine to what extent the complete denture may be eclipsed by the implant-supported prosthesis. In the meantime, there is little doubt that both techniques can address the needs of the edentulous individual.

Both patients and dentists have already benefited enormously from this enriched spectrum of treatment possibilities. This edition therefore continues to emphasize osseointegration's unique and adjunctive role in patient treatment, but without losing sight of the truism that basic principles of complete denture construction are now more necessary than ever. Our entire editorial team remains convinced that our professional and educational mandate is to continue to take full advantage of currently available alternative treatment choices. However, we also remain committed to managing edentulous patients in the context of established and traditional prosthodontic principles.

George Zarb, John A. Hobkirk, Steven E. Eckert, and Rhonda F. Jacob

Acknowledgments

Numerous teachers and colleagues influenced and guided our clinical academic commitment over the years; we stood on their shoulders as we sought to expand the scope of our discipline. They, together with our dental technicians and assistants, secretaries, and photography personnel, contributed immeasurably to the continuum of effort that culminated in both past and this particular edition. These individuals are far too numerous to mention, but they continue to occupy a special place in our hearts.

We are also grateful to contributors to previous editions, notably Ejvind Budtz-Jorgensen, Thuan Dao, Mary Faine, Douglas Chaytor, Ross Bryant, Nancy Arbree, Howard Landesman, David Davis, Stig Karlsson, Alan Carr, Kenneth Shay, and Regina Mericske-Stern. Their original contributions provided outstanding frameworks for some of the revised and updated chapters in this 13th edition.

Contents

PART I THE PATIENT

Chapter 1 *The Edentulous State, 1*
John A. Hobkirk, George Zarb

Chapter 2 *Systemic Health Aspects and Nutritional Considerations for Edentulous Patients, 28*
Leslie P. Laing, Sreenivas Koka

Chapter 3 *The Aging Edentulous Patient, 35*
Michael I. MacEntee, Mario A. Brondani

Chapter 4 *Sequelae Caused by Wearing Complete Dentures, 42*
Leslie P. Laing, George Zarb

PART II TREATMENT OPTIONS

Chapter 5 *History Taking, Treatment Planning, and Improving Denture-Bearing Areas for Edentulous Patients, 53*
George Zarb, John A. Hobkirk

Chapter 6 *Additional Treatment Planning Options for Both Edentulous and Potentially Edentulous Patients, 93*
George Zarb, Steven E. Eckert, Rhonda F. Jacob, John P. Zarb

PART III THE MATERIALS USED

Chapter 7 *Materials Used in the Management of Edentulous Patients, 121*
Yoav Finer, Randa Diwan

PART IV CLINICAL PROTOCOLS FOR DIVERSE TREATMENT SCENARIOS

Chapter 8 *Maxillary and Mandibular Substitutes for the Denture-Bearing Area, 161*
Rhonda F. Jacob, George Zarb

Chapter 9 *The Dentures' Polished Surfaces, Recording Jaw Relations, and Their Transfer to an Articulator, 180*
James D. Anderson, George Zarb

Chapter 10 *The Occlusal Surfaces: The Selection and Arrangement of Prosthetic Teeth, 204*
Aaron H. Fenton, Ting-Ling Chang

Chapter 11 *The Try-in Appointment, 230*
Aaron H. Fenton, Ting-Ling Chang

Chapter 12 *Prosthesis Insertion and Follow-up Appointments, 255*
Ting-Ling Chang, Aaron H. Fenton

Chapter 13 *Modified Protocols for Immediate Dentures, Overdentures, and Single Dentures, 281*
Steven E. Eckert

Chapter 14 *Prolonging the Useful Life of Complete Dentures: Relines, Repairs, and Duplications, 303*
John A. Hobkirk, George Zarb

Chapter 15 *Speech Considerations with Complete Dentures, 315*
Li-Deh Lin

PART V CLINICAL PROTOCOLS SPECIFIC TO IMPLANT-RETAINED AND IMPLANT-SUPPORTED PROSTHODONTIC MANAGEMENT

Chapter 16 *The Science of Osseointegration, 323*
Tomas Albrektsson, Ann Wennerberg

Chapter 17 *Implant Overdentures, 330*
Alan G.T. Payne, George Zarb

Chapter 18 *Fixed Full Arch Implant-Supported Prostheses for the Edentulous Patient, 340*
Thomas J. Salinas, Sreenivas Koka

Chapter 19 *Maxillofacial Prosthodontics for the Edentulous Patient, 351*
Rhonda F. Jacob, Ting-Ling Chang

Chapter 20 *Managing Problems and Complications, 376*
Steven E. Eckert, David Chvartszaid

Chapter 21 *Immediately Loaded Complete Dental Prostheses, 387*
Steven E. Eckert

Chapter 22 *Current and Possible Future Directions in Implant Prosthodontics, 395*
Nikolai Attard, Emad S. Elsubeihi, David Chvartszaid, George Zarb

PART VI ADDITIONAL CONSIDERATIONS IN THE MANAGEMENT OF EDENTULOUS PATIENTS

Chapter 23 *The Impact of Socioeconomic, Cultural, and Technological Changes and the Notion of Standards of Care and Alternative Protocols, 409*
C. Peter Owen, Michael I. MacEntee

INDEX, *421*

This page intentionally left blank

The Patient

PART I

The Edentulous State

CHAPTER 1

John A. Hobkirk, George Zarb

HISTORICAL CONTEXT AND CURRENT CONSIDERATIONS

Although the face represents only a small proportion of the surface of the body, it embodies our social identities and is one of the major vehicles for interpersonal communication. Facial appearances that depart from culturally acceptable concepts of attractiveness have been shown to be disadvantageous to the individual; this is especially the case when those deviations are significant. They reflect inherited characteristics on which may be superimposed the effects of disease or trauma, the most common of which are probably untreated or poorly treated edentulism. Negative changes in facial appearance are often perceived by the persons affected, as well as those around them, as negative changes to the individuals themselves. Therefore when we treat edentulous patients, we are managing not just their oral biomechanics but more importantly their individuality (Fig. 1-1). Success demands not only technical expertise but also empathy with the patient's fears and aspirations.

This text seeks to provide an understanding of the edentulous state and its clinical management. It recognizes that tooth loss causes adverse anatomic, esthetic, and biomechanical sequelae, a predicament compounded by the resultant demise of the periodontal ligament with its support and sensory functions for which the residual ridges are a poor substitute.

For a long time, prosthodontic therapy focused mainly on the technical and clinical expertise required to fabricate complete dentures. This approach helped nurture the development of new materials and knowledge about overlapping considerations in esthetics, occlusion, and patients' expectations. Strong convictions also emerged about the inherent merits of complete denture treatment, and dentists all over the world presumed that their endeavors would virtually match the gold standard of the healthy intact natural dentition. Subsequent experience revealed the inability of treatment with complete dentures to match this standard. Nevertheless they considerably improved the lot of many who were edentulous or suffering from mutilated dentitions. The majority of patients appear to have benefited from this approach, as compromised oral health and appearance were managed with extractions and complete denture replacements. Regrettably, these successes resulted in partial and sometimes entire dentitions being needlessly sacrificed as complete denture treatment was all-too-often regarded as a preferable alternative to expensive periodontal and restorative therapy. Nonetheless, clinical experience suggests that the skills and ingenuity of complete denture fabrication contributed to a predictable and satisfactory quality of life for most edentulous patients. The passage of time also permitted dentists to refine the requisite technical skills and to develop scientifically based rationales for their use. As a result, treatment with complete dentures became, and indeed remains, an integral and important part of dental education and practice.

In a public-health context, complete denture prosthodontics is a relatively routine and inexpensive treatment method that offers scope for virtually universal application. As a clinical teaching and professional activity, it also demands knowledge of applied basic sciences, biomaterials, occlusion, and esthetics. In fact, the basis for most of the esthetic clues or decisions currently used to improve the appearance of the natural smile is an extension of the complete denture esthetic principles described in Part IV of this

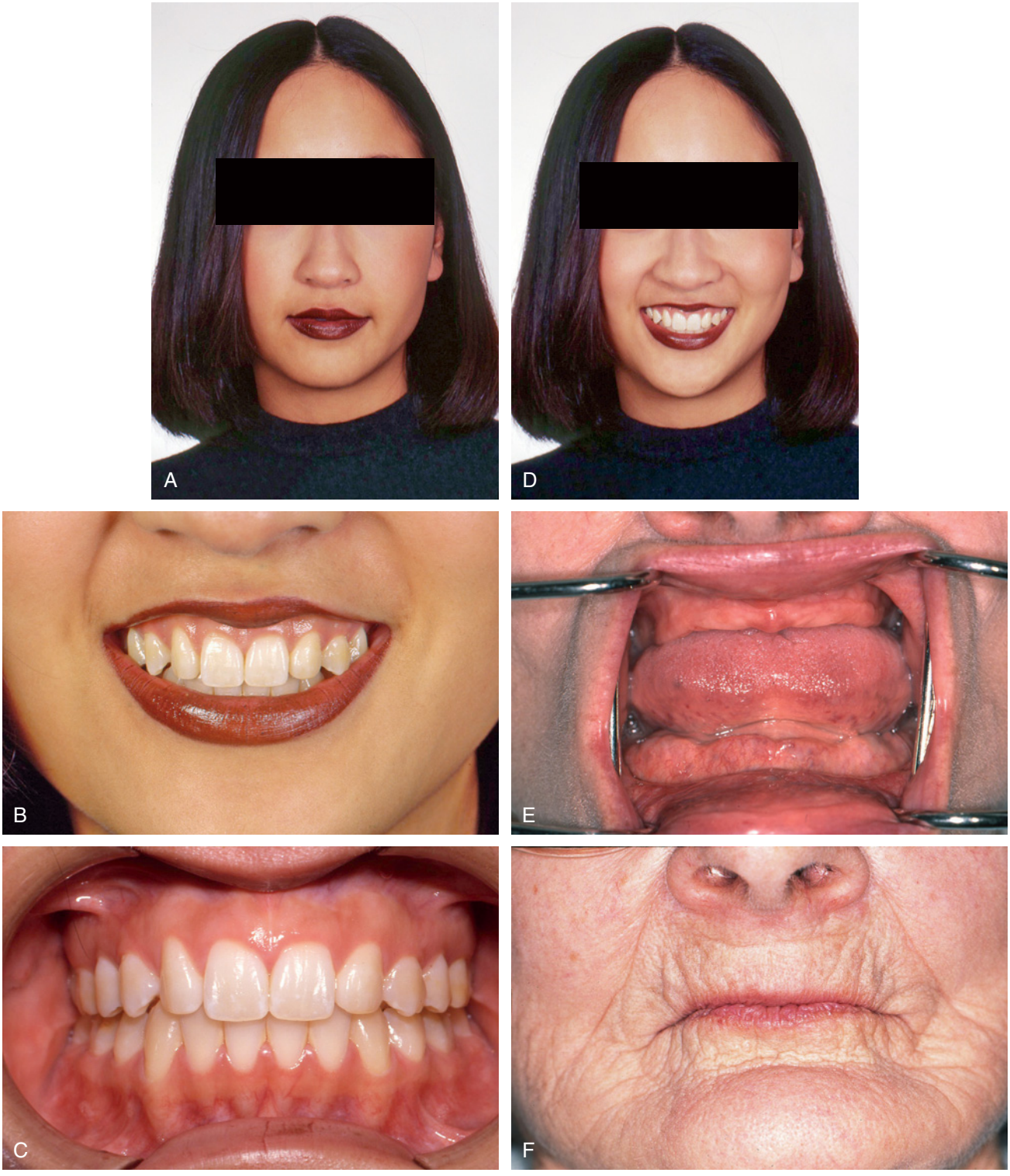


Figure 1-1 **A** to **D,** Characteristic facial and circumoral changes associated with a dentate young woman in her 20s. Parts **A** to **D** are in stark contrast with those observed in an aging woman who has been wearing dentures for several decades (**E** to **H**). The denture's three surfaces **(G)**—intaglio or fitting, polished, and occlusal—were established separately by the dentist. They were integrated to replace the missing teeth and the severely reduced supporting tissues as an integral part of routine prosthodontic protocol. Optimal esthetic support combined with adequate renewed function usually can be achieved for most edentulous patients with complete dentures.





Figure 1-1, cont'd.

text (Fig. 1-2). Above all, it offers dentists the challenge and satisfaction of managing patients' behavioral and age-related concerns and infirmities. It is not, however, a panacea for the edentulous predicament.

It has been demonstrated that within a population the decision of patients to become edentulous reflects not only their levels of caries and periodontal disease but also the effects of several nondisease factors such as attitude, behavior, dental attendance history, the characteristics of their health care system, and cost concerns associated with a low socioeconomic status. Indeed some authors have argued that tooth loss does not even bear a close relationship to the prevalence of dental disease, although this viewpoint is probably excessively polarized. It is nevertheless reasonable to conclude that edentulism is due to various combinations of dental disease together with cultural, financial, and attitudinal determinants, as well as previous dental treatment.

The heterogeneous etiology of edentulism has been tackled on several worldwide fronts by the dental profession. Recent reviews of tooth loss and edentulism in various countries have shown that in several countries, edentulism has declined and is predicted to continue to do so. At the same time, the number of partially dentate individuals is likely to increase in the short term. Although these observations may be used to imply the need for a reduced dental educational commitment to treatment of edentulous patients, some very compelling points must be underscored:

1. Documented evidence reveals that despite projections of declining edentulism, the unmet need for complete denture treatment will remain high even in industrialized countries and may even increase in some.
2. Predictions from several surveys of healthy elderly populations indicate that a high percentage of older people will be edentulous. The effective demand for prosthetic care for this expanding population cohort is therefore likely to increase.
3. The impact of longevity on edentulism has not been fully ascertained, although it is recognized that the treatment of the elderly long-term edentulous patient can be considerably more challenging than that of the younger recently edentulous individual. This will confront dentists with a significant increase in the number of edentulous patients requiring difficult treatment.
4. Many of the skills required for successful treatment of the edentulous patient are important to other areas of patient management.

Irrespective of precise future population needs, the psychological and biomechanical consequences of tooth loss must never be overlooked. Most patients regard tooth loss as a form of mutilation and as a strong incentive to seek dental care for the preservation of a healthy dentition and socially acceptable appearance. Dentists, on the other hand, also regard tooth loss as posing the additional hazard of an even greater mutilation: the destruction of part of the facial skeleton with the accompanying distortion of soft tissue

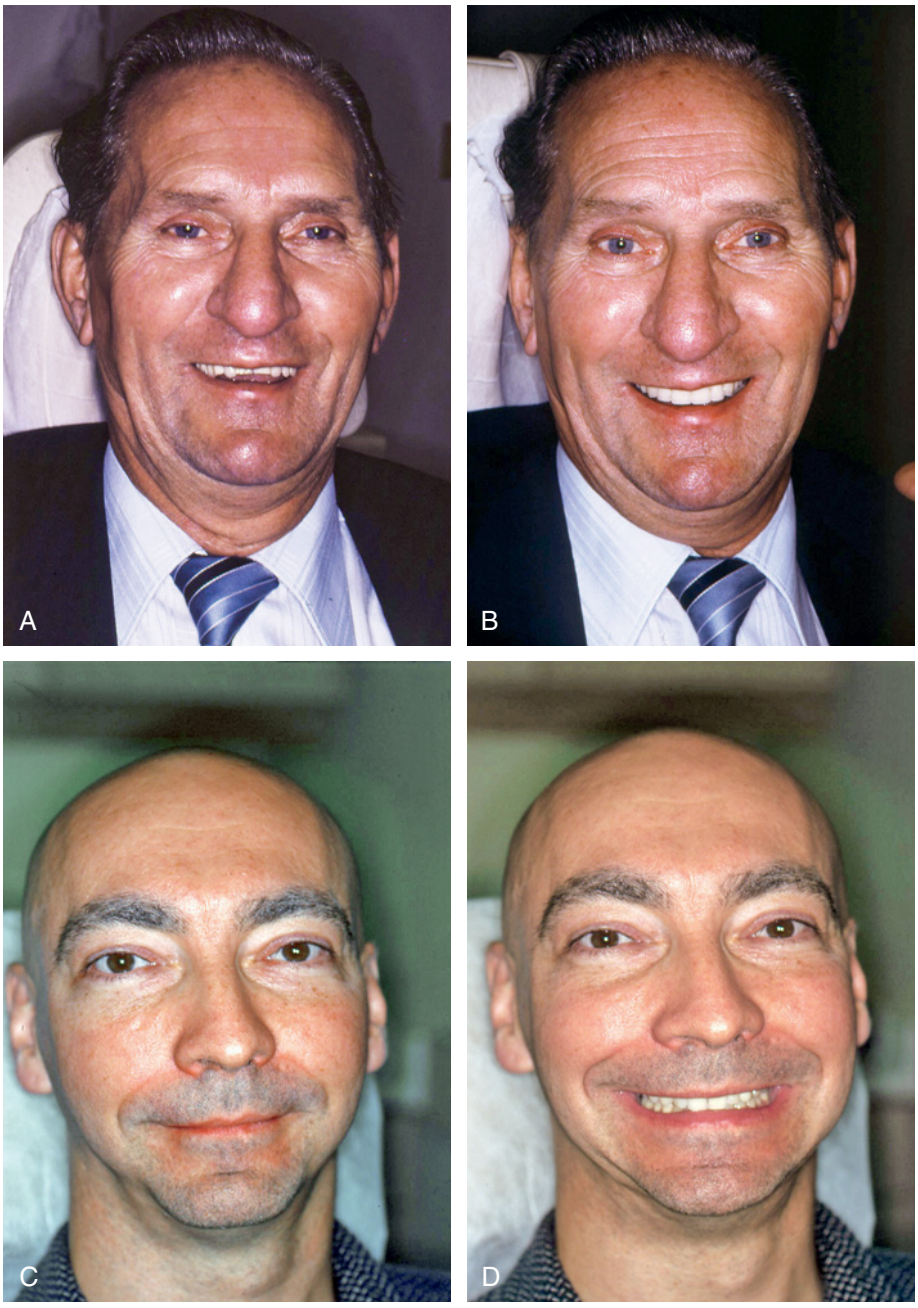


Figure 1-2 Four patients representing different age groups (50 years and older). The pretreatment (**A, C, E,** and **G**) and posttreatment (**B, D, F,** and **H**) pictures reflect the sort of esthetic clues or decisions routinely used by dentists in complete denture prosthodontics to improve their edentulous patients' natural smile.

shape and varying degrees of functional inadequacy (see Fig. 1-1, *E* to *H*)

BIOMECHANICAL SUPPORT FOR THE NATURAL DENTITION

The edentulous state represents a loss of the integrity of the masticatory system, which is frequently accompanied by adverse functional and esthetic sequelae. These are varyingly perceived by the affected patient, ranging from feelings of inconvenience to severe handicap. Many also regard total tooth loss as equivalent to the loss of a body part. Consequently, the required treatment must address a range of biomechanical problems that involve a wide spectrum of individual tolerances and perceptions.

The natural or prosthetic dentition and its supporting mechanism are the most visible, accessible, and frequently treated parts of the masticatory system. This is made up of closely related morphological, functional, and behavioral



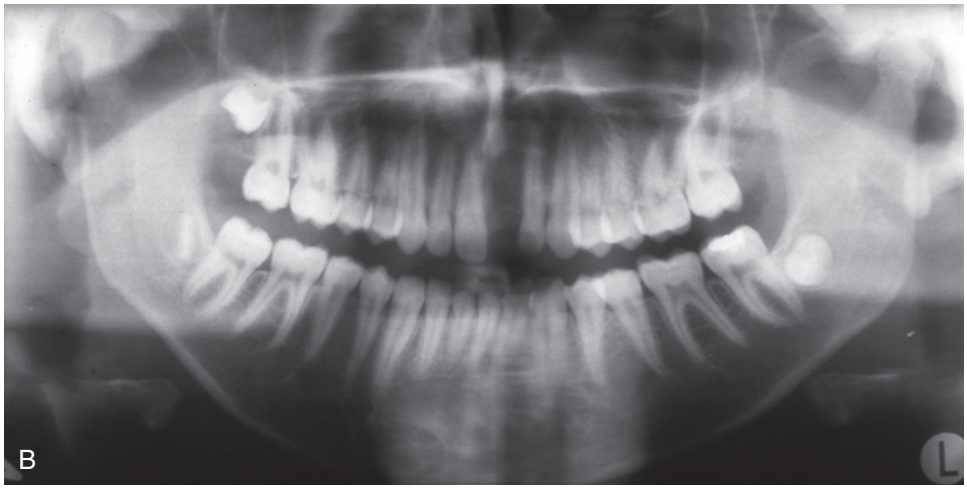
Figure 1-2, cont'd.

components whose interactions are affected by changes in the dentition's support mechanism when natural teeth are replaced by prosthetic ones. An understanding of the many subtleties associated with the transition from a dentate to an edentulous state requires a comparison of the support mechanisms for natural teeth and complete dentures (Fig. 1-3).

The masticatory apparatus is involved in the trituration of food in which the teeth and their supporting tissues play key roles. The attachment of teeth in sockets is but one of many important modifications that took place when the earliest mammals were evolving from their reptilian predecessors. The success of this modification is indicated by its rapid adoption throughout the many different groups of emerging Mammalia. Teeth function properly only if adequately supported, and this support is provided by the periodontium.

The periodontium attaches the teeth to the bone of the jaws, providing a resilient suspensory apparatus resistant to functional forces. It is comprised of the hard connective tissues (cementum and bone) and soft connective tissues (the periodontal ligament and the lamina propria of the gingiva), which are covered by epithelium. It also allows the positions of the teeth to change in response to stress. The periodontium is regarded as a functional unit and is attached to the dentin by cementum and to the jawbone by





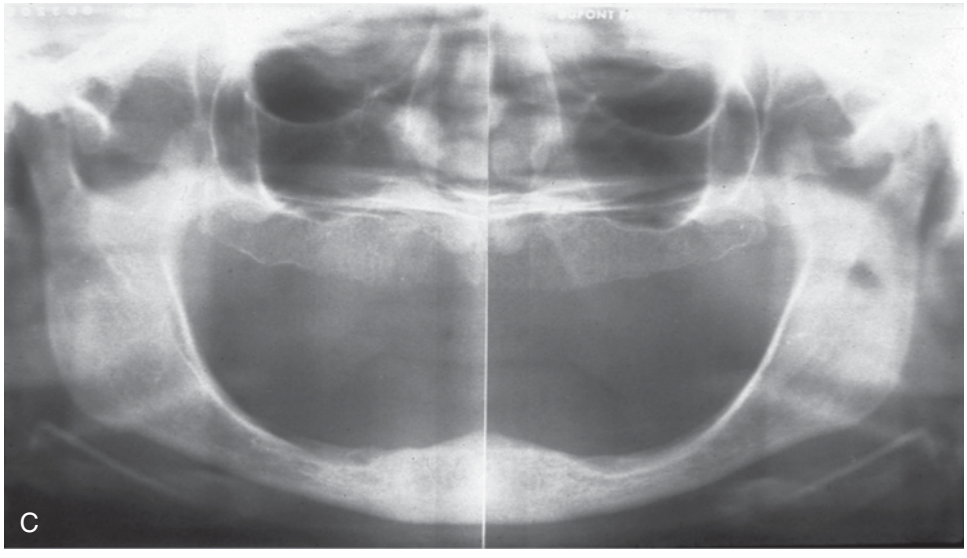


Figure 1-3 The transition from a dentate to an edentulous state requires an understanding of the entirely different support mechanisms available for natural teeth and complete dentures. The natural dentition (**A** and **B**) is supported and retained via an area of 45 cm^2 of periodontal ligament. This attachment mechanism, which evolved quantitatively and qualitatively for its specialized role, is substituted for by a compromised one when a patient becomes progressively more edentulous both in the maxilla (**C** to **E**) and mandible (**F** to **H**).

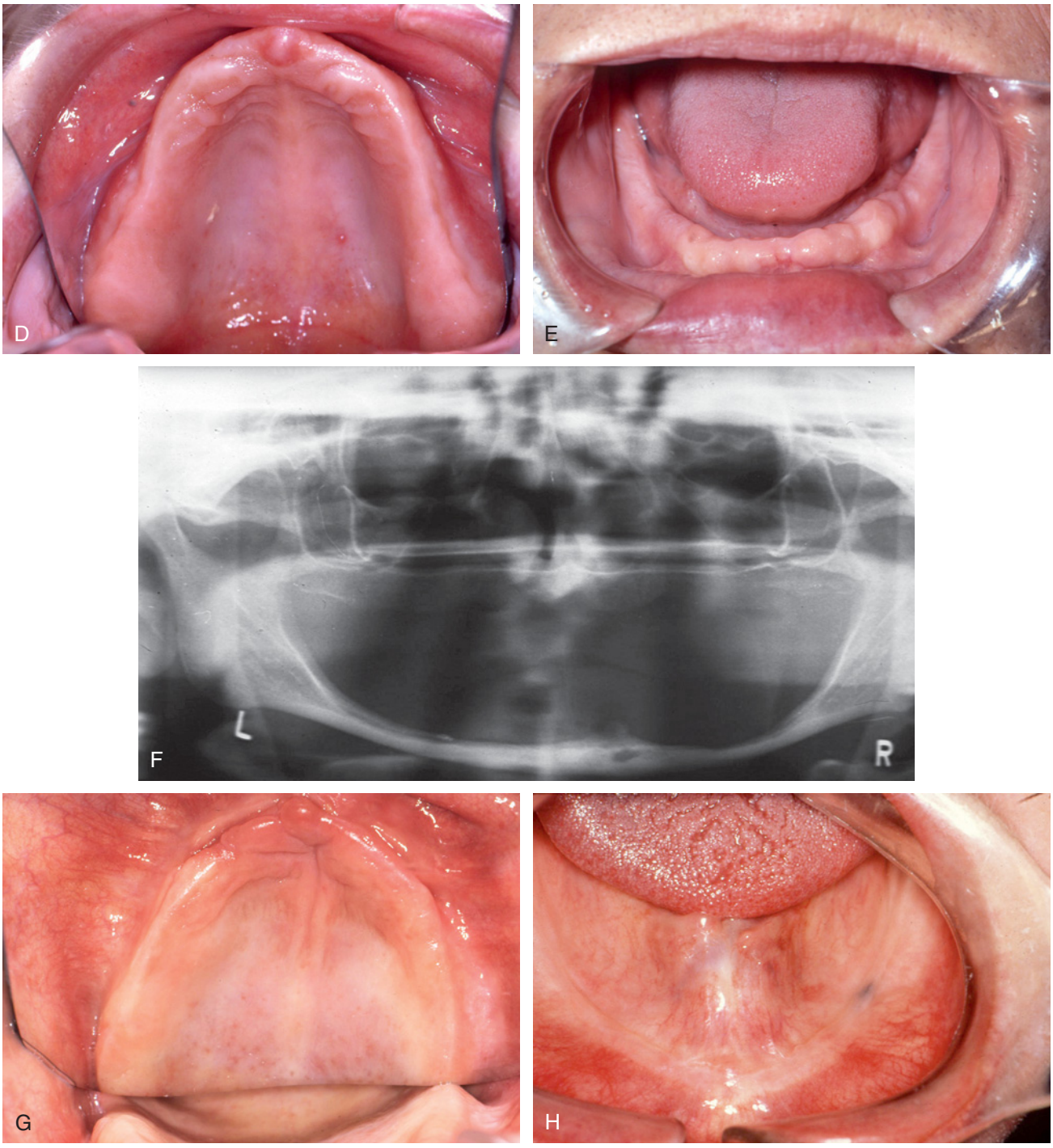


Figure 1-3, cont'd.

the alveolar process. The periodontal ligament and the lamina propria maintain continuity between these two hard tissue components, providing the means by which forces exerted on the tooth are transmitted to the bone that supports it, while the periodontium also allows the positions of the teeth to change in response to stress.

The two principal functions of the periodontium are support and positional adjustment of the tooth, together with the secondary and dependent function of sensory perception. The edentulous patient is deprived of this functionality.

The physiological occlusal forces exerted on the teeth are intermittent, rhythmic, and dynamic in nature, and are controlled by the neuromuscular mechanisms of the masticatory system. Reflex mechanisms with receptors in the muscles, tendons, joints, and periodontal structures regulate mandibular movements and the functional forces that are transmitted to the periodontal structures.

The greatest forces acting on the teeth are normally produced during mastication and deglutition and are essentially vertical in direction. Each thrust is of short duration, and for most people, chewing is restricted to short periods during the day. Deglutition, on the other hand, occurs about 500 times a day, and tooth contacts during swallowing are usually of longer duration than those occurring during chewing. Loads of a lower order but longer duration are produced throughout the day by the tongue and circumoral musculature. These forces are predominantly in the horizontal direction. Estimates of peak forces from the tongue, cheeks, and lips have been made, and lingual forces appear to exceed buccolabial forces during activity. During rest or inactive periods, the buccal and lingual forces may be of similar magnitude.

During mastication, biting forces are transmitted via the bolus to the opposing teeth whether or not they make contact. These forces increase steadily (depending on the nature of the food fragment), reach a peak, and abruptly return to zero. The magnitude, rise time, and interval between thrusts differ between individuals and depend on the consistency of the food, the point in the chewing sequence, and the individual's dental status. The direction of the forces is principally perpendicular to the occlusal plane in normal function, but the forward angulation of most natural teeth leads to the introduction of a horizontal component that tends to tilt the teeth medially, as well as buccally or lingually. Upper incisors may be displaced labially with each biting thrust, and these tooth movements probably cause proximal wear facets to develop.

In healthy dentitions, teeth are in occlusion during deglutition, occasionally while masticating and during the clenching and grinding associated with parafunction. It has been calculated that within a 24-hour period the teeth are subjected to the functional forces of mastication and deglutition for a total of some 17.5 minutes (Table 1-1). More than half of this time is attributable to jaw-closing forces applied during deglutition. These values indicate the tolerance threshold of the normal healthy supporting tissues. However, it must be emphasized that the collective forces acting on a prosthetic occlusion are unlikely to be controlled or attenuated as effectively as they appear to be by the natural dentition. Consequently, the time-dependent responses of tissues supporting complete dentures are likely to be different from those seen around natural teeth.

TABLE 1-1 CALCULATION OF TOTAL TIME DURING 24 HOURS WHEN DIRECT FUNCTIONAL OCCLUSAL FORCE IS APPLIED TO THE PERIODONTAL TISSUES

Chewing	
Actual chewing time per meal	450 sec
Four meals per day	1800 sec
One chewing stroke per sec	1800 strokes
Duration of each stroke	0.3 sec
Total chewing forces per day	540 sec (9 min)
Swallowing	
Meals	
Duration of one deglutition	1 sec
During chewing, three deglutitions per min, one third with occlusal force	30 sec (0.5 min)
Between Meals	
Daytime: 25/hr (16 hr)	400 sec (6.6 min)
Nighttime: 10/hr (8 hr)	80 sec (1.3 min)
Total	1050 sec = 17.5 min

From Graf H: Bruxism, Dent Clin North Am *13(3):659-665, 1969.*

BIOMECHANICAL SUPPORT MECHANISMS FOR COMPLETE DENTURES

The basic challenge in the treatment of edentulous patients lies in the differences between the ways natural teeth and their artificial replacements are supported. The previous section emphasized the superbly evolved quantitative and qualitative aspects of periodontal ligament support for a functioning dentition. This has an approximate area of 45 cm^2 in each arch, viscoelastic properties, sophisticated sensory mechanisms, and the potential for bone remodeling to cope with the diverse directions, magnitudes, and frequencies of occlusal loading. In contradistinction, the tissues pressed into service to support complete dentures are inherently unsuited to this role.

MUCOSAL SUPPORT AND MASTICATORY LOADS

The mean area of mucosa available for denture support has been calculated to be 22.96 cm^2 in the edentulous maxillae and approximately 12.25 cm^2 in an edentulous mandible. These figures, particularly in the mandible, are in dramatic contrast to the 45-cm^2 area of periodontal ligament available in each dental arch (see Fig. 1-3). It also must be remembered that the denture-bearing area (basal seat) becomes progressively smaller as the residual ridges resorb. Furthermore, the mucosa itself demonstrates little tolerance or adaptability to denture wearing, a disadvantage worsened by the presence of systemic diseases such as anemia, hypertension, or diabetes, as well as nutritional deficiencies. Indeed, any disturbance of the normal metabolic processes may lower the upper limit of mucosal tolerance and initiate inflammation.

Reported masticatory forces using complete dentures are much smaller than those produced by the natural dentition, which is of the order of 200 N. Although maximum forces of 60 to 80 N have been reported for complete dentures, the average loads are probably much less than these. Indeed

maximal bite forces appear to be five to six times less for complete denture wearers than for persons with natural teeth. Moreover, the forces required for mastication vary with the type of food being chewed. Patients with prostheses frequently limit the loading of supporting tissues by selecting foods that do not require masticatory effort that exceeds their tissue tolerance.

THE RESIDUAL RIDGES

The residual ridge consists of denture-bearing mucosa, the submucosa and periosteum, and the underlying bone. When the alveolar process is made edentulous, the alveoli that contained the roots of the teeth become filled with new bone, forming the residual alveolar processes. These become the residual ridges and are the foundation for dentures, a role for which they are ill-suited.

The loss of teeth and their periodontal support results in the removal of an important sensory mechanism and a change in the loading pattern of the alveolar bone from tensile to compressive with forces being predominantly vertical as well as horizontal. The edentulous ridge also has a considerably smaller surface area than that of the preceding periodontal ligaments, and the denture-supporting tissues demonstrate very little adaptation to their new functional requirements. This is in marked contrast to the frequently remarkable adaptive range of the dentate masticatory system.

Following teeth loss, the alveolar ridge is subject to ongoing resorption, which results in its gradual reduction and virtual disappearance (Fig. 1-4). This process apparently occurs at an exponentially reducing rate and is typically most rapid in the anterior mandible. The loss of bone does not occur evenly over the surface of the ridges, and so with time, their shapes and size become altered. The rate of bone resorption also varies markedly from person to person and is not predictable at an individual level. Little is known about which factors are most important for the observed variations Two concepts have been advanced concerning the inevitable loss of residual bone: one contends that as a direct consequence of loss of the periodontal structures, the latter's organizational influence on adjacent bone is altered and variable progressive bone reduction occurs. The other maintains that residual bone loss is not an inevitable consequence of tooth removal but depends on a series of poorly understood factors.

Clinical experience strongly suggests a definite relationship between the presence of a healthy periodontal ligament and the maintained integrity of alveolar bone (Fig. 1-5). This accounts for a strong professional commitment to the preservation and protection of any remaining teeth to minimize or avoid advanced residual ridge reduction. The tissue support for complete dentures is conspicuously limited in both its adaptive ability and inherent capability of simulating the roles of the periodontium. These disadvantages are compounded by the movement of complete dentures in relation to the underlying bone during function. This is related to the resiliency of the supporting mucosa and the inherent instability of the dentures during functional and parafunctional movements. Because these recurrent movements and the forces that produce them can cause damage to the supporting tissues, almost all "principles" of complete denture construction have been formulated so as to minimize them. Although unproven, it is tempting to conclude that the recurrent functional movements of removable prostheses may be a major factor contributing to residual ridge reduction.

Two physical factors are involved in denture retention that are under the control of the dentist and are technique driven. One is the optimal extension of the denture base; the other is the maximally intimate contact of the denture base to its basal seat.

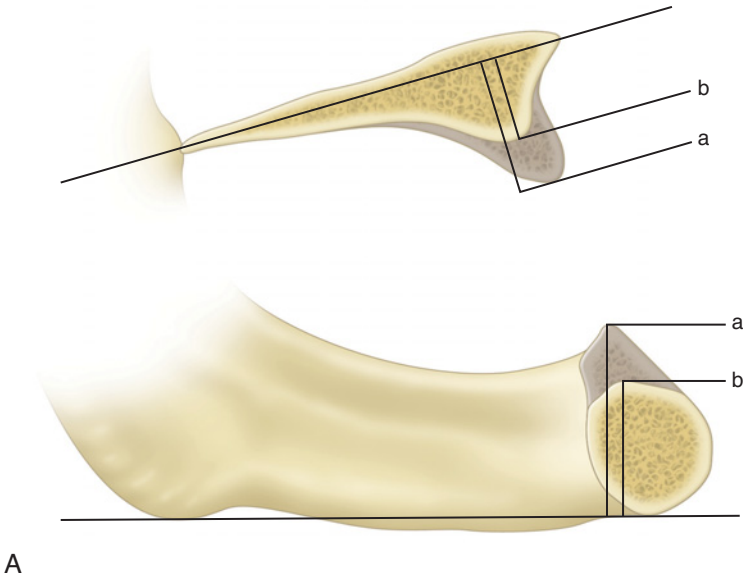
Muscular factors can be used to increase the retention (and stability) of dentures. The actions of the buccinator, the orbicularis oris, and the intrinsic and extrinsic muscles of the tongue can be harnessed by the dentist to achieve this with appropriate impression techniques. Furthermore, the design of the labial, buccal, and lingual polished surfaces of the dentures and the forms of the dental arches must be considered when balancing the forces generated by the tongue and the perioral musculature. As the form and size of the denture-supporting tissues (the basal seat) change, harnessing muscular forces in complete denture design becomes particularly important for denture retention.

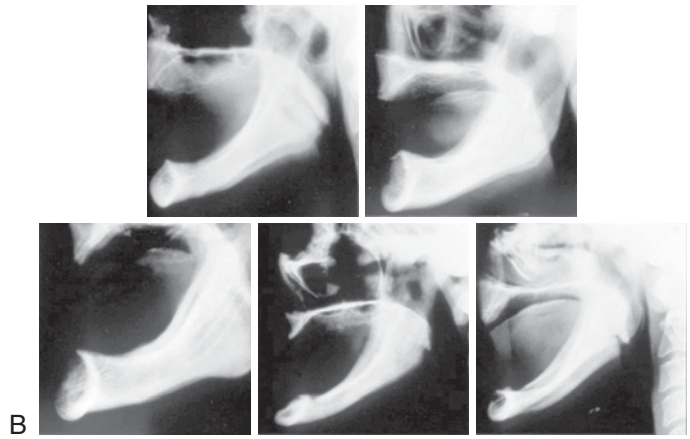
Wearing dentures may have an adverse psychological effect on some patients, and the nervous stimuli that result may influence salivary secretions and thereby adversely affect retention. Eventually, most patients seem to acquire an ability to retain their dentures by means of oral muscle control. This muscular stabilization of the prostheses is probably also accompanied by a reduction in the physical forces used in retaining the dentures. Clearly, the physical forces of retention can be improved and reestablished, up to a point, by careful and frequent attention to the status of the dentures. Periodic inspection, including relining procedures, will help prolong the usefulness of the prostheses.

NATURAL AND PROSTHETIC DENTAL OCCLUSION: FUNCTIONAL AND PARAFUNCTIONAL CONSIDERATIONS

The masticatory system appears to operate best in an environment of continuing functional equilibrium. This depends on the interactions of the occlusion's components—the dentition, the neuromuscular system, and the craniofacial structures—that are disturbed by the substitution of a complete denture for the teeth/periodontium.

The development and maturation of these components are interrelated so that growth, adaptation, and change actively participate in the development of an adult occlusion. Dentition development is characterized by a period of





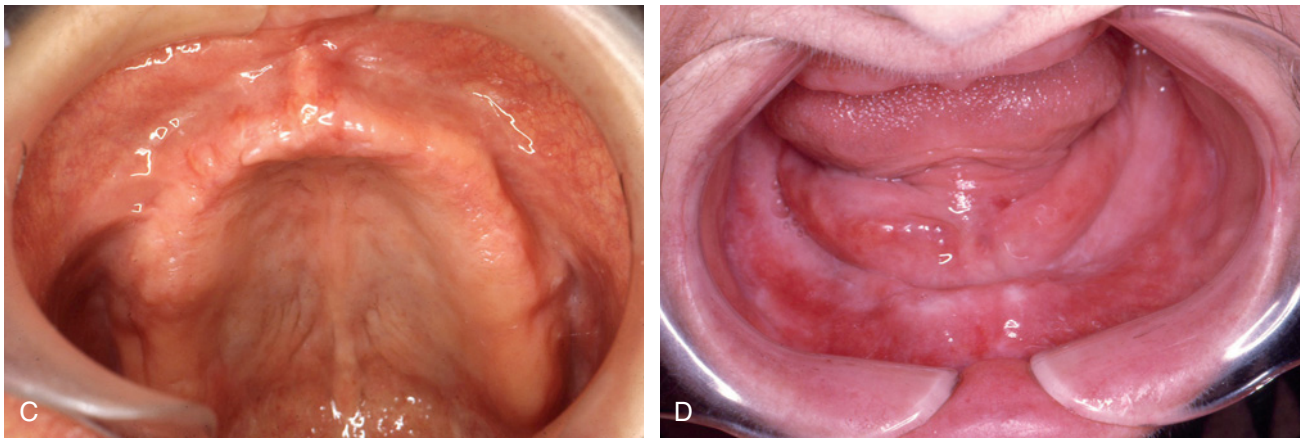
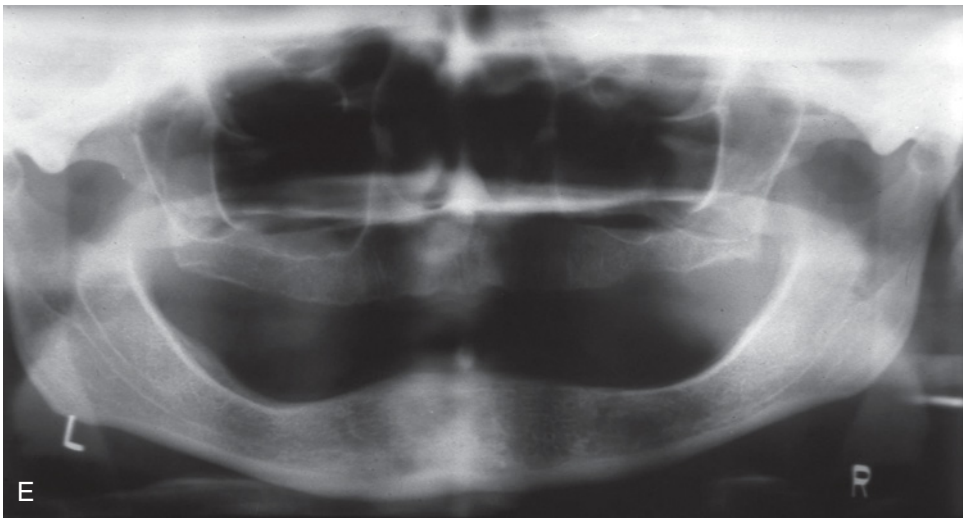
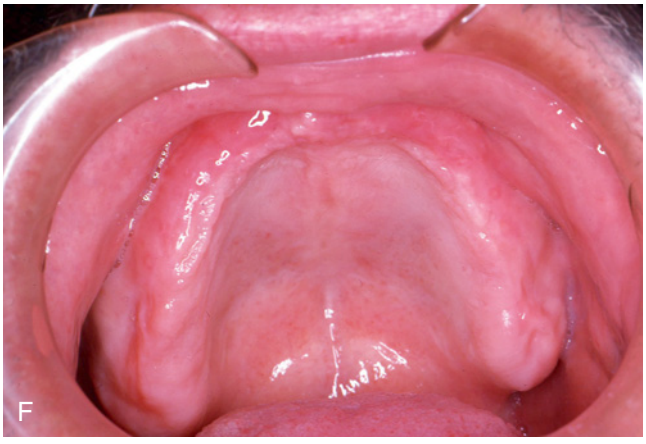
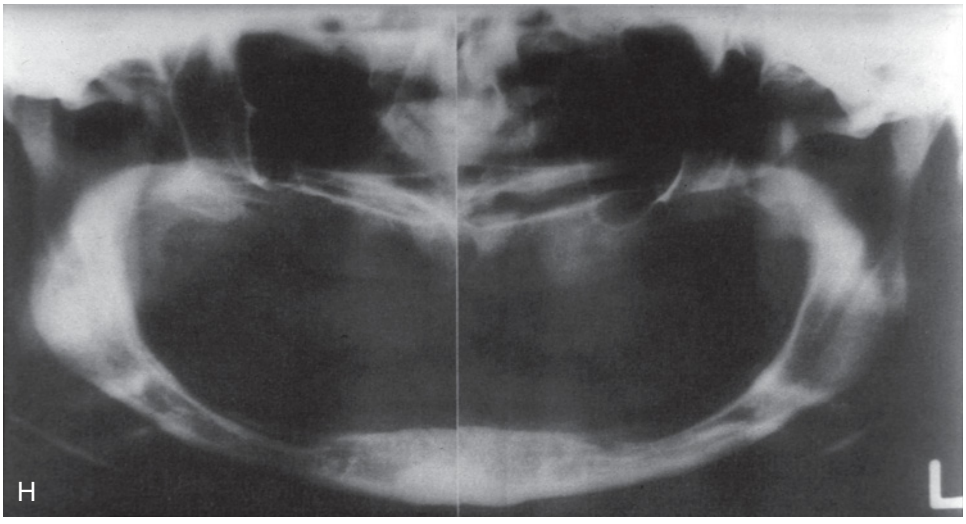


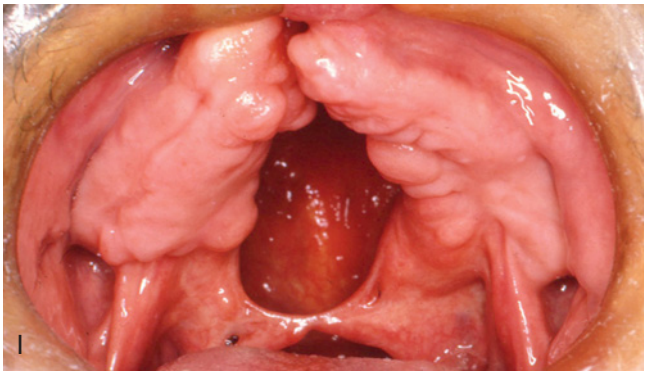
Figure 1-4 **A,** The overall reduction of the edentulous residual alveolar ridges. The *a* refers to bone height following extractions, while the *b* shows the bone level several years later. **B,** The bone reduction may be generalized or uneven but appears to be inevitable and variable. **C** to **H** illustrate the range of clinical and radiographic changes seen in two different edentulous mouths. Note that potential denture-bearing support can be compromised even further as a result of the presence of a congenital anomaly **(I)** or by an oncological surgical intervention **(J).** *(**A,** Modified from Tallgren A: The continuing reduction of the residual alveolar ridges in complete denture wearers: a mixed-longitudinal study covering 25 years,* J Prosthet Dent *27[2]:120-132, 1972.)*











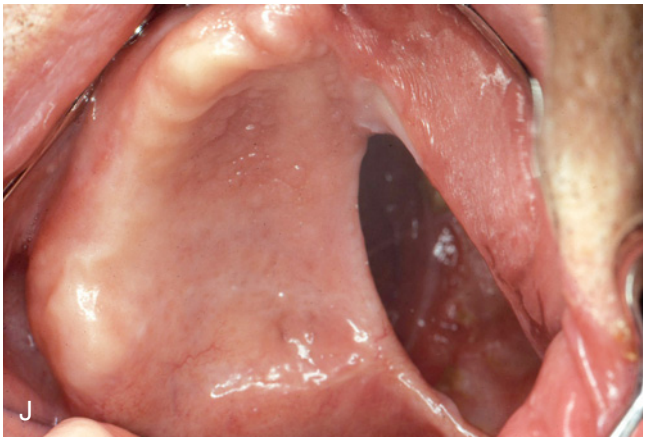


Figure 1-4, cont'd.



Figure 1-5 **A** and **B,** The contrast between alveolar bone sustained by a healthy periodontal ligament and the resorption-vulnerable residual ridges that have been "periodontally deprived" for several years. **C,** Periodontal disease also leads to a similar result, a process that is even more dramatic once such teeth are extracted. **D,** In contrast, implant placement in the mandible aims at preserving what is left of the residual ridge and presumably reducing the risk of even further bone loss in the posterior ridges, a result of a prosthesis design that is more favorable for adverse occlusal stress distribution. The masticatory system's potential for self-inflicted enamel wear and tear (the body's hardest substance) is underscored in parts **E** to **H.**





Figure 1-5, cont'd.

TABLE 1-2 DEVELOPMENT AND ADAPTATION OF THE OCCLUSION

Development	Adaptation
Developing dentition	Extensive sensory input Development of motor skill and neuromuscular learning Dental, alveolar, craniofacial adaptability
Healthy adult dentition	Dental adaptation (wearing, drifting, extrusion) Bone adaptation is reparative Learned protective reflexes and function adaptation
Deteriorating adult dentition	Partial edentulism Periodontal disease Diminished dental reflex adaptation Risk of maladaptive prosthesis-wearing experience
The edentulous state	Residual ridge reduction Compromised reflex adaptability Possible increase in parafunctional movements Increased risk of maladaptive denture-wearing experience

dental alveolar and craniofacial adaptability (Table 1-2), which is also a time when motor skills and neuromuscular learning are developing. Clinical treatment at this time may take advantage of such responsive adaptive mechanisms; for example, teeth can be guided into their correct alignment by orthodontic procedures.

In a healthy adult dentition, dental adaptive mechanisms are restricted to wear, extrusion, and drifting of teeth. Bony adaptations are essentially of a reparative nature and are slow in their operation. Protective reflexes are learned so as to avoid pain and inefficiency in the masticatory system. If and when an adult dentition begins to deteriorate, the dentist frequently uses fixed or removable prosthodontic therapy in attempts to maintain a functional occlusal equilibrium. This period is also characterized by greatly diminished dental and reflex adaptation and by bone resorption. Obviously, the presence of tooth loss and disease plus the depletion of reparative processes pose major prosthodontic problems. Finally, in the edentulous state, few natural adaptive mechanisms remain. The prosthesis rests on tissues that will change progressively and irreversibly, and the artificial occlusion serves in an environment characterized by constant and predominantly regressive change.

The design and fabrication of prosthetic occlusions have led to fascinating controversies. Dental occlusion was studied first in the field of complete dentures and then in other disciplines. Early workers encountered enormous mechanical difficulties in constructing reasonably well-fitting dentures that would be both durable and esthetic. Quite inevitably, dentists had to be mechanically minded. Because anatomy was the first of the biological basic sciences to be related to prosthodontic services, its application dominated prosthodontic protocol. Later, histology, physiology, and bioengineering were recognized as playing essential roles in the treatment of edentulous patients. The emphasis on and application of these basic sciences lifted prosthodontics from the early mechanical art to the applied clinical science it is today.

The modern complete denture service is characterized by an integration of biological information with instrumentation, materials, and clinical techniques. Complete dentures are designed so that their occlusal surfaces permit multidirectional contact movements of the mandible. Orofacial and tongue muscles play an important role in retaining and stabilizing complete dentures. This is accomplished by arrangement of the artificial teeth to occupy a so-called "neutral zone" in the edentulous mouth, determined by the functional balance of the orofacial and lingual musculature.

FUNCTION: MASTICATION AND OTHER MANDIBULAR MOVEMENTS

Mastication consists of a rhythmic separation and apposition of the jaws and involves biophysical and biochemical processes, including the use of the lips, teeth, cheeks, tongue, palate, and other oral structures to prepare food for swallowing. During masticatory movements, the tongue and cheek muscles play an essential role in keeping the food bolus between the occlusal surfaces of the teeth. The control of mastication within the narrow limits of tolerance of the mouth requires considerable sensory information because deviations from the normal path of mandibular movement can injure the tongue, buccal mucosa, and even the teeth and their supporting tissues. Here again, the reader's attention must be drawn to the importance of the correct positioning of the artificial dental arches when making complete dentures. It is important that the teeth are placed within a zone defined by the functional balance of the musculature involved in controlling the food bolus if the denture is to be minimally displaced and the bolus positioned between the occlusal surfaces of the teeth.

The comminution of much twenty-first century food does not demand a vigorous masticatory performance. Mastication has other functions however. It is necessary for a full appreciation of the flavor of foods and is therefore indirectly involved in the excitation of salivary and gastric secretions. Because mastication results in the mixing of food with saliva, it facilitates not only swallowing but also the digestion of carbohydrates by amylase. Although this is of minor importance while food is in the mouth, it is responsible for the continuation of carbohydrate digestion in the stomach, a phase that can account for as much as 60% of total carbohydrate digestion. Although data on the importance of chewing on the various stages of digestion are limited, it has been concluded that masticatory efficiency as low as 25% is adequate for complete digestion of foods. Patients do not however compensate for a smaller number of teeth by more prolonged, or a larger number of, chewing strokes—they merely swallow larger food particles. Nevertheless, loss of teeth can lead to a diminished masticatory efficiency, and there is evidence of this restricting dietary choice with resultant systemic effects. Thus while it appears that the importance of a good dentition or denture in promoting digestion and use of food has not been adequately demonstrated, food choices themselves may be restricted. Clinical experience suggests a relationship between the quality of the prosthetic service and denture wearer's masticatory performance.

As mentioned previously, the maximal bite force in denture wearers is five to six times less than that in dentate subjects. Edentulous patients are clearly handicapped in masticatory function, and even clinically satisfactory complete dentures are a poor substitute for natural teeth.

Studies of patterns of mandibular movement in dentate patients and those using complete dentures have shown them to be similar; consequently prosthodontic treatment of partially dentate and edentulous patients could improve their chewing efficiency and masticatory muscle activity. This would be typically accompanied by a decreased duration of the occlusion phase and contribute to a lessening of elevator muscle activity.

Chewing occurs chiefly in the premolar and molar regions, and both right and left sides are used to a similar extent. The position of the food bolus during mastication is dependent on the consistency of the food, and the tougher the consistency the greater is the person's preference for using the premolar region. This is apparent even in patients who have worn bilateral, soft-tissue–supported, mandibular partial dentures opposing complete upper dentures. Such findings demonstrate an obvious advantage that the patient accrues with the replacement of missing premolar and molar segments, especially as these patients do not chew predominantly in the segments where natural teeth are present.

The pronounced differences between persons with natural teeth and patients with complete dentures are conspicuous in this functional context: (1) the mucosal mechanism of support as opposed to support by the periodontium, (2) the movements of the dentures during mastication, (3) the progressive changes in maxillomandibular relations and the eventual migration of dentures, and (4) the different physical stimuli to the sensory motor systems.

Dentures move during mastication because of the dislodging forces of the surrounding musculature. These movements manifest themselves as displacing, lifting, sliding, tilting, or rotating of the prostheses. Furthermore, opposing tooth contacts occur with both natural and artificial teeth during function and parafunction when the patient is both awake and asleep. The denture-bearing tissues are thus constantly exposed to the frictional contact of the overlying denture bases.

Displacement of the supporting tissues under loaded dentures typically results in tilting of the prostheses and tooth contacts on the nonchewing side. In addition, occlusal forces on the dentures displace the soft tissues of the basal seat and allow the dentures to move closer to the supporting bone. This change of position under load induces an alteration in the relationship of the opposing dental arches.

PARAFUNCTIONAL CONSIDERATIONS

Nonfunctional or parafunctional habits involving repeated or sustained occlusal contacts can be harmful to the teeth or other components of the masticatory system. The profession lacks compelling epidemiological studies of the incidence of parafunctional occlusal stress in populations with both natural and artificial dentitions. Nevertheless, clinical experience indicates that tooth clenching is common and that parafunctional habits (Table 1-3) in the denture wearer may cause additional loading on the denture-bearing tissues with a consequent complaint of soreness.

TABLE 1-3 DIRECTION, DURATION, AND MAGNITUDE OF THE FORCES GENERATED DURING FUNCTION AND PARAFUNCTION

	Force Generated	
	Direction	Duration and Magnitude
Mastication	Mainly vertical	Intermittent and light Diurnal only
Parafunction	Frequently horizontal and vertical	Prolonged, possibly excessive Both diurnal and nocturnal

The neurophysiological basis underlying bruxism (tooth grinding) has been studied experimentally both in animals and in human beings, and part of its mechanism can be explained by an increase in the tonic activity in the jaw muscles. It is a very complex area of research and bruxism has been shown to result from psychosocial factors (such as stress or anxiety) or to be a reaction to strong emotions (e.g., anger, frustration). It also may be associated with specific medical conditions (e.g., oral tardive dyskinesia, Parkinson's disease) or with sleep parasomnia (e.g., bruxism, rapid eye movement [REM] behavior disorders, oromandibular myoclonus) or sleep disorders (apnea). It also may be found concomitantly with certain intraoral conditions such as pain, oral lesions, xerostomia, and discomfort associated with prostheses or occlusal problems.

The initial discomfort associated with wearing new dentures is known to evoke unusual patterns of behavior in the surrounding musculature. Frequently, the complaint of a sore tongue is related to a habit of its being thrust against the denture. The patient usually is unaware of the causal relationship between the painful tongue and its contact with the teeth. Similarly, patients tend at first to frequently occlude the teeth of new dentures. This is perhaps to strengthen confidence in retention until the surrounding muscles become accustomed to their presence or to provide some accommodation in the chewing pattern, experimental closure of the teeth being part of the adaptation process. A strong response of the lower lip and mentalis muscle has been observed electromyographically in long-term complete denture wearers with impaired retention and stability of the lower denture. It is feasible and indeed probable that the resulting tentative occlusal contacts may trigger the development of habitual nonfunctional occlusion.

The mechanism whereby pressure causes soreness of the mucous membrane is probably related to an interruption or a diminution of the blood flow in the small blood vessels in the tissues. These vascular changes could very well upset the metabolism of the involved tissues. The relationship between the incidence of parafunction in denture-wearing population groups and residual ridge reduction has not been investigated. However, it is tempting to consider, or even include, parafunction as a possible prosthetic variable that may contribute to the magnitude of ridge reduction.

CHANGES IN MORPHOLOGICAL FACE HEIGHT AND THE TEMPOROMANDIBULAR JOINTS

While the final stage of skeletal growth is usually accepted as occurring at 20 to 25 years of age, growth and remodeling of the bony skeleton continue well into adult life and account for dimensional changes in the adult facial skeleton. It has been reported that morphological face height increases with age in persons possessing an intact or relatively intact dentition. Nevertheless, a premature reduction in morphological face height can occur as a result of occlusal tooth surface loss, predominantly due to attrition and abrasion of the occlusal surfaces of the teeth. This reduction tends to be even more conspicuous in edentulous and complete denture-wearing patients because the widely used acrylic artificial teeth are less wear resistant than the natural dentition, and resorption of the ridges allows the dentures to move closer to the basal bone. In Table 1-3 the presumed range of changes that take place during the development and adaptation of the occlusion is summed up. It also underscores the resiliency of the masticatory system as it adapts to the effect of disease and attendant tooth loss.

Morphological changes in the maxilla and mandible occur slowly over a period of years and depend on the balance of osteoblastic and osteoclastic activity. The articular surfaces of the temporomandibular joints (TMJs) also are involved, and at these sites, growth and remodeling are mediated through the proliferative activity of the articular cartilages. Changes in morphological face height or the shapes of the jawbones due to tooth loss are inevitably transmitted to the TMJs. It is not surprising, then, that these articular surfaces undergo a slow but continuous remodeling throughout life. Such remodeling is probably the means whereby the congruity of the opposing articular surfaces is maintained, even in the presence of dimensional or functional changes in other parts of the facial skeleton.

Resorption of the residual ridges supporting complete dentures and the consequent reduction in the vertical dimension of occlusion tend to cause a decrease in total face height and a resultant mandibular prognathism. Indeed in complete denture wearers, the mean reduction in height of the mandibular process measured in the anterior region may be approximately four times greater than that in the corresponding maxillary process. Furthermore, longitudinal studies suggest that the rest vertical dimension of the jaws, which was once considered unrelated to the presence of teeth, is not stable and can change over time. These findings contradict the previously popular and convenient concept

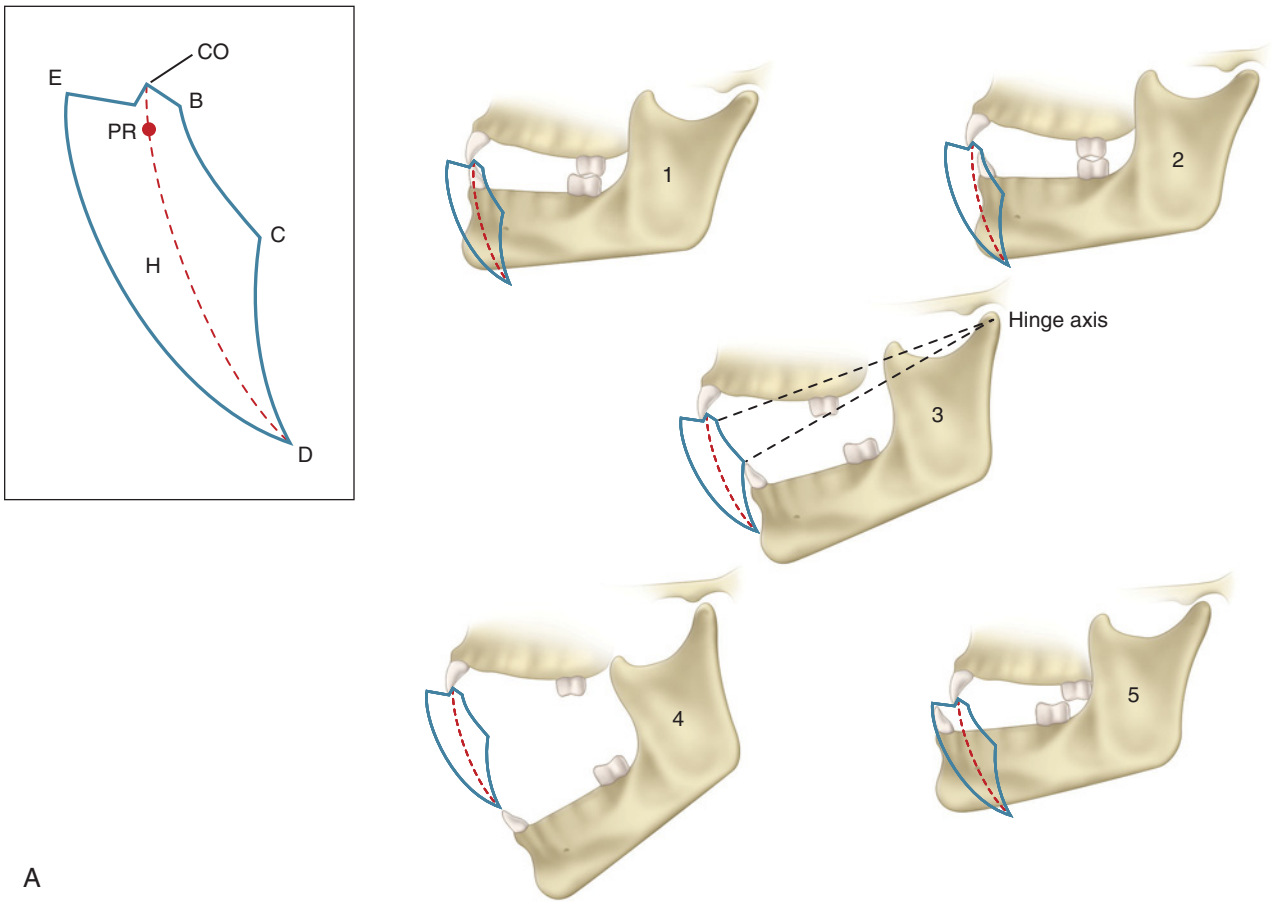


Figure 1-6 In **A** and **B**, the notion of a centric relation position may be best understood by studying mandibular border movements in both the sagittal and horizontal planes. **A**, The mandibular position in centric occlusion (CO) is depicted in *1*, and centric relation or the most retruded position (B) in *2*. Rotation, the terminal hinge movement *(3)* takes place between B and C, from which the translation phase of the posterior opening occurs to D, the maximum opening position *(4)*. The most protrusive closure from D ends in E, maximum protrusion with tooth contacts, *5*. The postural rest position (PR) and the habitual closure (H) are located well inside the borders. *(**A,** Modified from Mohl ND, Zarb GA, Carlsson GE et al, editors*: A textbook of occlusion, *Carol Stream, IL, 1988, Quintessence Publishing.)*

of a rest vertical dimension, which was fixed throughout the patient's adult lifetime.

Complete dentures constructed to conform to clinical decisions regarding jaw-relation records are placed in an environment that retains considerable potential for change. Consequently concepts of reproducible and relatively unchangeable mandibular border movements may not apply as closely to edentulous patients as they do to persons with a healthy dentition. Nevertheless, it must be reemphasized that while jaw relations are not unchangeable, this does not invalidate the clinical requirement of using a centric relation record as a starting point for developing a prosthetic occlusion.

Concepts of centric relation (CR) of the upper and lower jaws have long been a dominant factor in prosthodontic thinking on occlusion (Fig. 1-6). CR is defined as the most posterior position of the mandible relative to the maxillae at the established vertical dimension. It coincides with a reproducible posterior hinge position of the mandible, and it may be recorded clinically with a high degree of accuracy. It is therefore regarded as a very useful reference or starting point for establishing jaw relationships in any prosthodontic treatment, particularly in complete denture fabrication. It also is conceded that in the natural dentition, most functional tooth contacts occur in a mandibular position slightly anterior to centric relation, a position referred to as centric occlusion (CO). The lack of natural teeth makes it impossible to record the centric occlusion position in the edentulous patient; therefore this cannot be used as a basis for establishing the occlusal scheme for complete dentures (Fig. 1-7). Consequently, a logical clinical protocol objective when fabricating complete dentures is to record the CR, which is not dependent on the presence of occluding teeth, and to then establish CO at this jaw relationship

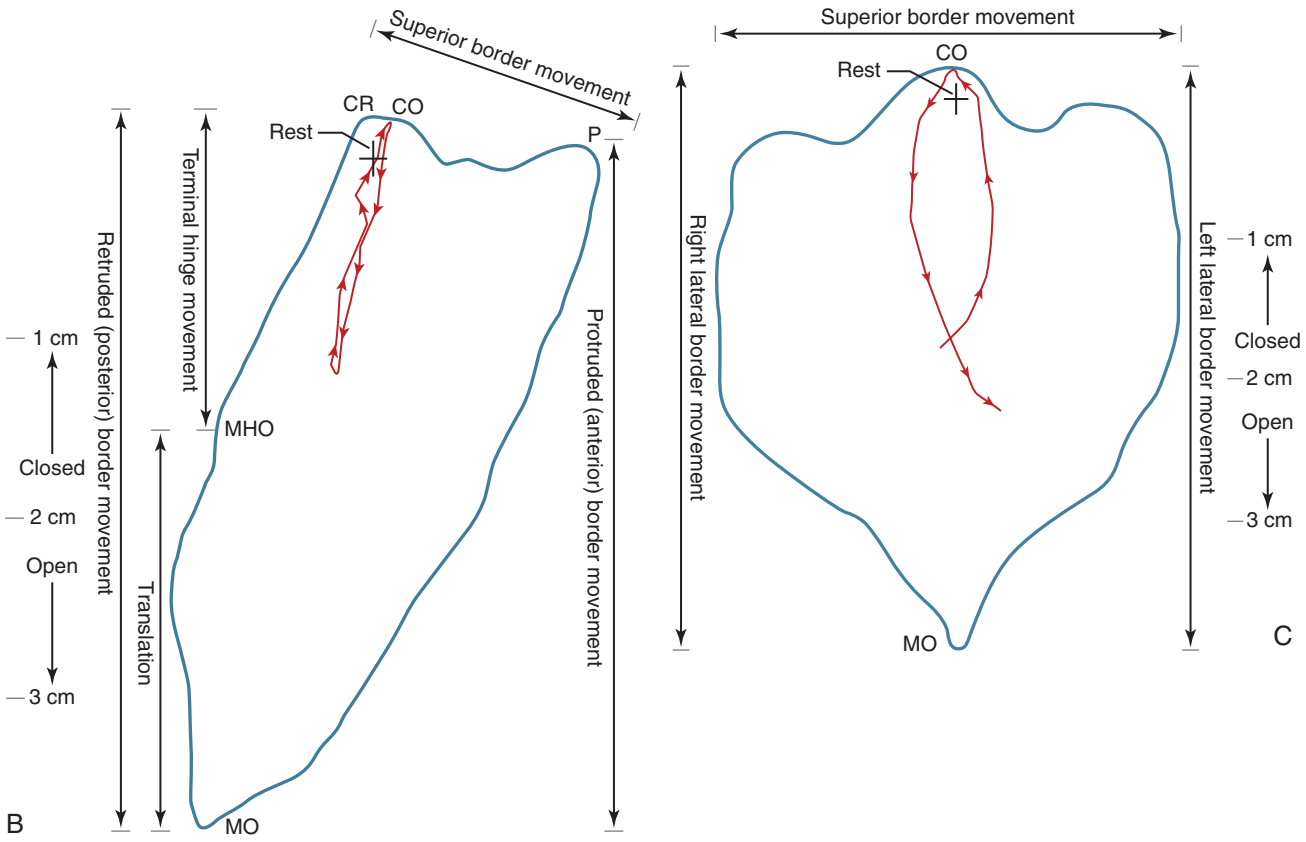


Figure 1-6, cont'd **B,** Envelope of motion (mandibular border movements) in the sagittal plane builds upon the previous illustration. **C,** The envelope of motion (mandibular border movements) as seen in the frontal plane. *CO,* Centric occlusion; *CR,* centric relation; *MHO,* maximum hinge-opening position; *MO,* point of maximum opening of the jaws; *P,* most protruded position of the mandible with the teeth in contact; *Rest,* postural rest position.



Figure 1-7 Overt facial changes, especially circumoral, also may be seen in elderly patients with an intact dentition **(A)** as well as edentulous ones **(B).**

using the preferred vertical dimension of occlusion (VDO), CR and CO thus being coincident. It should be noted that the preferred VDO reflects an informed decision based on a range of clinically derived information.

In addition to its utility, the employment of CR has a physiological basis because unconscious swallowing in the vast majority of patients is carried out with the mandible at or near the centric relation position. The unconscious, or reflex swallow, and its frequency are important in the developing dentition because the activity of the adjacent muscles (the muscle matrix) strongly influences tooth positions and occlusal relations, whereas the position of the mandible is determined by its location in space during the act of unconscious swallowing. The contacts of the inclined planes of the teeth also aid in the alignment of the erupting dentition. During this developmental period most of the mandibular activities have not yet been learned, or at least not in their adult form. The occlusion of complete dentures is therefore designed to harmonize with the primitive and unconditioned reflex of the patient's unconscious swallow. Tooth contacts and mandibular bracing against the maxillae occur during this process, suggesting that complete denture occlusions must be compatible with the forces developed during deglutition to prevent disharmonious occlusal contacts that could cause trauma to the basal seats of the dentures.

Nevertheless, it must be recognized that an integral part of the definition of centric relation—at the established vertical dimension—has potential for change. This is brought about by alterations in denture-supporting tissues and facial height, as well as by morphological changes in the TMJs. An appreciation of the dynamic nature of centric relation in denture-wearing patients, particularly in the context of an aging patient, recognizes the changing functional and adaptive requirements of the masticatory system. It also accounts for different concepts and techniques when designing an occlusion.

TEMPOROMANDIBULAR JOINT CHANGES

The numerous descriptions of TMJ function reflect the range of research methods used to study them. The basic physiological relationships between condyles, disks, and glenoid fossae appear to be maintained during maximal occlusal contacts and during all movements guided by occlusal elements. It is therefore logical that the dentist should seek to maintain or restore these basic physiological relations when treating a patient with complete dentures. The classic "envelopes of motion," which define the border movements of the mandible are reproducible, and it is within these that all other movements occur. Researchers have concluded that the passive hinge movement tends to have a constant rotational and reproducible character. This reproducibility of the posterior border path is of tremendous practical significance in patients undergoing prosthodontic treatment, although it has largely been established only in healthy young persons. It also must be recognized that before becoming edentulous, many patients have had a mutilated dentition of varying severity over often extensive periods, during which resultant pathological or adaptive structural alterations or changes in the TMJs may have occurred. These considerations are, however, largely based on autopsy investigations and must therefore be regarded as unproven.

It also has been reported that impaired dental efficiency resulting from partial tooth loss, inappropriate prosthodontic treatment, or indeed its absence can influence the outcome of temporomandibular disorders (TMDs). This is thought to be particularly the case when arthritic or degenerative changes have occurred. The hypothesis has been advanced that degenerative joint disease is a process rather than a disease entity. This process involves joint changes that cause an imbalance in adaptation and a degeneration that results from alterations in functional demands or the functional capacity of the joints. However, because the onset of degenerative conditions is frequently encountered in adults, the group most likely to be edentulous, the treatment of such conditions is very much the concern of the dentist. Clinical experience and long-term studies indicate that a combination of adjunctive prosthodontic protocols (including the use of soft liners to restore the VDO) together with appropriate pharmacological and supportive therapy, are usually adequate to provide these patients with comfort. A reduction and stabilization of TMD signs and symptoms should nevertheless precede the fabrication of new complete dentures.

One of the difficulties in managing degenerative joint involvement is achieving joint rest. Because of the necessity for mastication and for the avoidance of parafunctional habits, voluntary or even enforced rest may be difficult to achieve; although here too the use of soft liners is regarded as a valuable adjunctive step that can be readily repeated.

ESTHETIC CHANGES

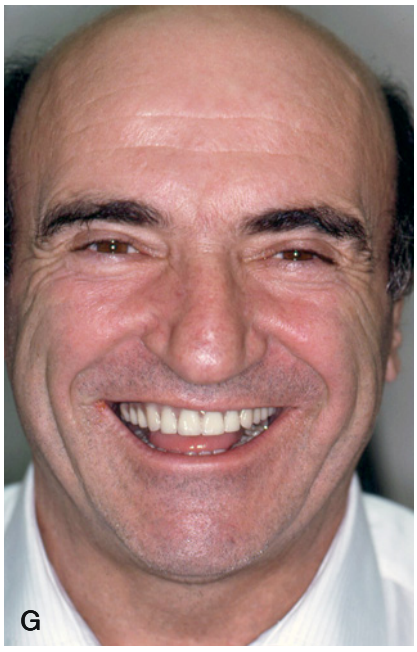
In most cultures it is thought highly desirable to appear to be dentate, and socially evident tooth loss is thus considered unacceptable. In addition, the edentulous state is typically associated with old age, and even when effectively treated, underlines to the patient their advancing years. These attitudes are so deeply ingrained that it is common for edentulous patients to have a great fear of being seen without their dentures even by their closest family members.

There is little doubt that tooth loss can adversely affect a person's appearance and that the resultant changes may range from subtle to overt. Box 1-1 lists some of the conspicuous and clinically challenging features that frequently accompany the edentulous state. It must be emphasized that one or more of these items also are frequently encountered in persons with intact dentitions since the compromised facial support of the edentulous state is not the exclusive cause of such morphological changes (Fig. 1-8). In clinical



Figure 1-8 **A** and **B,** For over 30 years, maladaptive edentulous patients have been very successfully treated with osseointegrated, implant-retained fixed prostheses, especially in the mandible. **C** to **F,** The clinical technique also proved to be equally efficacious, indeed meritorious, for maxillary prescriptions. In this patient, advanced anterior bone resorption that resulted from prolonged occlusal overload at this site precluded traditional location for edentulous maxillary implant locations. The patient in parts **G** to **I** had enjoyed a prolonged adaptive complete denture experience but requested a "cure" for his edentulism. This was achieved via provision of osseointegrated teeth root analogues to support and retain fixed prostheses.





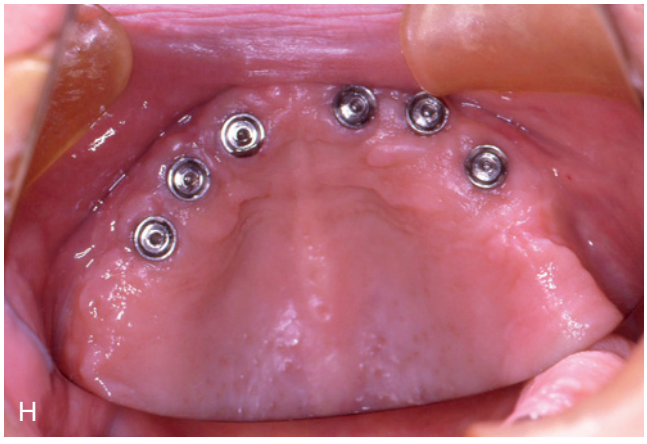




Figure 1-8, cont'd.

Box 1-1 Morphological Changes Associated with the Edentulous State

Deepening of nasolabial groove
Loss of labiodental angle
Decrease in horizontal labial angle
Narrowing of lips
Increase in columella-philtral angle
Prognathic appearance

practice, situations are frequently encountered in which factors such as a patient's weight loss, age, and heavy tooth attrition produce orofacial changes suggestive of compromised, or absent, dental support for the overlying tissues.

Patients seek dental treatment for functional, esthetic, or cosmetic reasons and dentists have been quite successful in restoring or improving many a patient's facial esthetics. Some individuals, however, fail to appreciate that aspects of their facial appearance for which they are seeking a solution are merely magnified perceptions or are unrelated to their edentulous predicament. Treatment with complete dentures, with its potential ability to modify facial contours, can raise hopes of a significantly altered appearance, sometimes with imagined benefits for the patient's interpersonal relationships or career prospects. Often such aspirations are beyond the scope of prosthodontic care. In such circumstances, the dentist must be prepared to guide the patient with a referral where appropriate to an experienced specialist in the field of cosmetic surgery. This does, however, depend on the patient's wishes being articulated or recognized from the outset. If this does not happen, then unrealistic expectations may only become evident after the dentures have been delivered, when it is more difficult to rescue the situation. Such events can cause the dentist considerable frustration. These issues underline the importance of the patient and clinician agreeing from the outset

on treatment objectives, procedures, likely outcomes, and potential problems.

Such discussions can be aided by patients providing photographs of their pre-edentulous appearance, and relevant details from these photographs should be carefully analyzed and discussed with the patient. If this is not possible, photographs of siblings or of children who resemble the patient may be helpful. This process also can help identify whether the patient's cosmetic desires exceed morphological or functional realities.

BEHAVIORAL AND ADAPTIVE RESPONSES

While the clinician can design and fabricate the prostheses so as to optimize the patient's appearance and create dentures that are as well supported and retained as circumstances will allow, success ultimately depends on the patient accepting their need for prostheses and learning to use them. This is a challenging matter for both patient and dentist, who must work together on the task, often for some time. It is also a process that should start at the onset of care so that the patient is mentally prepared for the challenge rather than experiencing profound disappointment at the delivery stage.

The process whereby an edentulous patient can accept and use complete dentures is complex, and the patient's ability and willingness to learn to do so ultimately determine the degree of success of the clinical treatment. The process requires the interpretation of new sensory inputs by the central nervous system (CNS) and the acquisition of additional motor skills so as to use the dentures when speaking and eating. Much of this has to occur in the company of others and in the knowledge that any lapses will be extremely embarrassing. Helping a patient adapt to complete dentures can be one of the most difficult but also one of the most rewarding aspects of clinical dentistry.

Edentulous patients expect, indeed are often expected, to adapt to their dentures more or less instantaneously. That adaptation must take place in the context of the patient's oral, systemic, emotional, and psychological states. Consequently, a real need exists for dentists to be able to understand a patient's motivation in seeking prosthodontic care and to identify potential difficulties before starting treatment. Emotional factors are known to play a significant role in the etiology of dental problems. The interview and clinical examination are obvious ways to observe the patient and form the best treatment relationship. Successful management begins with identification of anticipated difficulties before treatment starts and with careful planning to meet specific needs and problems. Dentists must train themselves to reassure the patient, to perceive their wishes, and to know how and when to limit the patient's expectations. An essential accompaniment of a denture design that is physically compatible with the oral complex is a good interpersonal relationship between dentist and patient. It is up to the dentist to explore the patient's symptoms and tensions. The way the patient handles other illnesses and dental situations will aid in the prediction of future problems. It has been observed that the secure patient will adjust readily, cope with discomfort, and be cooperative.

Optimal denture control requires the interpretation of impulses from both exteroceptors and proprioceptors, which are probably affected by the size, shape, position, and mobility of the prostheses and the pressures they generate. The exact role and relative importance of mucosal stimuli in the control of jaw movements need clarification, but it has been clearly demonstrated that control of dentures by muscle activity is reduced if a surface anesthetic is applied to the oral mucous membrane. There have been a number of investigations of the ability of patients to identify three-dimensional shapes placed in their mouths (oral stereognosis) or to assemble simple three-dimensional test pieces as a measure of oral manipulative ability. These were intended to test the hypothesis that such abilities were related to skill in using dentures; however, the results have been equivocal.

Learning means the acquisition of a new activity or change of an existing one and often involves the acquisition of muscular skill, that is, the capacity to coordinate muscular activity to execute movement. In the light of current knowledge, however, it remains very difficult to apply learning theory concepts to the presumed process by which an edentulous patient develops the skills to use their prostheses.

The acceptance of complete dentures is accompanied by a process of habituation, which is defined as a "gradual diminution of responses to continued or repeated stimuli." The tactile stimuli that arise from the contact of the prosthesis with the richly innervated oral cavity are probably ignored after a short time. Because each stage of the decrease in response is related to the memory trace of the previous application of the stimulus, storage of information from the immediate past is an integral part of habituation. Furthermore, stimuli must be specific and identical to achieve habituation. This is what probably prevents the transfer of habituation evoked by an old familiar denture to a new prosthesis, which inevitably gives rise to a different range of stimuli. Storage of information becomes more difficult in older age, which is why patients in this group often have difficulties becoming comfortable with dentures. In addition advancing age tends to be accompanied by progressive atrophy of elements in the cerebral cortex and a consequent loss in the facility of coordination.

A typical clinical adaptation problem is often encountered in the patient who has worn a complete upper denture opposing only a few natural anterior mandibular teeth. Such a patient usually finds it difficult to adapt to a complete lower denture, which commonly requires marked changes in the shape and activity of the tongue. The latter frequently responds to the loss of posterior mandibular teeth and alveolar bone by spreading laterally so as to contact the

buccal mucosa. The insertion of a new denture introduces an altered environment for the tongue, requiring its intrinsic musculature to reorganize both its shape and learned activity patterns so as to conform to the reduced available space. This process is often accompanied by frequent displacement of the lower denture. Furthermore, the posterior residual ridges are exposed to new sensations from the overlying prosthesis. Pressures transferred through the denture base replace tactile stimuli from the tongue and frictional contact with food. In addition, control of the upper denture frequently must be relearned because the posterior part of the tongue is no longer required to counter the tipping effect on the denture of the few remaining mandibular teeth.

Patient motivation is also important in dictating the speed at which adaptation to dentures takes place, and it is consequently imperative that the dentist determines and cultivates the patient's motivation in requesting treatment, seeking to foster it if lacking or absent.

It also has been reported that when a population including complete denture users was examined for depression most of the depressive symptoms were found in the age groups that included the greatest proportion of denture wearers. Awareness by the dentist of high-risk groups for depression within the patient pool may help explain difficulties in achieving patient satisfaction with dentures, facilitate recognition of a problem, and make possible suitable referral for diagnosis and appropriate treatment.

The absence of a yardstick to gauge a patient's adaptive potential to wearing a prosthesis is one of the most challenging facets of treating edentulism. The success of prosthetic treatment is predicated not only on the dentist's manual dexterity but also on the ability to relate to patients and to understand their needs. The importance of empathy and correct clinical judgment on the part of the dentist can hardly be overemphasized. The dentist's ability to understand and recognize the problems of edentulous patients, to select the proper course of treatment, and to reassure them has proven to be of greatest clinical value.

Many health care professionals also may forget that although much research and attention have been devoted to the effects of various types of organ loss, such as mastectomies and hysterectomies, the edentulous state has received relatively little attention by psychologists. Only a few authors have acknowledged the fact that it is a serious emotional life issue, albeit not a life-threatening one. Furthermore, outcome measures of health care treatment are only partially defined by technical excellence and are not exclusively dentist determined. Patient perceptions and responses to health care measures are now regarded as an integral part of the clinical decision-making paradigm. It is therefore not surprising to note that many edentulous patients may be described as unable to adapt to complete dentures and are labeled as prosthetically "maladaptive." The term is used in this very specific context in this text. It is recognized that such patients perceive their denture-wearing experience as one to which they cannot adapt and that this can occur despite the dentist's optimal skills and humanitarian concerns. Some dentists have been inclined to regard maladaptive denture wearing as a result of anatomical or physiological causes, to which they have sought technical solutions. Nevertheless the use of evermore complex techniques and occasional surgical attempts to enlarge the denture-bearing areas has often proved to be palliative at best in these situations. Regrettably, these patients have also been frequently identified as long-term complainers and sometimes even regarded as needing psychiatric help to cope with their maladaptation.

Clinical experience also has demonstrated that patients who are initially adaptive may eventually become maladaptive as regressive, or degenerative, changes in the supporting tissues and neuromuscular control gradually reduce their abilities to adapt. It also must be admitted that the research into determinants of treatment outcomes and the measurement of those outcomes themselves has been characterized by a lack of methodological rigor. As a result, there is a shortage of practical, clinically valid data on predictors of treatment outcomes for the edentulous patient, while methods for measuring patients' quality of life following prosthodontic treatment in these situations are still evolving.

TREATMENT OPTIONS: COMPLETE DENTURES

The edentulous patient faces many challenges: the loss of a major part of their facial structure, threats to their public and self-images, the emphasis on the aging process, a possible loss of self-confidence, and the need to learn to use new and possibly novel prostheses. While the tendency of complete dentures to move in relation to their bases is but one item on a long list, it can be a key concern, especially in relation to the lower prosthesis, since it can be frightening to lose control of a denture, particularly in a public situation. Looseness also can cause mucosal trauma and makes speech and mastication more challenging.

Ideally a denture should maintain a fixed relationship with the underlying bone; however, this is rarely possible with conventional techniques in which stability is optimized by maximizing retention via the peripheral seal, adhesion and cohesion and minimizing displacing forces by appropriate denture base extension, contouring of the polished surfaces, and design of the occlusion. Even with the greatest care, such prostheses tend to move in function as a result of the imbalance between displacing and stabilizing forces and the ease with which the supporting mucosa deforms under load. Where there has been severe alveolar resorption then the denture-bearing area may become essentially featureless. In these circumstances the prosthesis can be free to slide horizontally on its saliva lubricated mucosal bed at the whim of the many forces to which it is subjected.

The principal alternatives open to the dentist are rather limited. Where the patient is still partially dentate, then treatment with immediate dentures should be considered. Where edentulous, then the key issue relates to the extent to which the new dentures should inherit the characteristics of the old and the appropriateness of employing implant stabilization, which is discussed in the next section. If there are to be significant similarities with the old dentures, then this may be aided by employing a denture-copying technique. In any case, great care should be taken to optimize denture stability.

When assessing denture stability, it is important to recognize that this is based on the dentist's objective consideration, unlike complaints of looseness, which reflect the patient's subjective views. A degree of denture movement that one patient finds intolerable may be dismissed by another as of no concern. Although both observations must be treated with due respect, the ability to improve the former situation may be somewhat limited.

TREATMENT OPTIONS: IMPLANT PROSTHODONTICS

The possibility of linking dental prostheses to the facial skeleton via an implanted device was conceived as a way of overcoming the manifest disadvantages of conventional removable prostheses. Despite numerous pioneering efforts over many decades, predictable time-dependent and morbidity-free documented outcomes proved to be elusive until the publication of P-I Brånemark's seminal research on the technique of osseointegration. The ability to safely locate alloplastic tooth roots in the jawbones had finally become a reality. In 1982, the Toronto Conference on Tissue Integrated Prostheses introduced the concept of inducing a controlled interfacial osteogenesis between dental implant and host bone to the broader dental academic community. This was soon followed by an international research endorsement of the merits of the technique for treating maladaptive edentulous patients with implant-retained fixed or removable overdenture prostheses.

In subsequent publications, implant prosthodontics was demonstrated to be a valid treatment option for any adaptive denture-wearing patient, provided that the necessary systemic and local criteria for implant treatment could be met. These included the willingness of the patient to undergo the required preprosthetic surgical procedures and incur the necessary additional expenses.

The thirteenth edition of this book continues the half-century-old tradition of describing the objectives and methods of treating patients with complete dentures. The text has evolved over this period to reflect developments in the subject, including, since 1985, the significant impact of implant-supported prostheses on clinical decision making when treating the edentulous patient. This development has led many dentists to regard implant prosthodontics as a virtual panacea for managing all complete denture situations and problems. Although implants can provide impressive denture stability, their successful use can be far from straightforward or guaranteed to be problem free. Many challenges in the treatment of the edentulous stem from factors other than denture stability, and the misguided use of dental implants has proved a far from adequate substitute for a lack of knowledge and expertise in removable prosthodontics. It is for this reason that the current edition of this text continues to emphasize the importance of the clinical skills and judgment required to treat patients with conventional complete dentures. The use of osseointegrated implants represents not a different treatment modality but simply one side of the treatment currency coin that permits optimal prosthodontic therapy for edentulous patients (Fig. 1-9).

Because of these requirements, there is a need for this text to underscore a dual purpose. Today's dentist can potentially offer all edentulous patients two treatment options: complete dentures or implant-retained or supported prostheses (Table 1-4). Choosing the best form of therapy is not

TABLE 1-4 TREATMENT OPTIONS FOR EDENTULOUS PATIENTS*

Diagnosis	Evidence-based Treatment Choices	Burden of Illness
Edentulous in one or both arches	A. Complete dentures, or B. Implant-supported overdentures, or C. Implant-supported fixed prosthesis	Functional esthetic and perceptual consequences that are encountered on a time-dependent and escalating basis
I. Without prior denture experience	A, B, or C	
II. With an adaptive complete denture experience	A, B, or C	
III. With a current history of maladaptive denture-wearing experience	B or C	

*Treatment choice is influenced by both patient- and dentist-mediated concerns. However, scientifically documented evidence shows that the impact of time-dependent regressive changes in the prosthodontic adaptive experience can be significantly reduced through an implant-supported/retained prosthesis.



Figure 1-9 The osseointegration (OI) technique also can be used in an "abbreviated form" via the overdenture application. The technique lends itself to even more versatile applications. **A** to **D,** An example of an adult patient with surgically repaired edentulous cleft lip and palate. Both potential implant host bone site availability and circumoral morphology demanded the design of polished and occlusal surface that ensured the best facial support possible. The more routine use remains for edentulous mandibles using two or more abutments as well as diverse retentive components. **E** and **F,** Two implants splinted with a bar are used for clip retention.

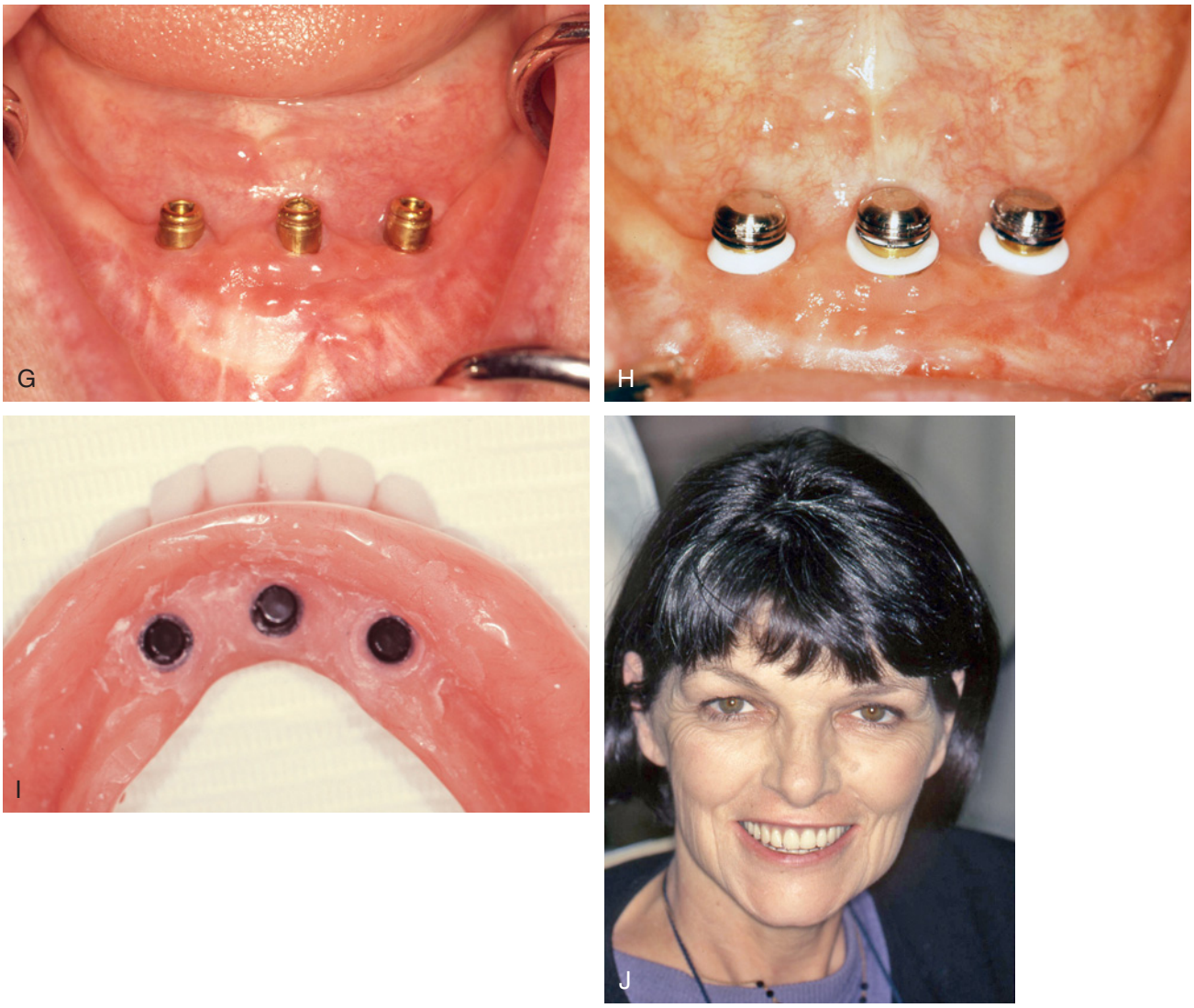


Figure 1-9, cont'd **G** to **J,** Adult patient in which snap attachments are employed for the three implant abutments.

always a clear-cut process. The clinical decision should reflect the dentist's thorough assessment of the patient's general health and oral status and an appraisal of how their needs may be best met, based on an understanding of all the available treatment options. In arriving at an informed decision, the patient will require an appreciation of the procedures involved, their risks, and likely outcomes. Biological, functional, personality, and fiscal considerations may preclude one option or the other. Admittedly, the conventional complete denture option lends itself to more frequent application than a fixed implant-supported prosthetic one, with costs being a major determinant of patient choice. On the other hand, an implant-supported overdenture appears to combine the best of both options without either method's restrictions. Functional and esthetic requirements are better achieved and maintained, with the risk of time-dependent supporting tissue morbidity compellingly reduced. These observations endorse the emerging clinical educational view that the current standard of complete denture service for prosthodontically maladaptive patients should be an implant-supported overdenture, particularly in the mandible (Fig. 1-10).

Osseointegration, with its robust research base, has ushered in a new era for the management of edentulous patients. Reconciliation of the technique's potential with the proven merits and ingenuity of complete denture fabrication can only improve dentists' ability to resolve the edentulous predicament.

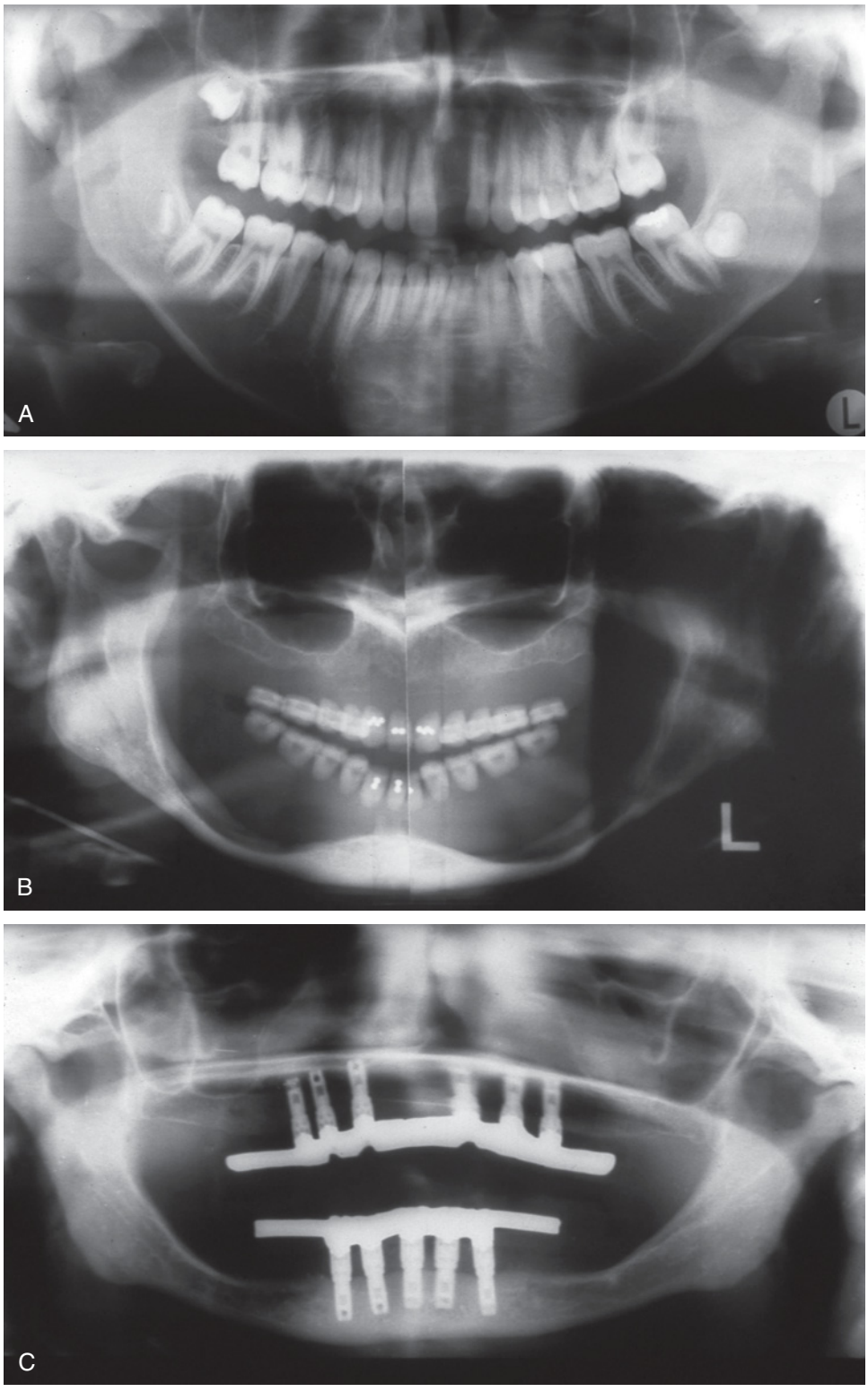


Figure 1-10 The challenge and dilemma of managing the edentulous predicament by means of complete dentures (with their time-dependent and unpredictable reliance on labile biological support) has been dramatically improved by the introduction of the osseointegration technique. The notion of a progressive, inevitable if variable RRR is no longer the dominant treatment concern since alternative and biologically tenable interventions are now available. The predicament of dealing with the substitution of PL support **(A)** by significantly less biomechanically suitable residual ridges **(B)** has been dramatically rectified by the predictability of successful outcomes associated with the induction of osseointegration **(C).** *RRR,* Residual ridge resorption; *PL,* periodontal ligament.

Bibliography

Allen F, Locker D: A modified short version of the oral health impact profile for assessing health-related quality of life in edentulous adults, *Int J Prosthodont* 15:446-450, 2002.

Atwood DA: The future of prosthodontics, *J Prosthet Dent* 51:262-267, 1984.

Berg E: Acceptance of full dentures, *Int Dent J* 43:299-306, 1993.

Brånemark PI, Zarb GA, Albrektsson T: *Tissue-integrated prostheses: on osseointegration in clinical dentistry*, Chicago, 1985, Quintessence.

Brill N: Factors in the mechanism of full denture retention, *Dent Pract* 18:9-19, 1967.

Celebic A, Knezovic-Zlataric D, Papic M, et al: Factors related to patient satisfaction with complete denture therapy, *J Gerontol A Biol Sci Med Sci* 58:M948-953, 2003.

Cooper LF: The current and future treatment of edentulism, *J Prosthodont* 18:116-122, 2009.

Douglass CW, Shih A, Ostry L: Will there be a need for complete dentures in the United States in 2020? *J Prosthet Dent* 87:58, 2002.

Graf H: Bruxism, *Dent Clin North Am* 13:659-665, 1969.

Gjengedal H, Berg E, Bøe OE, Trovik TA: Self-reported oral health and denture satisfaction in partially and completely edentulous patients, *Int J Prosthodont* 24:9-15, 2011.

Haraldsson T, Karlsson U, Carlsson GE: Bite force and oral function in complete denture wearers, *J Oral Rehabil* 6:41-48, 1979.

Harford J: Population ageing and dental care, *Community Dent Oral Epidemiol* 37:97-103, 2009.

Heydecke G, Vogeler M, Wollfkewitz M, et al: Simplified versus comprehensive fabrication techniques of complete dentures: patient ratings of denture satisfaction from a randomized crossover trial, *Quintessence Int* 39: 107-116, 2008.

Hobkirk JA, Abdel-latif HH, Howlett J, et al: Prosthetic treatment time and satisfaction of edentulous patients treated with conventional or implant-supported complete mandibular dentures: a case control study (part 2), *Int J Prosthodont* 22:13-19, 2009.

Larsson P, John MT, Nilner K, List T: Reliability and validity of the Orofacial Esthetic Scale in prosthodontic patients, *Int J Prosthodont* 23:257-262, 2010.

Lavigne GJ, Khoury S, Abe S, et al: Bruxism physiology and pathology: an overview for clinicians [review PMID: 18557915], *J Oral Rehabil* Jul 35(7):476-494, 2008.

Locker D: Self-esteem and socioeconomic disparities in self-perceived oral health, *J Public Health Dent* 69:1-8, 2009.

MacEntee MI, Hole R, Stolar E: The significance of the mouth in old age, *Soc Sci Med* 45:1449-1458, 1997.

Mueller F, Naharro M, Carlsson GE: What are the prevalence and incidence of tooth loss in the adult and elderly population in Europe? *Clin Oral Implants Res* 18(Suppl 3):214, 2007.

Mojon P, Thomason JM, Walls AW: The impact of falling rates of edentulism, *Int J Prosthodont* 17:434-440, 2004.

Newton J, Prabhu N, Robinson P: The impact of dental appearance on the appraisal of personal characteristics, *Int J Prosthodont* 16:429-434, 2003.

Sandström B, Lindquist LW: The effect of different prosthetic restorations on the dietary selection in edentulous patients: a longitudinal study of patients initially treated with optimal complete dentures and finally with tissue-integrated prostheses, *Acta Odontol Scand* 45(6):423-428, 1987.

Scott BJ, Leung KC, McMillan AS, et al: A transcultural perspective on the emotional effect of tooth loss in complete denture wearers [PMID: 12066643], *Int J Prosthodont* 14(5):461-465, 2001.

Tallgren A: The continuing reduction of the residual alveolar ridges in complete denture wearers: a mixed-longitudinal study covering 25 years, *J Prosthet Dent* 27:120-132, 1972.

Turker SB, Sener ID, Ozkan YK: Satisfaction of the complete denture wearers related to various factors, *Arch Gerontol Geriatr* 49:e126-129, 2009.

United Nations Population Fund: *Population aging and development: social, health and gender issues. Population and development strategies series*. Report No. 3. New York, 2002, United Nations Population Fund.

Yemm R: Stress-induced muscle activity: a possible etiologic factor in denture soreness, *J Prosthet Dent* 28:133-140, 1972.

York J, Holtzman J: Facial attractiveness and the aged, *Spec Care Dent* 19:84-88, 1999.

CHAPTER

2 Systemic Health Aspects and Nutritional Considerations for Edentulous Patients

Leslie P. Laing, Sreenivas Koka

Denture wearers' supporting tissues may be particularly vulnerable to specific oral-systemic conditions and compromised nutritional health. Because most oral-systemic conditions in edentulous patients are difficult and challenging to manage by health specialists, they may require alternative management strategies such as consideration for implant-supported prostheses. In addition, a professional dietitian's help and dietary guidance should be an integral part of the optimal overall prosthodontic management.

The interplay between the mouth and the body is intricate and of great importance when considering the health and treatment of edentulous patients. A number of systemic conditions affect the oral cavity and specifically influence the prognosis for wearing complete dentures or for accepting osseointegrated prostheses. Furthermore, the role of replacing missing teeth in improving the nutritional status of edentulous patients also deserves consideration.

Systemic conditions affecting the denture-bearing tissues are listed in Box 2-1.

MUCOSAL CONDITIONS

VESICULOEROSIVE

A number of vesiculoerosive conditions (VEC) may significantly limit the ability of oral mucosal tissues to withstand the mechanical pressures that result from wearing complete dentures.[1,2] The most common VECs that can have this impact are oral lichen planus (OLP), mucous membrane pemphigoid (MMP), and erythema multiforme (EM). These conditions are often associated with periods of quiescence and exacerbation with the latter routinely characterized by pain. Briefly, all three disorders are inflammatory in nature and the role of autoimmunity in their development is likely critical for OLP and MMP. In the case of EM, a viral or bacterial etiology is often presented. Therefore treatment of these conditions with steroids or retinoids is common although benefits are unpredictable. The episodic nature of these conditions (i.e., their time-dependent and fluctuant severity) is also a challenge. Clearly, a patient who suffers from one of these conditions has a poorer prognosis for complete denture therapy. Therefore the use of fixed osseointegrated prostheses is a prudent alternative so as to limit reliance on mucosa for prosthesis support.

SYSTEMIC LUPUS ERYTHEMATOSUS (SLE)

Systemic lupus erythematosus has been reported to favor women over men at a ratio of 10:1 and is believed to be a form of autoimmune type III hypersensitivity reaction consequent to an environmental trigger (e.g., the Epstein-Barr virus).[3] Other systems, such as the skin, hematologic, and musculoskeletal, are often involved and like the VECs described above are characterized by routine periods of remission and exacerbation. Subepithelial inflammation of the oral mucosa accompanies the intraoral erosive lesions with a resultant compromise in tissue tolerance to complete denture loading. Prosthodontic management of patients with SLE follows a similar philosophy as patients with VECs and osseointegrated prostheses also may be indicated. However, any planned surgical interventions must be considered in light of the fact that patients with SLE are sometimes placed on blood-thinning medications because of the increased risk of stroke.

BURNING MOUTH SYNDROME

The diagnosis of burning mouth syndrome (BMS) as a clinical entity is usually based on subjective reports by patients rather than by pathological signs. The majority of patients, the most prevalent of whom are postmenopausal women, describe a painful, burning sensation affecting the oral mucosa. Although the tongue is the most frequently affected site, BMS also may occur in the lips, buccal mucosa, and/or floor of the mouth. The intensity ranges from mild to severe.

Box 2-1 Oral-Systemic Considerations That May Influence an Adaptive Prosthodontic Experience

1. Mucosal conditions
   a. Vesiculoerosive
      i. Oral lichen planus
      ii. Erythema multiforme
      iii. Mucous membrane pemphigoid/pemphigus
   b. Systemic lupus erythematosus
   c. Burning mouth syndrome
2. Oral movement disorders
3. Salivary dysfunction
   a. Xerostomia/hyposalivation
   b. Sjögren's syndrome
4. Diabetes
5. Nutrition



Figure 2-1 Geographic tongue. Irregularly bordered areas of dekeratinized and desquamated filiform papillae appear as erythematous patches on the dorsum of the tongue bordered by elevated grayish white areas of acantholysis and hyperkeratosis.

While BMS may be associated with Sjögren's syndrome or postradiation treatment in the head and neck region, it is more frequently associated with antipsychotic medications and/or other systemic diseases and drugs affecting salivary flow.

The etiological factors associated with BMS may be local (candidiasis, geographic tongue [Fig. 2-1], reactions to dental materials), systemic (nutritional deficiencies [e.g., vitamin B_{12}, iron], hormonal disturbances, anemia, diabetes), psychogenic (anxiety, depression), or due to neurogenic factors (alterations in peripheral nerves, dopamine levels). Mouth burning arising from systemic diseases or local factors is distinguishable from BMS, which is frequently associated with emotional disorders. The salivary alterations noted in patients with BMS include xerostomia, increased saliva viscosity, and altered taste (Box 2-2). The management of BMS is usually palliative and not curative. Although multiple combinations of medications may be available, patient education and encouragement may be the best approaches to improve the patient's quality of life.

Box 2-2 Documented Possible Causes of Burning Mouth Syndrome

Local Factors
Mechanical irritation
Allergy
Infection
Oral habits and parafunctions
Myofascial pain

Systemic Factors
Vitamin deficiency
Iron deficiency anemia
Xerostomia
Menopause
Diabetes
Parkinson's disease
Medication

Psychogenic Factors
Depression
Anxiety
Psychosocial stressors

ORAL MOVEMENT DISORDERS

The knowledge gap in the management of oral movement disorders is a particularly challenging problem for the health professions. Clinical presentation as excess or diminished movement may be hyperkinetic (bruxism, dystonia, dyskinesias) or hypokinetic (Parkinson's disease), respectively, with the reduced ability of patients to control muscular movement of the jaws thereby seriously impacting the prognosis for complete denture therapy. Numerous complications such as pain, compromised function, and depression may be encountered, and early recognition and appropriate medical referral are essential whenever uncontrolled jaw movement is encountered. Furthermore, patients with oral dyskinesias may be suffering from systemic dyskinesias (e.g., Parkinson's disease, Tourette's

syndrome, or Huntington's disease) and their ability to handle their prostheses with necessary dexterity and control may be very limited.[4] Therefore the use of removable prostheses in patients suffering from dyskinesias should only be considered after careful review of the patient's limitations and capabilities.[5]

SALIVARY DYSFUNCTION

Saliva plays a significant role in the preservation and maintenance of oral health and function. It aids digestion by preparing food for mastication and swallowing and contributes to taste perception[6] and the facilitation of communication while providing protection of the oral tissues from desiccation, microbial penetration, or ulceration. By reducing clotting time and accelerating wound contraction,[7] saliva can stimulate soft tissue repair. In addition, the lubricating ability of saliva provides comfort while wearing dentures.

SJÖGREN'S SYNDROME

The most common disorder associated with xerostomia is Sjögren's syndrome (SS). This chronic inflammatory autoimmune disorder can appear at any age, but the peak incidence occurs between 40 and 50 years of age. Approximately 3% of the American population is estimated to suffer from SS, 90% of whom are women. A diagnosis of SS is based on a subjective feeling of dry mouth and dry eyes (xerostomia and xerophthalmia, respectively), objective oral and ocular signs of dryness, definite lymphocytic infiltration within minor salivary glands of the lip, and the presence of auto-antibodies to Ro/SSA and La/SSB. Although the manifestations vary according to the individual, symptoms may include persistent or intermittent enlargement of the salivary glands; dry, gritty, sore, or burning eyes that may be sensitive to the sun and/or tear excessively; recurrent eye and mouth infections; difficulty speaking, chewing, or swallowing; frequently using liquids to help swallow dry foods; increased dental decay (Fig. 2-2, *A* and *B*); altered sense of



Figure 2-2 Devastating effects of hyposalivation in four patients with Sjögren's syndrome. Note the extensive decay **(A)** and the typical pattern that develops at the gingival margins (**A** and **B**). Heavily restored dentitions (**C** and **D**) illustrate previous "Band-Aid" approaches to addressing the decay. Also note the dried, cracked tongue in both patients.

taste/smell; fatigue; sore weak muscles; joint pain; dry nasal passages and throat; headaches; digestive problems; dry skin and rashes; dry cough; sore or cracked tongue (Fig. 2-2, *C* and *D*) or lips; constipation; and vaginal dryness. Diagnosis of xerostomia may be based on the patient's history, especially complaints of dry mouth, particularly at night. Upon oral examination, a tongue depressor may stick to the buccal mucosa. Since it takes anywhere from 5 to 9 years for SS to be diagnosed definitively, we in the dental community must be alert to patients with reduced salivary flow and suggest appropriate medical consultations.

HYPERSALIVATION/HYPOSALIVATION

Hypersalivation is associated with Parkinson's disease, Down's syndrome, autism, cerebral palsy, and amyotrophic lateral sclerosis. An increase in salivary flow rate is also a common phenomenon associated with the insertion of dentures.[8-11] This is true regardless of whether the dentures are for the partially or completely edentulous patient, or whether it is an initial insertion, or insertion of a replacement set of removable dentures.[12,13] It is speculated that the dentures act as foreign bodies in the mouth and consequently as sialogogues, thereby stimulating salivary flow.

Yet dry mouth is a frequent complaint of the elderly, primarily caused by dehydration, therapeutic medication (especially parasympathetic drugs), head and neck radiotherapy, autoimmune disorders such as SS, rheumatoid arthritis, diabetes, or even an age-related decline in salivary gland function.[6,14-20] Hyposalivation may leave patients susceptible to dry or cracked lips, angular cheilitis, dry tongue, oral candidiasis, difficulty swallowing, and difficulty wearing removable dental prostheses. Dry mouth has been reported to be associated with dissatisfaction with chewing and speaking, as well as soreness in denture-bearing areas in complete denture wearers.[6] Clearly, dry tissues are not well-prepared to support removable dentures. On a cautionary note, although there are only a limited number of short-term case studies in the literature involving the outcome of implant-supported prostheses in patients with dry mouth, the use of osseointegrated prostheses should be considered in such instances even though some of the other difficulties that ensue from hyposalivation, such as difficulty chewing, swallowing, and speaking, are still very possible. However, it may be such that the xerostomic patient may be noticing the discomfort associated with a lack of unstimulated saliva that coats the oral tissues and provides lubrication and relief from desiccation rather than a decreased stimulated salivary flow rate and that the decline in salivary gland function may be associated with reduced masticatory function.[13] By providing an optimal occlusal force through prosthetic treatment with more functional complete dentures, a synergistic effect of stimulation for salivary glands on bolus formation in addition to lubrication and protection of the oral mucosa may be generated. In such a manner, proper prosthetic rehabilitation may contribute to the treatment of hyposalivation.

DIABETES

The microvascular complications of diabetes have wide-ranging systemic and oral effects. Systemic consequences include coronary artery disease, cerebrovascular disease, and peripheral vascular disease that predisposes to retinopathy, neuropathy, and nephropathy. Oral consequences of microvascular compromise include hyposalivation, mucositis, OLP, and candidiasis. In addition, diabetic patients are at increased risk of infection and also have poorer healing potential, again a consequence of microvascular compromise. However, it should be noted that many asymptomatic and satisfied denture wearers are controlled or nonbrittle diabetics and that diabetes per se is not a contraindication for complete denture therapy. Following on, there is conflicting evidence whether diabetes is a contraindication for dental implant therapy. Current best evidence indicates that poorly controlled diabetes may increase the risk for dental implant failure, whereas implants placed in patients whose diabetes is well-controlled have similar survival profiles as implants placed in healthy nondiabetics.

NUTRITION AND THE IMPACT OF DENTAL STATUS ON FOOD INTAKE

The food choices of older adults are closely linked to their dental status and masticatory efficiency. Although an intact dentition is not a necessity for maintaining nutritional health, the loss of teeth often leads adults to select diets that are lower in nutrient density. Investigators in the United States and Sweden have reported that adults with compromised dentitions are overrepresented in groups with nutritionally poor diets. Furthermore, denture wearers invariably report that food such as raw carrots, lettuce, corn on the cob, raw apples with peels, steaks, and chops are difficult to chew.

Viewed solely in the context of nutrition, restoration of missing or depleted masticatory function has limited importance. A review of the scientific literature indicates that diminished chewing function does not lead to a loss of nutritional status that has significant physiologic consequences.[21,22] This is especially noteworthy in spite of the fact that complete denture wearers have more difficulty eating harder foods[23,24] and are typically able to generate only approximately 20% of the bite force generated by dentate individuals.[25,26] Consequently, admonishing edentulous patients to receive treatment in order to improve their nutritional state is unjustifiable. Indeed, the fact that loss of chewing ability in complete denture wearers does not have nutritional consequences underscores the multifactorial etiology of poor nutrition with patient age, socioeconomic status, general health, and education level influencing nutritional status greatly.

However, with regard to quality of life, there is strong evidence that improving the ability of edentulous patients to chew does matter a great deal and that the contribution of chewing ability to a patient's perception of overall quality of life is pertinent to the patient-centered clinician.[27,28] Even though denture wearers are not able to perceive food taste, temperature, texture, and consistency as well as non-denture wearers, the many interactions with family and friends that involve enjoyment of meals together increase the importance of chewing confidence and how patients perceive their quality of life.

It also should be noted that replacing a complete denture with a prosthesis supported by osseointegrated implants results in significant improvement in masticatory function. Increased intake of fresh fruits and crisp bread was reported by a small group of Swedish adults who received tissue-integrated prostheses in the lower jaw. Others who previously wore dentures reported that their chewing ability was markedly improved after insertion of a mandibular fixed prosthesis on osseointegrated dental implants. However, it has to be reiterated that improved oral function does not automatically lead to selection of a higher quality diet. Some individuals will eat a more varied diet and increase their intake of fruits and vegetables, but nutrient intake of patients with dental implants is generally similar to complete denture subjects. To improve diet quality, individual patients undergoing prosthodontic care also require dietary counseling.

DIETARY COUNSELING OF PATIENTS UNDERGOING PROSTHODONTIC TREATMENT

The quality of a denture-wearing patient's diet can be improved with nutrition counseling. One expectation of patients seeking new dentures is that they will be able to eat a greater variety of foods, and such patients often are receptive to suggestions aimed at improving their diet composition. Consequently, the long-term relationship dentists establish with their patients can create an ideal situation for the identification of older patients at nutritional risk, increasing nutrition awareness, and referral to a physician or dietitian. However, a single structured nutritional interview is not likely to result in much change in choice of foods.

It often is difficult, based on a visual inspection or an interview, to identify patients in need of nutritional care because most patients are inclined to tell the dentist that they eat a healthy diet. Patients receiving dentures also should be carefully screened for nutritional risk factors at the first appointment so that suitable counseling and follow-up can occur during the course of treatment (Box 2-3). The dentist and dental hygienist who have backgrounds in basic nutrition can often provide nutrition care, although clinical signs of frank malnutrition are not seen very often in industrialized nations. However, certain denture-wearing patients are known to be at greater risk for malnourishment (Box 2-4). Dietary evaluation and counseling should be included in treatment if patients have any of the following physical or social conditions: older than 75 years of age, low income, little social contact, involuntary weight loss, daily use of multiple drugs, or assistance required with daily self-care.

The main objective of diet counseling for patients undergoing prosthodontic care is to correct imbalances in nutrient intake that interfere with body and oral health. The dentist is not expected to diagnose specific nutrient deficiencies, but to determine the general adequacy of the diet. If the patient reports involuntary weight loss or gain greater than 10 lb during the past 6 months, untreated hypertension, a diabetic state, or demonstrated oral tissue changes suggestive of malnutrition, referral to a physician

Box 2-3 Nutrition Guidelines for Patients Undergoing Removable Prosthodontic Treatment

- Eat a variety of foods.
- Build diet around complex carbohydrates (fruits, vegetables, whole grain breads, and enriched cereals).
- Eat at least five servings of fruits and vegetables daily.
- Select fish, poultry, lean meat, eggs, or dried peas and beans every day.
- Consume four servings of calcium-rich foods daily.
- Limit intake of bakery products high in fat and simple sugars.
- Limit intake of prepared and processed foods high in sodium and fat.
- Drink several glasses of water, juice, or milk daily.

Box 2-4 Risk Factors for Malnutrition in Patients with Dentures

- Eating less than two meals per day
- Difficulty chewing and swallowing
- Unplanned weight gain or loss of more than 10 lb in the last 6 months
- Undergoing chemotherapy or radiation therapy
- Alcohol or drug abuse
- Unable to shop for, cook for, or feed oneself
- Specific prosthodontically related determinants:
  - Oral lesions (glossitis, cheilosis, or lingual discomfort)
  - Loose denture or sore spots under denture
  - Severely resorbed mandible with consequent inability to wear lower denture

should be made. Patients who express concern about obesity or low body weight or who report poor adherence to a diabetic, reduced sodium, or low cholesterol diet can be referred to a consulting dietitian.

Providing nutrition care for the denture-wearing patient entails the following steps and can be readily carried out by dentists should they feel that this is a responsibility they would want to undertake.

1. Obtain a nutrition history and an accurate record of food intake over a 3- to 5-day period or complete a food frequency form.
2. Evaluate the diet and assess nutritional risk.
3. Teach about the components of a diet that will support the oral mucosa, bone health, and total body health.
4. Help the patient establish goals to improve the diet.
5. Follow up to support the patient in efforts to change food behaviors.

Dietary questions can be incorporated into the medical history form or presented in one of the readily available nutrition questionnaires administered at the first appointment. However, seeking help from a qualified dietitian is arguably the better way to optimize this objective.

Nutrition goals for the denture-wearing patient are to eat a variety of foods, including protein sources, dairy foods, fruits, vegetables, grains, and cereals, and to limit salt, fat, and sugar intake. Lack of diet diversity, that is, omitting one or more food groups from the daily diet, has been associated with greater risk of death over time. Using the USDA's MyPyramid or recently released (June 2011) MyPlate (Fig. 2-3) as a visual tool, the dentist can suggest desirable, nutrient-dense foods to improve the diet, but patients must establish their own dietary goals.

For socially isolated or disabled older adults, there are community-based nutrition programs including food stamps, home-delivered meals, and communal meal programs served in local senior centers, churches, or community centers. Nutrition education, as well as food, is provided. These nutrition services can have a significant impact on nutrient intake and nutritional status of participating older adults. Dental providers can refer patients to these programs.

The quality of a denture-wearing patient's diet can be influenced positively by nutrition counseling. Since many patients are hoping to chew better, they may be well engaged in conversations regarding their dietary habits, and these conversations that extend out over time into the maintenance phase of therapy have a better chance of long-term impact because of the reinforcement of valuable principles. If desirable, clinicians may choose to incorporate diet questions into their standard medical history questionnaire, which also would provide for the opportunity for annual evaluation as medical histories are updated. In some instances, using a diet history in which a patient records all dietary intake over a period of days can provide valuable opportunity for discussion and may highlight key areas for

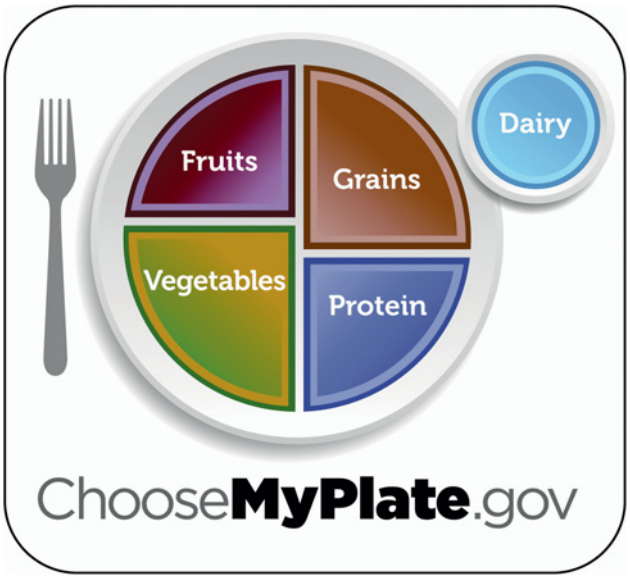


Figure 2-3 USDA's food guidance icon: MyPlate. *(From the U.S. Department of Agriculture.)*

diet changes to improve a patient's nutrition. For patients who are crippled by poor chewing function and who are at risk of compromised nutrition, commercially available liquid supplements exist that provide for adequate intake of proteins, carbohydrates, vitamins, minerals, and calories. For lactose-intolerant patients, soy milk–based products are available. However, it is advisable for these patients to consult with their physician regarding their overall nutritional condition in order to obtain a full evaluation. It is conceivable that other liquid products like milkshakes or instant breakfast drinks can provide the nutritional elements missing without the extra cost involved in purchasing liquid dietary supplements.

SUMMARY

Denture wearers may be particularly vulnerable to both oral-systemic conditions and compromised nutritional health. The latter can be addressed relatively readily with a professional dietitian's help and dietary guidance should be an integral part of the overall management of the denture-wearing patient. On the other hand, most oral-systemic conditions are very difficult and challenging to manage and may require alternative treatment interventions such as osseointegrated implant prostheses.

References

1. Scully C, Carrozzo M: Oral mucosal disease: lichen planus, *Br J Oral Maxillofac Surg* 46(1):15-21, 2008.
2. Sciubba JJ: Autoimmune oral mucosal diseases: clinical, etiologic, diagnostic, and treatment considerations, *Dent Clin North Am* 55(1):89-103, 2011.

3. Brennan MT, Valerin MA, Napeñas JJ, et al: Oral manifestations of patients with lupus erythematosus [review], *Dent Clin North Am* 49(1):127-141, 2005.
4. Lobbezoo F, Naeije M: Dental implications of some common movement disorders: a concise review, *Arch Oral Biol* 52(4):395-8, 2007. Epub Nov 27, 2006.
5. Blanchet PJ, Rompré PH, Lavigne GJ, et al: Oral dyskinesia: a clinical overview, *Int J Prosthodont* 18(1):10-19, 2005.
6. Ikebe K, Morii K, Kashiwagi J, et al: Impact of dry mouth on oral symptoms and function in removable denture wearers in Japan, *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 99:704-710, 2005.
7. Dawes C: Physiological factors affecting salivary flow rate, oral sugar clearance, and the sensation of dry mouth in man, *J Dent Res* 66:648-653, 1987.
8. Arslan A, Orhan K, Canpolat C, et al: Impact of xerostomia on oral complaints in a group of elderly Turkish removable denture wearers, *Arch Gerontol Geriatr* 49:263-267, 2009.
9. Gabay EL: Flow rate, sodium and potassium concentration in mixed saliva of complete denture-wearers, *J Oral Rehabil* 7:435-443, 1980.
10. Jensen JC, Brodin P, Orstavik J: Parotid salivary flow rates in two patients during immediate denture treatment, *J Oral Rehabil* 18:155-162, 1991.
11. Yurdukoru B, Terzioglu H, Yilmaz T: Assessment of whole saliva flow rate in denture wearing patients, *J Oral Rehabil* 28:109-112, 2001.
12. Wolff A, Ofer S, Raviv M, et al: The flow rate of whole and submandibular/sublingual gland saliva in patients receiving replacement complete dentures, *J Oral Rehabil* 31:340-343, 2004.
13. Matsuda K, Ikebe K, Ogawa T, et al: Increase of salivary flow rate along with improved occlusal force after the replacement of complete dentures, *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 108:211-215, 2009.
14. Narhi TO: Prevalence of subjective feelings of dry mouth in the elderly, *J Dent Res* 73:20-25, 1994.
15. Billings RJ, Proskin HM, Moss ME: Xerostomia and associated factors in a community-dwelling adult population, *Commun Dent Oral Epidemiol* 24:312-316, 1996.
16. Sreebny LM: Saliva in health and disease: an appraisal and update, *Int Dent J* 50:140-161, 2000.
17. Thomson WM, Chalmers JM, Spencer AJ, et al: Medication and dry mouth: findings from a cohort study of older people, *J Public Health Dent* 60:12-20, 2000.
18. Ikebe K, Nokubi T, Sajima H, et al: Perception of dry mouth in a sample of community-dwelling older adults in Japan, *Spec Care Dentist* 21:52-59, 2001.
19. Moore PA, Guggenheimer J, Etzel KR, et al: Type I diabetes mellitus, xerostomia, and salivary flow rates, *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 92:281-291, 2001.
20. Matear DW, Locker D, Stephens M, et al: Associations between xerostomia and health status indicators in the elderly, *J R Soc Health* 126:79-85, 2006.
21. Mobley CC: Nutrition issues for denture patients, *Quintessence Int* 36(8):627-631, 2005.
22. Wöstmann B, Michel K, Brinkert B, et al: Influence of denture improvement on the nutritional status and quality of life of geriatric patients, *J Dent* 36(10):816-821, 2008.
23. Wayler AH, Chauncey HH: Impact of complete dentures and impaired natural dentition on masticatory performance and food choice in healthy aging men, *J Prosthet Dent* 49(3):427-433, 1983.
24. Osterberg T, Tsuga K, Rothenberg E, et al: Masticatory ability in 80-year-old subjects and its relation to intake of energy, nutrients and food items, *Gerodontology* 19(2):95-101, 2002.
25. Helkimo E, Carlsson GE, Helkimo M: Bite force and state of dentition, *Acta Odontol Scand* 35(6):297-303, 1977.
26. Michael CG, Javid NS, Colaizzi FA, et al: Biting strength and chewing forces in complete denture wearers, *J Prosthet Dent* 63(5):549-553, 1990.
27. Kim HY, Jang MS, Chung CP, et al: Chewing function impacts oral health-related quality of life among institutionalized and community-dwelling Korean elders, *Community Dent Oral Epidemiol* 37(5):468-476, 2009.
28. Konishi C, Hakuta C, Ueno M, et al: Factors associated with self-assessed oral health in the Japanese independent elderly, *Gerodontology* 27(1):53-61, 2010.

The Aging Edentulous Patient

CHAPTER 3

Michael I. MacEntee, Mario A. Brondani

THE AGING POPULATION

Some world populations are aging at unprecedented rates (Table 3-1), whereas others, mostly in Sub-Saharan Africa, Southeast Asia, and Central America, are increasing slowly because of short life expectancies that have been devastated by acquired immunodeficiency syndrome (AIDS). The increase is particularly remarkable among the "middle-old" (75 to 84 years) and "old-old" (≥85 years) populations.[1] In Canada, for example, about half (47.8%) of the elderly population (≥ 65years) is older than 75 years[2], and in Japan the population over 75 years will more than double (from 3.7% to 7.5%) between 2000 and 2020.[3] These demographic changes have produced a major shift in health care from cure of acute disorders to management of chronic illness and an almost panic of concern for the likely effects on health care costs. However, as yet, the aging population has had little direct impact on the cost of health care in most industrialized countries, and debate continues on whether or not the impact will be as ominous as some health care economics reports project.[4] Cardiovascular disease, cancer, and cirrhosis of the liver have been particularly hazardous to men during the earlier part of the twentieth century, probably because of environmental pollutants, nicotine, and alcohol abuse. Women, in contrast, use preventive health care services more often than men and have benefited more from improved health care, especially in obstetrics, so that there are nearly twice as many older women than older men globally. Women on average have a longer life expectancy, although we do not understand fully why this is so or whether the difference will remain for much longer.[5]

A small proportion (~6% to 10%) of elders (≥ 65years) in most industrialized countries resides in long-term facilities, and, of course, the proportion increases substantially with advancing age. Nearly everyone by 75 years of age is burdened by at least one chronic disorder that may limit access to dental care and influences dental treatment. Furthermore, most elders feel that they have very little flexibility with their income, and a large proportion, at least in North America, live under considerable financial stress. Although Canada has no clear definition of *low income* or *poverty*, 7% of elders were living on incomes below the poverty line in 2003, whereas almost 20% were living near the line even though the overall poverty rate in Canada has fallen.[6] The poverty line is closely associated with economic vulnerability or marginalization not only in terms of insufficiency of income for clothing, food, and shelter but also in terms of loss of dignity and social inclusion. Consequently, many older people are very concerned by unexpected dental costs, unless they feel that the need for treatment is obvious and reasonable.[7]

DISTRIBUTION AND IMPACT OF EDENTULISM IN OLD AGE

DISTRIBUTION

The prevalence of edentulism can vary greatly worldwide, but it is believed to be in decline in most industrialized countries, but with large regional and age-related variations.[8,9] Men rather than women are more likely in old age to have teeth, probably because many women have had unsightly and aching teeth removed earlier in life. Loss of natural teeth is associated also with less affluent people. For example, about three quarters (74.7%) of the less educated, compared with only one third (37.2 %) of the more highly educated, older adult population were edentate in the United States[10] and Canada,[11] which reflects most likely the scope of health services accessible to individuals. The decrease in total tooth loss in the United States, for example, has dropped by about 10% each decade for the last 30 years or so,[12] yet with the net increase in the numbers of older people everywhere, many of whom are or will be edentate, the management of edentulism will remain a considerable challenge for the foreseeable future.[9,13] Moreover, those with little income or education are more prone to tooth loss because of difficulty accessing the knowledge and treatment needed to prevent caries and periodontal diseases.[14]

IMPACT

Residual alveolar ridges continue to resorb for several decades following extraction of teeth; however, elders rarely seek treatment for denture-related problems, possibly

TABLE 3-1 PERCENTAGE DISTRIBUTION AND PROJECTED INCREASES IN OLDER POPULATIONS BETWEEN THE YEARS 2000 AND 2020

	Percentage of Age Group					
	65+ years			80+ years		
	Distribution			Distribution		
Country	2000	2020	Increase	2000	2020	Increase
Australia	12.1	16.8	39	2.8	3.7	30
Canada	12.8	18.2	43	3.1	4.4	42
France	15.9	20.1	26	3.8	5.5	45
Germany	16.4	21.6	32	3.6	6.3	76
Japan	17.1	26.2	54	3.7	7.5	107
New Zealand	11.6	15.6	34	2.8	3.5	24
United Kingdom	16.0	19.8	24	4.2	5.1	22
United States	12.5	16.6	33	3.3	3.7	14

Adapted from Anderson GF, Hussey PS: Population aging: a comparison among industrialized countries, *Health Affairs* 19:191-203, 2000.

because many of them have been dissatisfied with previous treatment.[7] In general, old people usually adapt poorly to new dentures, which probably explains why they seldom return to have old but familiar prostheses replaced. However, when they do complain, it is usually about difficulty chewing hard foods with uncomfortably loose dentures on flat residual ridges, and this is not an easy complaint to manage.

THE IMPACT OF AGE ON THE EDENTULOUS MOUTH

MUCOSA

Stomatitis and other mild inflammations are the mucosal lesions encountered most frequently in older edentulous mouths, especially of older men who wear dentures, smoke tobacco, and drink alcohol excessively.[15] Oral cancer or precancerous lesions are unusual in Western countries (~2% to 4% of all malignancies), although it is among the most common forms of cancer in Asia. The incidence of oral cancer is higher and the prognosis poorer among African Americans than among the rest of the U.S. population, which probably reflects the influence of low socioeconomic status more than genes or culture.[16] External carcinogens, such as nicotine and alcohol, and viral infections, such as human papillomavirus,[17] might be more damaging to the oral mucosa in old age because of atrophy, increased mitosis with slow turnover of cells, and an increased number of elastic fibers. There is, however, no strong evidence to fully support these associations. Possibly of greater importance to the initiation and progress of oral cancer is the neglect of oral care by elderly denture wearers, especially if they smoke tobacco and drink alcohol to excess.[15]

BONE

Bone mass is at its maximum in midlife with substantially more in men than in women and in some racial groups more than others. However, even within individuals, the quality of bone in all parts of the skeleton, including the jaws, varies greatly and decreases with age.[18] The decrease occurs in old age because osteoblasts are less efficient and estrogen production declines along with an overall reduction of calcium absorption from the intestine.

Turnover and metabolism of bone are influenced by many factors including exercise, genes, hormones, and nutrition, but usually resorption surpasses formation somewhere around midlife in both men and women. The jaws independently of gender also become more porous with time probably because of metabolic rather than functional changes in the bone.

Osteoporosis is a disorder caused by an accelerated loss of trabecular bone. It happens usually, but not exclusively, in women after menopause and is discovered frequently when an older person breaks a vertebra, hip, or forearm. It has primary and secondary forms that are difficult to diagnose. The more prevalent type I (postmenopausal) form affects women for a decade or so after menopause, whereas the type II (senile or idiopathic) form can attack men and women alike at any age for no obvious reason. Actually, the type II form can develop as a consequence of any disease, such as hyperparathyroidism, inducing bone loss. Residual ridge resorption may be a manifestation of primary type I osteoporosis, but there is very little evidence to show that the two conditions are associated. Estrogen replacement therapy, bisphosphonates, or other systemic treatments for osteoporosis do affect the density and content of jawbones as in other skeletal bone, but the extent of the effect varies considerably at different sites, and the preventive attributes of the treatments are unknown.[19]

SALIVA

The role of saliva as a lubricant and as a chemical buffer is central to the comfort and function of the mouth. The electrolytes, glycoproteins, and enzymes of mucous saliva lubricate, cleanse, and protect the mucosa, and they ease the passage of food around the mouth while contributing to the breakdown of carbohydrates and overall sense of taste. Inadequate quality or quantity of saliva is particularly difficult for complete denture wearers because mucous saliva produced by the minor glands of the palate helps retain and lubricate the dentures. We do not know whether or not the quantity or quality of saliva in healthy individuals is disturbed by age, but we do know that that elders take a vast array of potentially xerostomic medications for depression, sleeping disorders, hypertension, allergies, heart problems, and many other troubles of old age. Indeed, stress, depression, tobacco use, and abuse of alcohol alone can disturb salivary flow, whereas hyposalivation of the minor salivary glands of the palate, which disturbs denture retention, is a common side effect of digitalis preparations, tranquillizers, and polycyclic antidepressants. Pharmacological side effects, especially on submandibular glands, are complicated further by the biochemical interactions of multiple medications.[20] Sjögren's syndrome and radiation treatment also cause dry mouth. Food may have a metallic or salty taste, and an unpleasant sensitivity to bitter and sour foods increases when salivary flow is poor, whereas reduced sensitivity to sweet tastes can generate an unhealthy craving for sugar. A change in the quality of saliva might not be obvious clinically, but it should be suspected as a cause of denture intolerance when a patient is taking multiple medications. Management of hyposalivation is difficult, but recent evidence indicates that secretion of mucous saliva from the palate improves measurably after drinking 2 liters of water, when chewing, or when taking estrogen or pilocarpine.[21]

JAW MOVEMENTS IN OLD AGE

Although age *per se* has little effect on the ability to chew, people usually chew more slowly, and with less vertical movement of the mandible as they age.[22,23] Movements of the mandible are governed by a generator in the brain stem influenced by proprioceptors in muscles, joints, and mucosa. Advancing age may delay the central processing of nerve impulses, impede the activity of striated muscle fibers, and inhibit decisions. It can reduce also the number of functional motor units and fast muscle fibers, and decrease the cross-sectional area of the masseter and medial pterygoid muscles.[24] Consequently older people tend to have poor motor coordination and weak muscles. Muscle tone can decrease by as much as 50% between middle and old age, which probably explains the shorter chewing strokes and prolonged chewing time. Elders also have a less coordinated chewing stroke close to maximum intercuspation, probably because of a general deficit in the central nervous system, and some individuals who assume the characteristic stoop of old age experience pain on swallowing because of osteophytes and spurs growing on the upper spine adjacent to the pharynx. A noticeable change in swallowing is not a part of normal aging, and suggests strongly that there might be an underlying pathosis, such as Parkinson's disease or palsy.[23]

TASTE AND SMELL

Sensations of taste and smell are frequently confused because the sensory mechanisms are closely related and dependent. Indeed, the sensation of "tasting" rarely occurs in isolation, but results from an interaction of proprioception and smell—texture is felt, chemical constituents stimulate taste, and aromatic gases smell. Bitter, sweet, sour, and salty tastes stimulate receptors independently, so one may be damaged without necessarily disturbing the others. Olfactory cells send projections directly to the brain, so they can be traumatized anywhere along the way.

Sensitivity to taste declines with age and especially with Alzheimer's disease.[25] Although the preference for specific flavors also may change over time, complaints of an impairment affecting the sense of taste at any age should be investigated thoroughly because they forebode an upper respiratory infection or a serious neurological disorder. The three cranial nerves (VI, IX, and X) carrying sensations of taste can be disturbed and damaged by tumors and viruses (e.g., Bell's palsy, herpes zoster), and by trauma (e.g., head injury, ear washing). Fortunately, damage in one part of the system can be compensated readily by increased sensitivity elsewhere.[26]

NUTRITION

The elderly population is at particular risk of malnutrition because of a variety of factors that range from socioeconomic stress to an overconsumption of drugs and including to some extent the state of the dentition. National surveys in the United States[27] and in the United Kingdom[28,29] revealed that older people frequently had inadequate calories, fibers, or calcium in their diet and that many of them did not consume adequacies of vitamins (notably A, B, and C) and minerals (Fig. 3-1).

The role of the dentition in mastication and food selection is complicated. Some edentulous people with self-reported faulty dentures restrict themselves to soft foods high in fermentable carbohydrate, whereas others, even with uncomfortable and well-worn dentures, can eat nearly all of the food available to them.[30,31] A population-based study in the United Kingdom found that some edentulous elders, compared with elders with natural teeth, had significantly lower levels of plasma ascorbate and plasma retinol, which could disturb their skin and eyesight.[32]



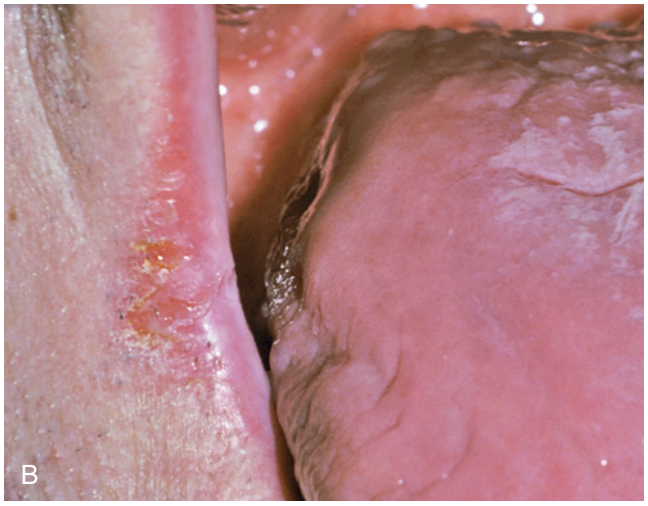




Figure 3-1 Angular cheilitis (**A** and **B**) and stomatitis **(C)** in an elderly man caused by malnutrition and/or liver dysfunction (white blood cell count, 3.19; hemoglobin, 12.4; hematocrit, 36.3; vitamin B_{12}, 203).

AGING SKIN AND TEETH

SKIN

The scars of a lifetime are revealed dramatically on the skin as wrinkles, puffiness, and pigmentations, but the changes are not all manifestations of degeneration. For example, fewer Langerhans cells in older skin can prevent undesirable immunological responses, while mottling of the skin protects against the sun. The leathery look characteristic of the older sun worshipper is caused by epidermal growths with large melanocytes, *solar lentigines*, which thicken in the epidermis. Gradually the dermis thins, enzymes dissolve collagen and elastin, and wrinkles appear when layers of fat are lost.



Figure 3-2 An older face demonstrating the typical droop of the upper lip that accentuates the mandibular incisors.

Age reduces the concavity and "pout" of the upper lip, and it flattens the philtrum. The nasolabial grooves deepen, which produces a sagging look to the middle third of the face, whereas atrophy of the subcutaneous and buccal pads of fat hollows the cheeks. Subsequently, as the loss of fat continues, support for the presymphysial pad of fat disappears and the upper lip droops (cheiloptosis) over the maxillary teeth (Fig. 3-2). Of course, these changes are accentuated even more dramatically when teeth are missing or when there is a loss of occlusal vertical dimension (Fig. 3-3).

TEETH

The color of healthy natural teeth ranges in hue from yellow to orange, with large variation in chroma and value.[33] The chroma, and occasionally the hue, changes with abrasion of enamel, which exposes the dentine to extrinsic stains. Various medications, particularly those containing heavy metals, also can deepen the chroma. Ultimately, natural teeth take on the jagged brownish appearance of an aging dentition when the incisal edges break and the exposed dentine gathers extrinsic stains. It is not always easy to reproduce this rugged appearance in artificial teeth. In fact, some patients in conflict with the esthetic sense of their dentist prefer to have complete dentures with teeth that are smaller, straighter, and whiter than natural teeth.



Figure 3-3 The influence of the vertical dimension of occlusion on the appearance of the face without teeth or dentures **(A),** with "old" dentures **(B),** and with "new" dentures **(C).**

CONCERNS FOR PERSONAL APPEARANCE IN OLD AGE

Old people worry about their self-image as much as, if not more than, at any other stage of life.[34] They may be ambivalent about growing old, but typically they attempt to strike a psychosocial balance between the good and the bad effects because aging has implications for corporeal existence. Unfortunately, the respect afforded occasionally to older people can be diminished by feelings of social rejection and physical collapse compounded by the stigma of aging and dentures.[35,36]

The profits of the cosmetic industry, including plastic surgery and esthetic dentistry, along with the keep-fit industry, attest to a widespread concern that wrinkles, shifting body fat, and other "disfigurements" may inhibit or damage personal relationships. Concealment of age has become a preoccupation of the Western world, a fixation that seems to disturb women more directly than men. The aging woman is considered unattractive and judged, even by other women, more harshly than the aging man, whereas women in general seem less repelled by the graying or "mature look" of the older man.

Society frowns on anyone, young or old, but especially on elderly men, who use cosmetics or other concealments

of age. Apparently, we admire those who do not have to cover up their defects. Consequently, men are more furtive than women about seeking improvements to their appearance. Furthermore, age concealment is acceptable for oneself but not for others, a clear indication that there are double standards operating on the public image.

An attractive appearance is considered important to self-satisfaction. Healthy elders frequently admit that they try hard to feel and look young. A healthy person will accept the natural consequences of aging without undue disturbance, although psychosocial pressures can cause an unhealthy obsession with appearance, even to the point of anorexia surfacing in old age.[37,38] Unusual requests for alterations to appearance should be managed with caution and related directly to the psychosocial status of the patient. Indeed, expectations that seem to be in any way unrealistic, particularly if the patient is depressed or deluded, should be offered a very guarded prognosis. Actually, a marked discrepancy between the assessment of the clinician and the patient offers a valuable diagnostic clue to a problem, assuming of course that the clinician has a rational rather than a distorted view of aging!

SUMMARY

The need for complete dentures in the Western world will continue for the foreseeable future despite the successes of preventive dentistry and the apparent affluence of contemporary society. Management of elderly edentulous patients involves a constant sensitivity to the potential impact of a multitude of medical disorders. Few disorders are exclusive to older individuals; nevertheless, the mouth is a fine sensor of systemic stability and occasionally it offers the first physical manifestation of a disease. For example, the edentulous mouth can suffer from a very painful attack of shingles involving sensory nerves of the face, neck, and trunk or display angular cheilitis with a denture-related stomatitis usually without symptoms. Wounds heal more slowly and possibly less effectively in old age because of decreased turnover of cells or poor blood circulation. Consequently, the mucosa and underlying bone supporting complete dentures heals more slowly from the trauma of ill-fitting dentures.

Prosthodontic treatment for older people requires accurate diagnoses of systemic and local problems before attending to the design of dentures. Systemic problems, including psychological distress and physiological disturbances, are complicated very frequently by inappropriate use of prescribed medications. Local inflammation of the alveolar mucosa is caused usually by unhygienic and structurally defective dentures and can be corrected relatively easily by relining and repairing the dentures. Subsequently, mucosal inflammation should resolve following improved hygiene.

New dentures are not accepted easily by older patients, so, whenever possible, modify dentures that are familiar to the patient rather than make new dentures. However, if the denture must be replaced, it is preferable when possible to duplicate the general shape and tooth arrangement of the old prosthesis. Lastly, every denture should have the patient's identity embedded visibly but inconspicuously in the acrylic resin.

Overall, the management of problems encountered in an aging population can seem like a series of objectionable compromises, but adaptation is the hallmark of successful aging, and coping with difficulties is an acceptable part of everyday life. And life at any age does have pleasant surprises and rewards.

References

1. Leahy E, Engelman R, Vogel CG, et al: *The shape of things to come—why age structure matters to a safer, more equitable world*, Washington, 2007, US Population Action International.
2. Statistics Canada: Canadian statistics: population and demographics online: http://www41.statcan.gc.ca/2008/3867/ceb3867_000_e.htm. Accessed August 4, 2010.
3. Anderson GF, Hussey PS: Population aging: a comparison among industrialized countries, *Health Aff* 19:191-203, 2000.
4. Christiansen T, Bech M, Lauridsen J, et al: Demographic changes and aggregate healthcare expenditure in Europe, Enepri Policy Brief No 4, December 2007.
5. Stindl R: Tying it all together: telomeres, sexual size dimorphism and the gender gap in life expectancy, *Med Hypotheses* 62:151-154, 2004.
6. National Advisory Council on Aging: Seniors on the margins: aging in poverty in Canada, 2005. http://dsp-psd.pwgsc.gc.ca/Collection/H88-5-3-2005E.pdf. Accessed August 4, 2010.
7. MacEntee MI, Hill PM, Wong G, et al: Predicting concerns for oral health among institutionalized elders, *J Public Health Dent* 51:82-91, 1991.
8. Mojon P, Thomason JM, Walls AW: The impact of falling rates of edentulism, *Int J Prosthodont* 17:434-440, 2004.
9. Cooper LF: The current and future treatment of edentulism, *J Prosthodont* 18:116-122, 2009.
10. Oral Health US: Section 4: tooth loss, 2002. http://drc.hhs.gov/report/pdfs/section4-toothloss.pdf. Accessed August 4, 2010.
11. Statistics Canada: Canadian health measures survey: a portrait of seniors in Canada, Catalogue No 89-519-XIE. http://www.statcan.gc.ca/pub/89-519-x/89-519-x2006001-eng.pdf, pp. 46-47, 2006.
12. Douglass CW, Shih A, Ostry L: Will there be a need for complete dentures in the United States in 2020? *J Prosthet Dent* 87:5-8, 2002.
13. Thorstensoon H, Johansson B: Why do some people lose teeth across their lifespan whereas others retain a functional dentition into very old age? *Gerodontology*. Published online June 22, 2009.

14. Dharamsi S, MacEntee MI: Dentistry and distributive justice, *Soc Sci Med* 55:323-329, 2002.
15. MacEntee MI, Nolan A, Thomason JM: Oral mucosal and osseous disorders in frail elders, *Gerodontology* 21:78-84, 2004.
16. Skarsgard DP, Groome PA, Mackillop WJ, et al: Cancers of the upper aerodigestive tract in Ontario, Canada, and the United States, *Cancer* 88:1728-1738, 2000.
17. Brondani MA, Cruz-Cabrera MA, Colombe C: Oral sex and oral cancer in the context of human papillomavirus infection: lay public understanding, *Oncol Rev* 4:171-176, 2010.
18. Berger C, Langsetmo L, Joseph L, et al: Canadian Multicentre Osteoporosis Study Research Group: Change in bone mineral density as a function of age in women and men and association with the use of antiresorptive agents, *Can Med Assoc J* 178:1660-1668, 2008.
19. Vondracek SF, Linnebur SA: Diagnosis and management of osteoporosis in the older senior, *Clin Interv Aging* 4:121-136, 2009.
20. Eliasson L, Birkhed D, Osterberg T, et al: Minor salivary gland secretion rates and immunoglobulin A in adults and the elderly, *Eur J Oral Sci* 114(6):494-499, 2006.
21. Shirota Y, Illei GG, Nikolov NP: Biologic treatments for systemic rheumatic diseases, *Oral Dis* 14:206-216, 2008.
22. Karlsson S, Carlsson GE: Characteristics of mandibular masticatory movement in young and elderly dentate subjects, *J Dent Res* 69:473-476, 1990.
23. Kossioni AE, Dontas AS: The stomatognathic system in the elderly. Useful information for the medical practitioner, *Clin Interv Aging* 2: 591-597, 2007.
24. Newton JP, Abel RW, Robertson EM, et al: Changes in human masseter and medial pterygoid muscles with age: a study by computed tomography, *Gerodontics* 3:151-154, 1987.
25. Murphy C: Nutrition and chemosensory perception in the elderly, *Crit Rev Food Sci Nutr* 33:3-15, 1993.
26. Wieloch, T, Nikolich K: Mechanisms of neural plasticity following brain injury, *Curr Opin Neurobiol* 16:258-264, 2006.
27. Hung NC, Willett W, Ascherio A, et al: Tooth loss and dietary intake, *J Am Dent Assoc* 134:1185-1192, 2003.
28. Steele JG, Sheiham A, Marcenes W, et al: *National Diet and Nutrition Survey: people aged 65 years and over. Volume 2: Report of the Oral Health Survey*, London, 1998, TSO.
29. Stanner S, Denny A: Healthy aging: the role of nutrition and lifestyle—a new British Nutrition Foundation Task Force Report, *Nutr Bull* 34:58-63, 2009.
30. Millwood J, Heath MR: Food choice by older people: the use of semi-structured interviews with open and closed questions, *Gerodontology* 17:25-32, 2000.
31. Brondani MA: The voice of the elderly in accepting alternative perspectives on oral health, *Comm Dent Health*. Published online Apr. 16, 2009.
32. Sheiham A, Steele J: Does the condition of the mouth and teeth affect the ability to eat certain foods, nutrient and dietary intake and nutritional status amongst older people? *Public Health Nutr* 4:797-803, 2001.
33. MacEntee MI, Lakowski R: An instrumental colour analysis of vital and extracted human teeth, *J Oral Rehabil* 8:203-208, 1981.
34. Clarke LH, Griffin M: The body natural and the body unnatural: beauty work and aging, *J Aging Stud* 21:87-201, 2007.
35. MacEntee MI, Hole R, Stolar E: The significance of the mouth in old age, *Soc Sci Med* 45:1449-1458, 1997.
36. Phoenix C, Sparkes AC: Athletic bodies and aging in context: the narrative construction of experienced and anticipated selves in time, *J Aging Stud* 22:211-221, 2008.
37. MacIntosh C, Morley JE, Chapman IM: The anorexia of aging, *Nutrition* 16:983-995, 2000.
38. Visvanathan R, Chapman IM: Undernutrition and anorexia in the older person, *Gastroenterol Clin North Am* 38:393-409, 2009.

CHAPTER

4

Sequelae Caused by Wearing Complete Dentures

Leslie P. Laing, George Zarb

CONTROL OF SEQUELAE WITH THE USE OF COMPLETE DENTURES

Complete dentures for edentulous patients can restore function, improve esthetics, and enhance self-esteem. However, the oral cavity, irrespective of the presence or absence of teeth, is not a static biologic entity. Time-dependent changes occur, particularly at the interfaces between prostheses and their supporting and surrounding tissues. Just as regular dental visits are recommended for dentate patients, so they are for edentulous patients, since even the best designed and well-fitting dentures are not meant to last a lifetime. Long-term denture wearing is accompanied by consequences in local morphology, plus functional and esthetic changes. However, there are strategies that can be followed in order to prolong optimal use of dental prostheses and keep the otherwise inevitable consequences of long-term wear to a minimum.

DENTURES IN THEIR ORAL ENVIRONMENT

Placement of a removable prosthesis in the oral cavity leads to time-related direct and indirect changes in the oral environment. Direct mucosal reactions (Box 4-1) often result from mechanical irritation together with an accumulation of microbial plaque on the dentures plus an infrequent toxic or allergic reaction to constituents of the denture material. Moreover, long-term and continuous denture wearing also may have a negative effect on residual ridge form because of progressive alveolar bone resorption. In addition, wearing complete dentures that function poorly and impair masticatory function could be a negative factor with regard to maintenance of adequate muscle function and nutritional status, particularly in older persons.

DIRECT SEQUELAE: CHANGES IN LOCAL MUCOSAL MORPHOLOGY

Surface properties of the prosthetic material may affect plaque formation on prostheses. Surface irregularities or microporosities promote plaque accumulation by enhancing both the surface area exposed to microbial colonization and the attachment of plaque. Furthermore, plaque formation is greatly influenced by environmental conditions such as the design of the prosthesis, health of adjacent mucosa, composition of saliva, salivary secretion rate, oral hygiene, and denture-wearing habits of the patient.

The presence of different types of dental materials in the oral cavity (e.g., a cast metal mandibular partial denture opposing a maxillary complete one) also may give rise to mucosal symptoms. It is often difficult to establish a definite causal relationship because mechanical irritation or infection also may be involved. For instance, local irritation of the mucosa by the dentures may increase mucosal permeability to allergens or microbial antigens. This makes it difficult to distinguish between a simple irritation and an allergic reaction to the prosthetic material, microbial antigens, or agents absorbed to the prosthesis capable of eliciting an allergic response. The matter is further complicated by the fact that certain microorganisms (e.g., yeasts) are able to use methyl methacrylate as a carbon source, thereby causing a chemical degradation of the denture resin.

It is believed that microbial plaque may have an important negative or harmful effect at the interface between prosthesis and the oral mucosa. Adverse changes also result from a prosthesis promoting irritation and infection of the underlying mucosa (Fig. 4-1, *A* and *B*), dental caries, and periodontal disease in overdenture abutments, together with peri-implant gingivitis (Fig. 4-1, *C* and *D*), as well as chemical degradation or corrosion of prosthetic materials (Box 4-2).

Box 4-1 Direct Sequelae Caused by Wearing Removable Prostheses: Complete or Partial Dentures

Mucosal reactions
Oral galvanic currents
Altered taste perception
Burning mouth syndrome
Gagging
Residual ridge reduction
Periodontal disease (abutments)
Caries (abutments)

Box 4-2 Interaction of Prosthetic Materials and the Oral Environment

Surface Properties: Plaque Accumulation
Chemical stability
Adhesiveness
Texture
Microporosities
Hardness

Chemical Properties
Corrosion
Toxic reactions
Allergic reactions

Physical Properties
Mechanical irritation
Plaque accumulation

Changes of Environmental Conditions
Plaque microbiology



Figure 4-1 **A** and **B,** Mild to more severe palatal mucosal irritation and infection suggest stages in the development of a denture sore mouth (DSM). **C,** An implant gingivitis (often erroneously referred to as a so-called peri-implantitis) is present, and this is readily addressed with improved hygiene and soft tissue massage **(D)**.



Figure 4-2 A recently worn mandibular denture has caused a traumatic ulceration associated with a peripheral overextension.



Figure 4-3 Very severe denture irritation hyperplasia in the mandible showing a central groove on the patient's right side in which the denture flange rests (indicated by the *arrow*).

TRAUMATIC ULCERS AND CHEEK BITING

When dental prostheses are first inserted, the supporting mucosa will be compressed. If pressure areas or overextensions of flanges are not identified and relieved, sore spots or traumatic ulcers will result and risk a counter effect on the dentures' occlusal harmony and stability. Traumatic ulcers or sore spots most commonly occur within days after placement of new dentures. They tend to be small, painful lesions covered by a gray necrotic membrane and surrounded by an inflammatory halo with firm, elevated borders (Fig. 4-2). They usually arise as a result of over-extended denture flanges or errors in occlusion. In order to correct the situation, the lesion(s) may be marked intraorally with a Thompson color transfer stick, followed by careful insertion of the denture so as not to smudge the marking or to aggravate the lesion, and then relieving the area on the denture where the color has been transferred. Once corrected, the lesions usually heal within a few days. However, if uncorrected, the patient may actually adapt to the situation, albeit a transient painful one, which may lead to a denture irritation hyperplasia.

Cheek biting may be due to the posterior denture teeth being in violation of the neutral zone concept (e.g., placed too far buccally). This is commonly corrected by selective recontouring of the prosthetic teeth or even having to reset them.

DENTURE IRRITATION HYPERPLASIA

Patients who wear ill-fitting dentures for a prolonged period of time may develop denture irritation hyperplasia, also known as epulis fissuratum. Such a mucosal hyperplasia develops slowly from chronic low-grade trauma, typically induced by unstable dentures or an overextended denture flange. As a consequence of the resorption of the alveolar ridge, the denture moves further into the vestibular mucosa, creating inflammatory, yet usually asymptomatic, fibrous tissue in the form of folds that proliferate over the denture flange. The edge of the denture generally fits into the "fissure" or groove between the mucosal folds (Fig. 4-3). Single or multiple lesions of variable size are usually observed at the facial aspect of the denture and appear primarily in the anterior regions of either the maxilla or mandible[1,2] and may be found more commonly in men.[3] The lesions may be small or may extend the entire length of the vestibule. Curative procedures include adjustment or replacement of the ill-fitting dentures and/or surgical excision of the hyperplastic tissue.

DENTURE STOMATITIS

The extent and severity of a diagnosed stomatitis (Fig. 4-4) are the criteria that determine the classification.[4]

- Type I: a localized simple inflammation or pinpoint hyperemia (see Fig. 4-4, *A*)
- Type II: a more generalized erythematous area involving either a portion of or the entire surface of the denture-covered mucosa (see Fig. 4-4, *B*)
- Type III: a composite of types I and II in addition to a granular, inflammatory hyperplasia usually involving the midline of the hard palate and the alveolar ridges (see Fig. 4-4, *C*)

Various etiological factors of denture stomatitis have been reported. They include tissue trauma associated with occlusal discrepancies, denture defects, lack of oral and denture hygiene, denture age, and continuous denture wearing.[3] Ensuring appropriate stability in the denture's design will provide consistent biting forces that reduce the

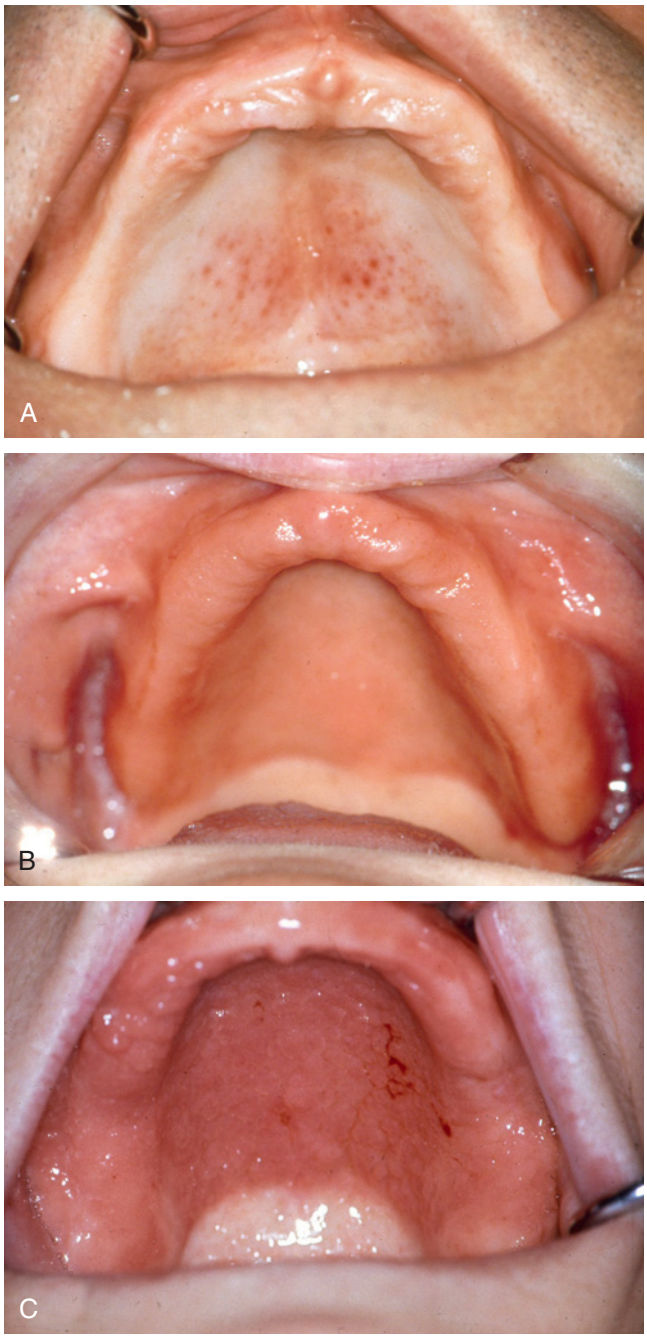


Figure 4-4 Pinpoint hyperemia is a characteristic feature of type I denture stomatitis **(A),** while erythema of the entire mucosa in contact with the denture surface is characteristic of the type II variety **(B).** In type III, additional papillary hyperplasia, which may be nodular or mossy, is present **(C).**

risk of trauma to the underlying mucosa. Although dentures may cause a wide range of lesions of the oral mucosa, the majority of these could be prevented by providing instructions on how to maintain healthy oral tissues, denture hygiene, and with postinsertion follow-up appointments to evaluate the dentures.

Box 4-3 Factors Predisposing to *Candida*-Associated Denture Stomatitis

Systemic Factors
Old age
Diabetes mellitus
Nutritional deficiencies (iron, folate, or vitamin B_{12})
Malignancies (acute leukemia, agranulocytosis)
Immune defects
Corticosteroids, immunosuppressive drugs

Local Factors
Dentures (changes in environmental conditions, trauma, denture usage, denture cleanliness)
Xerostomia (Sjögren's syndrome, irradiation, drug therapy)
High-carbohydrate diet
Broad-spectrum antibiotics
Smoking tobacco

Candida-*Associated Denture Stomatitis* (Fig. 4-5)

Various species of *Candida* have been identified as opportunistic pathogens that reside in the oral cavities of even those individuals considered as healthy.[5] *Candida* biofilms play a role in the development and maintenance of denture stomatitis, regarded as the most prevalent and clinically important lesion of denture wearers[3,6] by virtue of their ability to adhere to acrylic resin.[7] There is a far higher prevalence of denture stomatitis in maxillary rather than mandibular dentures[3,8] with the appearance of the affected soft tissue tending to be erythematous, with areas of mild edema sharply localized to areas where the denture contacts the gum ridge.

The diagnosis of *Candida*-associated denture stomatitis is confirmed by the finding of mycelia or pseudohyphae in a direct smear or the isolation of *Candida* species in high numbers from the lesions (≥50 colonies). Usually, yeast colonies are recovered in higher numbers from the intaglio surface of the denture than from corresponding areas of the palatal mucosa, indicating that the primary source of the infection is the *Candida* adhering to the fitting surface of the denture.

Etiology and Predisposing Factors

The direct predisposing factor for *Candida*-associated denture stomatitis is simply the presence of the dentures, or "acrylic foreign bodies," in the oral cavity (Box 4-3), especially in patients who wear their dentures both day and night. The infection frequently disappears if the dentures are not worn and the supporting tissues are allowed to rest



Figure 4-5 **A,** Severe tissue trauma from an ill-fitting denture has led to both hyperplastic tissue changes and a *Candida* infection. The latter also can be manifested at the corners of the mouth as an angular cheilitis (**B** and **C**) that can be quite painful. Antifungal therapy combined with correct prosthodontic management helps alleviate the problem **(D).** Microbial plaque on the denture's intaglio surface is visualized with the stain erythrosine **(E),** while amicrobial deposits are seen penetrating irregularities in a denture's intaglio surface **(F). G,** A diffuse atrophic glossitis.

and are treated hygienically. Unclean dentures and poor hygiene care are major predisposing factors because healing of the lesions is often seen after meticulous oral and denture hygiene is instituted. However, the tissue surface of the dentures usually shows micropits and microporosities that harbor microorganisms that are difficult to remove mechanically or by chemical cleansing. Several in vitro studies report that the microbial contamination of denture acrylic resin occurs very quickly, and yeasts seem to adhere well to denture base materials.

The colonization of the fitting denture surface by *Candida* species depends on not only the surface properties of the acrylic resin but also adherence of the yeast cells to the acrylic, interactions with oral commensal bacteria, palatal trauma, and redox potential of the site. The pathogenicity of denture plaque can be enhanced by factors stimulating yeast propagation, such as continuous denture wearing, poor oral hygiene, high carbohydrate intake, and reduced salivary flow. Trauma to the palatal epithelial cells reduces the degree of keratinization, thereby reducing the barrier function of the epithelium, and facilitating the initial penetration of fungal and bacterial microorganisms. Additional factors that can modulate the host-parasite relationship and increase the susceptibility to *Candida*-associated denture stomatitis include aging, malnutrition, immunosuppression, radiation therapy, diabetes mellitus, and possibly treatment with antibacterial antibiotics.

Angular cheilitis is often correlated with the presence of *Candida*-associated stomatitis. It is thought that the infection may be initiated between the palatal mucosa and the maxillary denture and from that area spread to the angles of the mouth (see Fig. 4-5). The infection also may result from local or systemic predisposing conditions such as reduced vertical dimension of occlusion, overclosure of the jaws, nutritional deficiencies (such as the B vitamins or zinc), or iron deficiency anemia. Frequently, a secondary infection caused by *Staphylococcus aureus* is present. Although denture stomatitis and angular cheilitis usually do not reflect a serious predisposing disease or abnormality, it should be realized that severe candidal infections may occur in the immunocompromised host. Visible infection by *Candida* species can be an early indicator of immune dysfunction, the discovery of which should prompt a review of the patient's clinical background.

Management and Preventive Measures

Because of the diverse possible origins of denture stomatitis, several treatment procedures could be used, including antifungal therapy, correction of ill-fitting dentures, and efficient plaque control.

The most important therapeutic and preventive measures are the institution of efficient oral and denture hygiene and correction of the denture-wearing habits because the major etiological factor is the presence of the denture(s). The patient should be instructed to remove the dentures after each meal and to wash them gently but vigorously with soap and rinse with water before reinserting them. The mucosa in contact with the denture should be kept clean and massaged with a soft toothbrush. Patients with recurrent infections should be persuaded not to use their dentures at night but rather leave them exposed to air, which seems to be a safe and efficient means of preventing microbial colonization, or in an appropriate antimicrobial cleanser. The dentures often may cause trauma because they are old and ill-fitting or because there are faults in the design. Rough areas on the fitting surface should be smoothed or relined with a soft tissue conditioner. Since microorganisms penetrate the internal surface to a depth of approximately 1 mm, the acrylic surface of the denture should be removed and relined frequently. A new denture should be provided only when the mucosa has healed and the patient is able to achieve good denture hygiene.

Antifungal drugs could be used to inhibit the growth of *Candida albicans* on oral mucosa and the fitting denture surface, but recurrence of the infection has been observed frequently if the hygiene has not improved. Treatment with antifungal agents should be used mainly in those patients:

- Once the clinical diagnosis has been confirmed by a mycological examination
- With associated burning sensations from the oral mucosa
- With infection that has spread to other sites of the oral cavity or the pharynx
- With an increased risk of systemic mycotic infections caused by debilitating diseases, drugs, or radiation therapy

Local therapy with nystatin, amphotericin B, miconazole, or clotrimazole is preferred over systemic therapy with ketoconazole or fluconazole because resistance of *Candida* species to the latter drugs frequently occurs. To prevent the risk of relapse, please note the following:

- Treatment with antifungals should continue for no more than 4 weeks.
- If the antifungals are in the form of lozenges, the dentures should be removed when the lozenges are in the mouth.
- Meticulous oral and denture hygiene is necessary.
- The dentures should be worn as little as possible, keeping them dry or in a disinfectant solution of 0.2% to 2.0% chlorhexidine at night.

In cases of type III denture stomatitis, surgical elimination of deep crypt formations may be necessary for effective mucosal hygiene, which could be achieved cryosurgically.

Again, it must be emphasized that the relationship between host status and the clinical presentation of oral candidiasis is a reflection of the patient's overall health.

Such insight may help in the early diagnosis and treatment of a more serious and underlying disease.

FLABBY RIDGE AND PENDULOUS MAXILLARY TUBEROSITIES (SEE ALSO CHAPTER 5)

Edentulous ridges that are mobile or resilient with little evidence of underlying supportive bone, may give the appearance of being "flabby." Such a situation arises in some complete denture wearers where alveolar bone has been replaced by fibrous tissue. It is particularly evident in the maxillary anterior, especially when only the natural mandibular anterior teeth remain. Similarly, the maxillary tuberosities may become hypertrophied and appear to grow downward. The likely cause in both situations of fibrous tissue where there would otherwise be bone is excessive occlusal loading on the residual maxillary ridge and/or unstable occlusal relationships elsewhere in the mouth. These areas of mobile tissue provide limited support for the complete denture. In extreme cases, where the patient has a complete upper denture and only anterior mandibular teeth remaining, a so-called combination or Kelly's syndrome[9] may be evident. In addition to the bone resorption of the premaxilla and hypertrophy or downgrowth of the maxillary tuberosities, there may be papillary hyperplasia of the hard palate, extrusion of the mandibular anterior teeth in a labio-incisal direction, and posterior bone loss in the mandible under a Kennedy class I removable partial denture (RPD). As a result, there is an accompanying loss of vertical dimension of occlusion (VDO) and dramatically altered facial esthetics, giving rise to a "witch's chin." In such cases, surgical intervention may be required to improve the stability of the complete upper denture and to minimize alveolar ridge resorption.

HYPERKERATOSIS AND ORAL CANCER

Although the majority of oral cancers develop in partially or completely edentulous patients, there is no evidence that oral cancer and chronic denture-related mucosal irritation (i.e., hyperkeratosis) are related. Rather, excessive use of tobacco and/or alcohol, frequent exposure to ultraviolet radiation, age, low socioeconomic status, and poor dental health may be predispositions to oral cancer. Regular recall visits on a semiannual or annual basis are recommended for comprehensive oral examinations. The persistent appearance of an oral lesion even after appropriate denture adjustment has occurred should be strong indication for patient referral to a pathologist for further investigation.

RESIDUAL RIDGE REDUCTION

Longitudinal studies of the bulk and outline of edentulous residual ridges in complete denture wearers demonstrated a continuous loss of bone tissue after tooth extraction and placement of complete dentures. The reduction is a sequel of alveolar remodeling due to altered functional bone stimulus. It follows a chronic progressive and irreversible course that often results in severe impairment of prosthetic restoration and oral function. The process of remodeling is particularly important in areas with thin cortical bone (e.g., the buccal and labial parts of the maxilla and the lingual parts of the mandible). During the first year after tooth extraction, the reduction of the residual ridge height in the midsagittal plane is about 2 to 3 mm for the maxilla, and 4 to 5 mm for the mandible. After healing of the residual ridge, the remodeling process will continue but with decreased intensity. In the mandible, the annual rate of reduction in height is about 0.1 to 0.2 mm and, in general, four times less in the edentulous maxilla. However, intraindividual variations are very common.

The pathogenesis of residual ridge reduction is not well understood (Box 4-4). It is assumed that the degree of residual ridge reduction results from a combination of anatomical, metabolic, and mechanical determinants. For example, severe residual ridge reduction of the mandible has been related to a small gonial angle (i.e., a marked mandibular base bend and a posterior position of the lower incisal edges in relation to the mandibular body). Women appear to be particularly vulnerable to the frequency and extent of residual ridge reduction, and it has been suggested that progressive loss of bone under dentures may be a manifestation of osteoporosis. In fact, there is a strong association between the skeletal bone density and that of the mandible, the mandible also being affected by osteoporosis. Recently, it has been shown that low bone mineral content and osteoporotic changes may predispose to a more rapid residual ridge reduction, particularly in the maxilla.

Box 4-4 Some Proposed Etiological Factors of Reduction of Residual Ridges

Anatomical Factors
- More important in the mandible versus the maxilla
- Short and square face associated with elevated masticatory forces
- Alveoloplasty

Prosthodontic Factors
- Intensive denture wearing
- Unstable occlusal conditions
- Immediate denture treatment

Metabolic and Systemic Factors
- Osteoporosis
- Calcium and vitamin D supplements for possible bone preservation



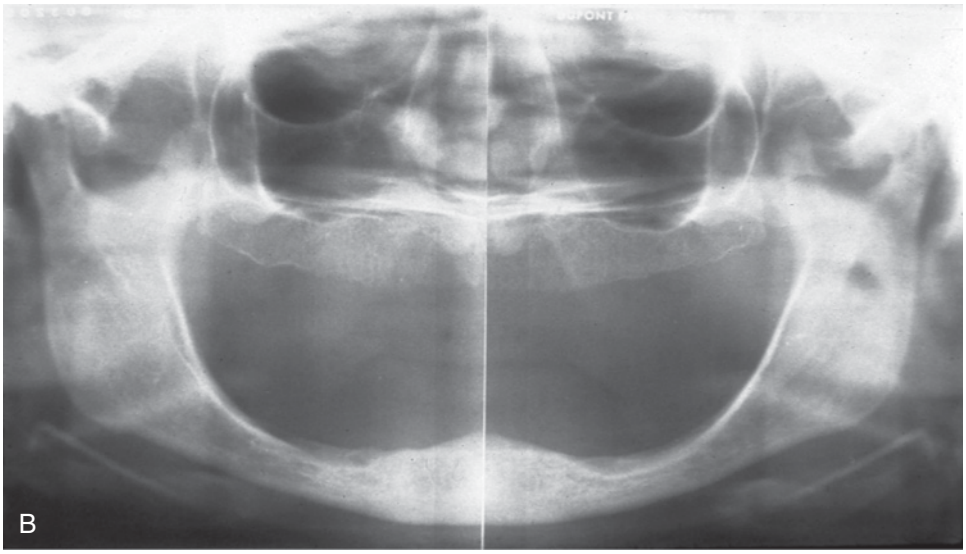


Figure 4-6 Moderate to advanced residual ridge reduction in the mandible frequently leads to palpable and superficial location of the mental foramina. Consequently, painful denture pressure at these sites is frequently encountered.

Time-dependent mechanical factors (i.e., functional and parafunctional occlusal forces) transmitted by the dentures to the residual ridge are presumed to impact the remodeling process. However, there is no scientific evidence that parafunctional forces are related to the degree of residual ridge reduction.

The consequences of residual ridge reduction are an apparent loss of sulcus width and depth, with displacement of the muscle attachment closer to the crest of the residual ridge; loss of VDO; reduction of the lower face height; an anterior rotation of the mandible; and an increase in a relative prognathic appearance. Accompanying changes in alveolar bone such as sharp, spiny, uneven residual ridges and a new location of the mental foramina close to the top of the residual ridge are also frequently encountered (Fig. 4-6). It should be noted that painful ridges are frequently managed with "permanent" soft liners as an alternative to a surgical intervention (for sharp ridges with the risk of causing additional bone reduction), or inconvenient frequent replacements of temporary soft liners. While the so-called permanent liners are discussed in Chapter 7, it is important to keep in mind that the silicone liners appear to be particularly vulnerable to *Candida* growth and progressive material deterioration (Fig. 4-7).

A close correlation between a patient's satisfaction with dentures and the anatomical conditions of the residual ridges is not always present. However, in long-term complete denture wearers, the morphological changes and the reduction of the residual ridges present serious clinical management challenges on how to provide adequate support, stability, and retention of new dentures. In the past, these problems were approached by prescribing preprosthetic surgical initiatives such as vestibuloplasties with skin or mucosal grafts or, in severe situations, by performing ridge augmentation procedures. These techniques have now been virtually eclipsed by the introduction of the osseointegration technique, which is discussed in Part V.



Figure 4-7 *Candida* growth on a permanent silicone liner in a mandibular complete denture leads to a rough, unclean surface that can provoke additional soft tissue irritation. In both **A** and **B,** this generalized material deterioration *(left)* is contrasted to a clean and uncolonized liner *(right)*.

INDIRECT SEQUELAE: CHANGES IN FUNCTIONAL MORPHOLOGY

ATROPHY OF MASTICATORY MUSCLES

It is essential that oral function in complete denture wearers is maintained throughout life. This depends on the skeletal muscular force and the facility with which the patient is able to coordinate oral functional movements during mastication. Maximal bite forces tend to decrease in older patients. Furthermore, computed tomography studies of the masseter and the medial pterygoid muscles have demonstrated a greater atrophy in complete denture wearers, particularly in women. This indicates that reduced bite force and chewing efficiency are sequelae caused by wearing complete dentures, resulting in impaired masticatory function. Indeed, elderly denture wearers often find that their chewing ability is insufficient and that they are obliged to eat soft foods.

Direct measurement of the capacity to reduce test food to small particles has verified that chewing efficiency decreases as the number of natural teeth is reduced and is worse for subjects wearing complete dentures. One of the consequences is that wearers of conventional complete dentures need approximately seven times more chewing strokes than subjects with a natural dentition to achieve an equivalent reduction in particle size. As a consequence, complete denture wearers either prefer food that is easy to chew, or they swallow large food particles.

To some extent, the retention of a small number of teeth used as overdenture abutments seems to play an important role in the maintenance of oral function in elderly denture wearers. Therefore, treatment with overdentures has particular relevance in view of the increasing numbers of older people who are retaining a part of their natural dentition later in life.

In the completely edentulous patients, placement of implants is usually followed by an improvement of the masticatory function and an increase of maximal occlusal forces. This improvement may persist in a long-term perspective, and maximal occlusal forces may even increase with the years of denture wearing.

There is no evidence of similar benefits after a preprosthetic surgical intervention to improve the anatomical conditions for wearing complete dentures.

NUTRITIONAL STATUS AND MASTICATORY FUNCTION

Four widely cited factors are related to dietary status and nutrition of complete denture wearers: oral health and masticatory function, systemic health, socioeconomic status, and dietary habits. In healthy individuals there is no compelling evidence that nutritional intake is impaired by wearing complete dentures or that replacement of ill-fitting dentures with well-fitting new dentures will cause a major improvement of nutrition. In institutionalized patients, some amelioration of the nutritional intake could take place after prosthetic treatment because some patients are then more likely to select a broader range of foods and to select nutritious items such as vegetables and fruits.

It is also reported that the principal causes of malnutrition risk among elderly denture wearers are primarily associated with poor general health characterized by poor absorption; intestinal, metabolic, and catabolic disturbances; or anorexia. Additionally, reduced salivary secretion as a side effect of medications may reduce its rate during mastication, which also may have a negative effect on masticatory ability and efficiency (Box 4-5). The improvement and maintenance of optimal nutritional status often demands modification of dietary habits as emphasized in Chapter 2. Such a necessary re-education and motivation of elderly denture wearers may be challenging and even unrealistic since dietary habits are often firmly fixed and moreover, these patients often have decreased appetites. In addition, inadequate dentures usually prevent patients from achieving improved dietary habits. While the mechanical

Box 4-5 Associations Among Xerostomia, Denture Wearing, Impaired Masticatory Function, and Undernutrition in Frail and Dependent Older Persons

Reduced Stimulated Salivary Flow Rate Associated with:

Complaints of xerostomia
Chewing difficulties
Complaints related to wearing complete dentures
Increased number of chewing cycles before swallowing
Loss of appetite
Reduced serum albumin level
Reduced body mass index
Reduced skinfold thickness

preparation of food before eating can aid mastication and reduce its influence on food selection, it will regrettably not stimulate appetite and increase life quality. While challenging and sometimes not even feasible, the maintenance or reestablishment of oral health and masticatory function remains an integral part of the desired overall medical health care of the elderly patient who is medically compromised.

CONTROL OF SEQUELAE WITH THE USE OF COMPLETE DENTURES

The major time-dependent consequences of wearing complete dentures are pathological changes of the oral mucosa and residual ridge reduction. They often compromise patient comfort, masticatory function, and appearance, and destabilize the occlusion. The patient may eventually no longer tolerate the denture-wearing experience and become prosthetically maladaptive. However, every professional effort possible should be made to preclude or minimize such a predicament. The adverse sequelae described in this chapter can be at least partially managed by the following considerations:

- Restoration of the partially edentulous patient with complete dentures should only be considered if this is the only option as a result of poor periodontal health, unfavorable location of the remaining teeth, and economic limitations. Every effort should be made to retain some teeth in strategically good positions to serve as overdenture abutments. Maintenance of tooth roots in the mandible is particularly important.
- The patient with complete dentures should follow a regular, controlled maintenance schedule at yearly intervals so that an acceptable fit and stable occlusal condition can be maintained.
- Edentulous patients should be informed about the benefits of implant-supported prostheses (see Part V) as early as possible in their long range dental management planning. In younger patients, the primary yield from this approach would be both functional efficiency and a retardation of residual ridge reduction. In elderly patients, the main advantages would be improved comfort and enhanced masticatory function. These well-documented treatment outcomes now offer the edentulous patient an extraordinary opportunity to avoid the inherent shortcomings of complete denture management.

The following precautions also should be taken to preclude or minimize the development of soft tissue morbidity:

- Patients wearing overdentures supported by natural roots or implants should follow a program of recall and maintenance for continuous monitoring of both their prostheses and oral tissues. If patient compliance is difficult to obtain, it may become necessary to recall the patient more frequently, namely every 3 to 4 months.
- The patient should be motivated to practice proper denture-wearing habits, such as not wearing dentures during the night.
- It is essential to remind and explain to our patients that wearing complete dentures is not a "definitive" treatment and that their collaboration is important to prevent the long-term risks associated with wearing complete dentures.

SUMMARY

The realization that edentulous oral tissues change in the context of time, and that the associated wear and tear effects of wearing removable prostheses can exact a biomechanical price must be regarded as an important consideration when managing the long-term health of the edentulous patient. The well-documented time-dependent changes that occur at the interfaces between prostheses and their supporting and surrounding tissues must be examined during patients' regular dental visits. Moreover, applied strategies to minimize the risk of such changes need to be followed in order to prolong optimal use of dental prostheses.

References

1. Ralph JP, Stenhouse D: Denture-induced hyperplasia of the oral soft tissues: vestibular lesions, their characteristics and treatment, *Br Dent J* 132(2):68-70, 1972.

2. Coelho CM, Zucoloto S, Lopes RA: Denture-induced fibrous inflammatory hyperplasia: a retrospective study in a school of dentistry, *Int J Prosthodont* 13(2):148-151, 2000.
3. Jainkittivong A, Aneksuk V, Langlais RP: Oral mucosal lesions in denture wearers, *Gerodontology* 27(1):26-32, 2009.
4. Newton AV: Denture sore mouth: a possible aetiology, *Br Dent J* 112:357-360, 1962.
5. Petersen PE, Yamamoto T: Improving the oral health of older people: the approach of the WHO Global Oral Health Programme, *Community Dent Oral Epidemiol* 33:81-92, 2005.
6. Ramage G, Tomsett K, Wickes BL, et al: Denture stomatitis: a role for *Candida* biofilms, *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 98(1):53-59, 2004.
7. Budtz-Jorgensen E: Ecology of *Candida*-associated denture stomatitis, *Microb Ecol Health Dis* 12:17-185, 2000.
8. Shulman JD, Rivera-Hildago F, Beach MM: Risk factors associated with denture stomatitis in the United States, *J Oral Pathol Med* 34:340-346, 2005.
9. Kelly E: Changes caused by a mandibular removable partial denture opposing a maxillary complete denture, *J Prosthet Dent* 27(2):140-150, 1972.

Bibliography

MacEntee MI, Glick N, Stolar E: Age, gender, dentures and oral mucosal disorders, *Oral Dis* 4: 32-36, 1998.
Petersen PE, Yamamoto T: Improving the oral health of older people: the approach of the WHO Global Oral Health Programme, *Community Dent Oral Epidemiol* 33:81-92, 2005.

Treatment Options

PART II

CHAPTER 5

History Taking, Treatment Planning, and Improving Denture-Bearing Areas for Edentulous Patients

George Zarb, John A. Hobkirk

ON HISTORY TAKING AND TREATMENT PLANNING FOR EDENTULOUS PATIENTS

A decision to supply a set of complete dentures to an edentulous patient does not require very sophisticated thinking. Left at that level, the results might be equally unsophisticated. Truly professional care requires the dentist to consider all information gathered and appropriately address it in the treatment plan. All patients seeking dental services do so with some degree of understanding and experience. The extent of their experience and the validity of their understanding vary greatly. This diversity must be recognized by the dentist and addressed in the treatment plan and its presentation. The information that should be gathered on an individual patient and the accompanying examination protocol are discussed at length in this chapter.

THE FIRST VISIT

The patient's first visit is a crucial one when providing treatment with complete dentures because it is the occasion when the seeds of success or failure are sown. Both patient and dentist approach the visit with preconceived expectations as to the procedures to be employed and their anticipated outcomes. Unless a treatment plan is based on realism rather than hope, disappointment and frustration frequently ensue. There must be mutual trust and understanding of the problems to be addressed, the procedures to be followed, and their likely outcomes. Explanations given to the patient at this stage form part of the implicit agreement between patient and dentist; later they can have the hollow ring of excuses.

PATIENT ATTITUDE

Key issues relating to patients are their attitude to the edentulous state and the aging process with which it is usually associated, their expectations as to treatment outcomes, and their understanding of the procedures involved. Their attitude to the use of complete dentures and their ability to control their prostheses are also crucial. The aspirations that patients may harbor as to the beneficial effects of new complete dentures can relate to many aspects of their lives and have been described elsewhere. The older patient also may be facing health-related challenges of which the dentist must be aware if he or she is to provide optimal support to the patient. The dentist frequently places undue emphasis on the value of technical expertise, and although a technically inferior prosthesis is very unlikely to provide optimal

performance, the opposite is not necessarily the case. Failure of the dentist to appreciate the patient's often unstated expectations from the outset will inevitably result in disappointment because these are most unlikely to be met in such circumstances. These aspirations must be explored, and if unrealistic, then the patient needs to fully appreciate this before treatment commences.

GENERAL HEALTH AND DENTAL HISTORY

Successful treatment also requires an understanding of the patient's general health and their dental history, as well as a thorough appreciation of the status of the oral and perioral tissues and any existing prostheses, be they successful or unsatisfactory.

It is easy to perceive the edentulous mouth as a featureless desert devoid of information and providing solely a prescription for new complete dentures and an indication for the prompt recording of primary impressions. This is far from the truth: time spent at this stage gathering information and developing mutual understanding is never time wasted.

Any patient's decision to seek prosthodontic care may be influenced by past dental treatment experiences, as well as current systemic and oral health concerns. The collection of medical and dental histories and their careful analysis, coupled with a thorough orofacial examination, are an essential and integral part of prosthodontic management and cannot be overemphasized. They are necessary to ensure the selection of an optimal treatment protocol with an associated favorable clinical outcome. A *health questionnaire* is a convenient method of collecting basic information and personal data. This can be sent to the patient before the appointment or administered in the reception area if facilities permit its confidential completion. The dentist can then review and clarify the information as necessary in the private operatory as part of the clinical examination. This area should be comfortably equipped, tastefully decorated, and well lit. It should be free of distractions and provide patients with the sense of security and privacy that will allow them to communicate honestly and completely. Data gathering starts as the patient enters the dentist's office and the appointment is best structured in a logical sequence of information collection, interpretation, and the joint development of a treatment plan. Nevertheless, the experienced clinician will be awake to nonsequential clues as to the patient's history and concerns. He or she also will be thinking ahead with particular reference to how a proposed clinical intervention might influence a particular prognosis. The ultimate objective of the first appointment is the development of a treatment plan that specifically addresses and accommodates the patient's needs. Placing these in the broader context of general health, socioeconomic status, lifestyle, and dental expectations will also assist in the delivery of the most appropriate treatment.

TREATMENT PLANNING

Treatment planning may be regarded as the process of matching treatment options with a patient's specific needs as determined by careful diagnosis. Detailed observations that allow the dentist to move from general to specific knowledge of the patient being examined, will lead to both a diagnosis and identification of any factors that have the potential to preclude desirable treatment. The following domains sum up key information items that facilitate the diagnostic exercise (Box 5-1). Their synthesis facilitates the selection of a treatment protocol that best serves the patient's needs.

SOCIAL AND BEHAVIORAL INFORMATION

Knowledge of a patient's social environment can help the dentist understand their expectations and the background of their current dental status. While family and social circle norms may positively influence most people's search for good oral health care, others are not distressed by tooth loss or by the prospect of wearing complete dentures. Most people also have close friends or relatives whose judgment they value and from whom they may seek advice before obtaining professional help. Some patients have suboptimal oral health because of inadequate care, rather than poor motivation. It is therefore helpful to gain some insight into a patient's reasons for requesting denture treatment.

Patients' perceptions of the causes of the loss of their teeth can provide insights into their appreciation of

Box 5-1 Synthesis of Key Information Domains That Facilitate Choice of Treatment Options

History: The Patient's Story
Social and behavioral information
Psychological considerations
Systemic health status

Dentist's Specific Observations
Extraoral evaluation
- Temporomandibular joints
- Lips and cheeks

Intraoral examination
- Mucosa
- Tongue
- Saliva
- Residual ridge morphology and ridge relations
- Tori, undercuts, enlarged tuberosities
- Teeth (when present)

Existing prostheses and their occlusal relationship
Radiographic imaging
Study casts

dentistry and contribute to the prognosis for prosthodontic success. Although patients can change their attitudes and habits, it is reasonable to presume that patients who have lost teeth in an accident might be more unhappy about their edentulous state than those who lost teeth as a consequence of decay resulting from neglect. Similarly, the expectations for the amount of alveolar bone remaining would be greater for the patient with a history of rapid tooth loss from decay than for the patient with a long history of progressive periodontal disease. Through the telling of their stories and responses to focused questions, patients will often provide the essence of a diagnosis of their dental health and needs. Patients' expectations are founded in the realities and perceptions of the past and influenced by knowledge and emotions of the present, but they are validated only in the unknowns of the future. In prosthodontics, the intelligent use of modern techniques and materials justifies raising the expectations of patients with poor dental histories and restricted knowledge of modern dentistry. When treatment results exceed such patients' expectations the results can be very rewarding for both the patient and the dental team, as well as being a great practice builder. On the other hand, there are also people whose expectations are unrealistic, even when treatment is provided by very skilled practitioners. Such a discrepancy between expectations and reality should be recognized and managed before treatment is started; otherwise clinical success will probably elude both dentist and patient. This objective is regrettably not always possible, and success or failure in the provision of prosthodontic care is frequently the direct result of the adequacy of the initial analysis of the patient's perceptions and expectations. Success in prosthodontic treatment is only partially dependent on the dentist's skills and is also heavily dependent on matching patients' expectations to realistic treatment outcomes. Although it is important to strive to always achieve care of the highest quality possible, even this standard can fail to meet a patient's desires, the prior management of which is an integral component of the provision of good dental care.

Patients' oral manipulative skills will be partly reflected in their ability to use their existing prostheses, the assessment of which can provide much useful information. Their expectations are also strongly influenced by previous denture experiences, be they positive or negative, and it is within this context that the dentist must work. The patient's satisfaction with the performance of a set of dentures will reflect their subjective assessment as judged against their own criteria, the skills of the dental team, and the patient's ability to adapt psychologically to the edentulous state and to use their prostheses. The warning to beware of patients who have a "bag of dentures" is widely known, and reflects an unfavorable balance between these factors. The dentist should refrain from treating such a patient, unless it is possible to determine ways in which new prostheses can significantly improve on their predecessors. An exploration of a patient's habits will help identify those that might have contributed to their present condition and those that will help ensure success or failure for the proposed treatment.

The dentist also should enquire as to potentially unfavorable habits such as tobacco smoking and alcohol consumption. In addition to advice as to their long-term systemic effects, a patient should be informed of their potential local impacts, including detrimental effects on wound healing, soft tissue health, or the durability of tissue conditioners. The dentist also should ask about a patient's oral and denture hygiene procedures. Parafunctional habits also must be considered and their presence and consequences assessed at the time of intraoral examination, together with their likely effects on the currently worn prostheses.

PSYCHOLOGICAL CONSIDERATIONS

Patients seeking prosthodontic care arrive with an accumulation of experiences and resulting attitudes. These may range from optimism, through resignation, to despair. All may be set against a background of psychoses or neuroses. When taking the patient's medical history and discussing conditions with them, the dentist must assess their mental health, particularly attitudes toward the wearing of dentures, or receiving new ones. Much of this can be revealed through a discussion of the reason for tooth loss, the importance of any remaining teeth, and the patient's experiences with dentistry, especially experience with any previously used prostheses. Danger lurks at both ends of the positive-negative spectrum. The overly optimistic patient may have unrealistically high expectations for success with all aspects of the dentures, such as esthetics and masticatory ability. At the other end of the spectrum is the patient who expects nothing more than another failure; such patients have often only agreed to treatment at the behest of someone else, such as a spouse. In all instances, the dentist must seek to improve patient understanding and strive to adjust expectations to reality. Dentists are in significant agreement that success or failure in fabricating dentures is not exclusively predicated on a patient's oral anatomy or the skills of the dental team, but also on the patient's attitude toward their prostheses. It has been noted that the body schema (the psychological image of the physical self) is heavily invested with emotional meaning. Significant changes in body image result in varying degrees of emotional instability that affect adaptive competence. Given time, most people can absorb the trauma involved in body changes and develop new adaptations to changed circumstance. Although it appears that most patients adapt to the denture-wearing experience, many do not. They comprise a group of people who are more emotionally fragile and who find that they cannot adjust to the physical change or else cannot cope with the tissues' complex adverse response to prostheses. The loss of teeth in both general patient groups, whether they are morphologically or emotionally maladaptive, is an obstacle they cannot surmount despite provision of excellent prosthetic replacements. There are therefore many critical elements to

consider in managing adaptive and maladaptive denture-wearing patients. The two most important are the behavior of the doctor and a thorough patient interview, both of which involve the skillful handling of verbal and nonverbal communication.

The specific interview is designed to help dentists mobilize their resources so that they operate in the most efficient way to create the climate of involvement and trust indispensable to altering maladaptiveness. It is a systematic, pragmatic, "cherished" interaction used to reduce or eliminate most of the dental fears or anxieties encountered in practice. Its goal is to create a relearning experience wherein the feelings originally learned will be unlearned and a new set of feelings generated as a consequence of the interaction between the doctor and the patient. The interview can comprise four parts: (1) the recognition and acknowledgment of the problem, (2) its identification and exploration, (3) its interpretation and explanation, and (4) the offering of a solution to the problem. All four parts can be incorporated into an evolving narrative that develops during the diagnosis and treatment planning appointment.

It is worth remembering that in general, dentists are excellent communicators in the areas of physical and anatomical problems but inclined to be reticent when emotional issues are involved. The iatrosedative interview is an effective method of communication to help patients who are already unable to adapt to dentures or are anxious about such an outcome. It creates an indispensable trusting relationship in the process of determining the factors responsible for the problem and seeks to offer a solution.

Psychological inventories have therefore been proposed and used to assess the personality characteristics of patients who have difficulty using dentures. Such studies tend to suggest that many of the so-called maladaptive patients have high scores on indices of neuroticism. Neurosis is regarded as a chronic anxiety state at the physiological level and is known to affect the performance of tasks requiring neuromuscular coordination. Both learning and skilled performance show optimal relationships with moderate levels of anxiety, whereas levels of anxiety that are too high or too low appear to be incapacitating. Although this suggests that only the most anxious patients should have trouble with their dentures, clinical experience confirms that such a conclusion is narrow and restrictive. On the other hand, cheerful extroverts are rarely found in the ranks of patients who have difficulty with dentures and who complain unceasingly, although no causative factors can be found for their problems.

All patients may be regarded as psychologically prepared for treatment. The problem for the dentist is to determine if that preparation is positive or negative. Some patients approach treatment with enthusiastic optimism; others will be merely resigned to it as a necessity. Some will be cooperative and keen to participate in the decision making and continuing care, while others will want to defer to the dentist and avoid accepting responsibility for their own well-being. With reasonable care and effort in patient management, most patients can be successfully treated. However, there are some who have significant psychological problems that require professional help. Occasionally these problems focus on dental needs, and when recognized, the patient should be referred to appropriate professionals. Because of the sensitive nature of this type of referral, it usually is best to start with the patient's physician. If patients reveal that they are already in the care of a psychologist or psychiatrist, then a direct consultation would be appropriate.

It is worth emphasizing that dentists tend to very rapidly become masters in technical skills and adept at providing quick solutions to problems. However, many clinical challenges, especially in prosthodontics, require significant commitment to "patience with patients." Effective techniques of communication remain an indispensable determinant of favorable management outcomes.

SYSTEMIC HEALTH STATUS

Dentists are responsible for the well-being of the patients under their care—a professional remit that goes beyond the technical aspects of providing treatment. They must be aware of each patient's general health, especially conditions that might influence the choice of treatment, or that can be aggravated by a clinical intervention. The initial evaluation starts by observing the patient's behavior in the office. This can provide valuable insights into the need for even more humanitarian and compassionate management than usual, especially in the case of elderly and frail patients. Much can be learned from watching the patient entering the operatory and sitting in the dental chair. Are the patients accompanied and are their movements coordinated, or do they seem physically impaired in any way? Does the patient use a walking cane or tend to rest on surrounding furniture? Is there pallor or flushing of the face? Does the patient appear to be short of breath? Are there any signs of injury or impairment? Is the patient wearing eyeglasses or a hearing aid? Do the patient's hands appear arthritic? Are there facial asymmetries? Does a handshake or the sipping of a drink of water reveal compromised muscular coordination?

Dentists should be cognizant of the merits of such observations because of their potential to influence everything else that follows. This is the type of data that also allows proceeding with diagnostic procedures without having to give undue emphasis to findings by asking related health questions during the visual examination. The exploration of a patient's medical history is a written and verbal art, one that is immeasurably aided by a well-designed health questionnaire. The primary objective is the identification of conditions or incidents that have implications for current treatment. Determination of vital signs will sometimes allow the dentist to note deviations from the norm, and in

turn, advise the patient to seek the services of a physician. It also provides a reference for the patient's record that may be important should a medical emergency occur during treatment. Other information assists the dentist in understanding the patient's current condition and in developing a prognosis. It also serves as a context for counseling about the relationship between aspects of general health and the denture-wearing experience.

Knowledge of all medications that a patient is taking is important to avoid any conflict in therapy. Such conflicts can range from interference with the effectiveness of medication to the precipitation of a medical emergency. Incidents of this nature resulting from failure to elicit a patient's medication history or to determine the significance and possible interactions of the medications are indefensible. Some systemic disorders may require adaptation of the proposed dental treatment, especially where they physically disadvantage the patient, require medication, or have the potential for causing unfavorable reactions to the proposed dental care. Physical incapacity is not always visible. Enquiry may reveal back problems that prevent the patient from tolerating long appointments or demand special seating arrangements.

After history taking and the preceding general observations, the dentist begins the specific extraoral and intraoral examinations that also will be supplemented by a radiographic one.

EXTRAORAL EXAMINATION

Extraoral examination is concerned principally with facial contours and symmetries, the appearance of the teeth and their relationships with the lips in repose, and function and patterns of jaw movement. It also may be supplemented by palpation of the temporomandibular joints (TMJs) and of the submandibular and cervical lymph nodes. Its noncontact physical aspects can be conveniently carried out during the initial stage of the consultation while evaluating the patient's complaints and history. Facial asymmetries, plus disparities in jaw size and concentricity, should be noted early on since they may require special accommodation in a treatment plan. The optimal activities of the numerous facial and masticatory muscles that influence oral function and jaw movement are dependent on adequate neuromuscular control, which underscores the successful use of dentures. Any apparent functional deficiencies should therefore be noted and compensatory measures planned where possible. If the muscles appear to be strong and their activity well coordinated, they will help the patient use a correctly designed denture. Conversely, poor denture design, weak muscles, and poor muscle coordination will detract from the desired denture stability and retention.

Good muscular control and coordination also are helpful in denture construction. For example, when tongue movements are used for border molding, the lingual flanges of a mandibular impression and the timing, direction, and amount of movement are critical to the success of the procedure. Similarly, coordination of jaw movements also is important since a patient lacking the ability to move the mandible to a requested position, reveals the potential for problems in making jaw relation records, even before they are attempted. To make an observation of muscular control, the dentist can ask the patient to open the mouth about halfway and move the lower jaw from left to right, then to put the tongue into the right and left cheeks in succession, and to protrude and then retrude the tongue. The ability, or lack of ability, to make these movements as requested will be apparent, and the treatment schedule should be modified accordingly. If the dentist feels the problems with muscle coordination are significant, then the patient can be asked to practice jaw movements at home. Emphasis should be placed on deliberate mandibular border movements ending in centric relation. Practicing in front of a mirror will allow the patient to visually coordinate the movements.

Unobtrusive observation of jaw relations will usually provide a first indication of the patient's jaw relations. Although the determination of these during treatment is discussed in Chapter 9, some of these approaches also can be applied at the diagnostic appointment. The vertical dimensions of the face at rest and with the teeth in occlusion, as well as anteroposterior jaw relations, should be estimated during diagnosis to permit provision for their acceptance or correction being included in the treatment plan.

The tone of the facial tissues is critical to several steps of denture construction. Tissue tone that is either too strong or too weak is unfavorable, often resulting in the relevant clinical procedures requiring more than the usual amount of time. If the muscles are too tense, cheek and lip manipulation will be difficult; if too slack, the lips and cheeks may be displaced easily by impression materials. In addition, patients may have perioral musculature that requires correct support from the natural teeth and ridges, or where this is lacking, from correctly designed and fabricated prostheses.

It has been noted previously that the extraoral examination should include the exposed head and neck; however, before carrying out such an examination, its purpose and nature should be explained to the patient to avoid misunderstanding.

TEMPOROMANDIBULAR JOINT

In addition to lymph node palpation, the dentist may need to explore other structures such as the TMJs and masticatory muscles. This is usually required when a temporomandibular disorder (TMD) is suspected and associated with one or more of the following symptoms: (1) pain and tenderness in the muscles of mastication and the TMJs, (2) joint sounds during condylar movements, and

(3) limitations of mandibular movement. Quite logically, the TMJs should be healthy before new dentures are made.

Unhealthy TMJs complicate the registration of jaw relation records since centric relation depends on the structural and functional harmony of osseous structures, the intraarticular tissue, and the capsular ligaments. If these are absent, the patient will be unable to position the mandible in a correct and repeatable centric relation. The routine evaluation of a patient's temporomandibular function is thus an integral part of complete denture treatment and the diagnosis and management of TMDs is well documented in the literature.

Dentists also should have a basic knowledge of speech, particularly its articulatory component. Articulation is the modification of speech sounds by structures of the throat, mouth, and nose. Fortunately, the neuromuscular activity that produces speech can adapt to, or accommodate, a certain amount of structural change. The relationship of the positions of the teeth, lips, and tongue in the articulation of speech is discussed later (see Chapter 15). An assessment should be made during the diagnosis appointment to identify existing problems and determine the potential for improvement.

Note also should be taken of any musical activities such as singing or the playing of wind instruments that can be profoundly affected by dental status, especially as a result of changes to a musician's *embouchure*, or the lip support from a denture's flange or teeth placement positions of the anterior teeth and shape of the palate. Alteration of these structures can have significant effects on the careers of professional musicians, as well as restricting the enjoyment of the amateur, and must be planned and undertaken with great care.

Cheeks and Lips (Fig. 5-1)

The external form of the cheeks and lips is dependent on their internal structure and underlying support, which may be provided by the natural teeth and ridges or their artificial replacements. The muscles of the cheeks and lips have a critical function in the successful use of dentures, the flanges of which must be suitably shaped to aid in maintaining the prostheses in place without conscious effort by the patient. This involves the development of the correct arch form and tooth positions, as well as the shape of the polished surfaces and the thickness of the denture borders. In doing so, note



Figure 5-1 **A** to **D,** The influence of the presence of teeth (or their absence) on lip fullness and support is self-evident. This is especially so when assessed in the context of age-related skin changes and vertical dimension of occlusal support.



Figure 5-1, cont'd **E,** Completion of complete denture treatment. **F,** Without *(left)* and with *(right)* complete dentures in place. **G** to **I,** The inevitable effects of skin aging do not detract from correct prosthetically created circumoral support.

must be taken not only of theoretical concepts but also of the patient's adaptability and the shape of any existing prostheses, be they successful or inadequate. The prosthetic envelope also must be considered particularly carefully if a fixed implant-supported prosthesis is planned because these do not usually incorporate a tissue-supporting base and also will be required to accommodate any implant-connecting components.

Patients with very thick cheeks may present technical problems during some clinical steps. Thick cheeks often do not allow easy manipulation for border molding of impression materials, which can impact denture retention. In addition, lip positions at rest and in function are very important in considerations of esthetics and phonetics. Fortunately, phonetic issues involving the lips do not tend to pose many independent problems when esthetic requirements are satisfied. If the tissue around the mouth has wrinkles and the rest of the face does not, lack of lip support may be suspected and improvement can be expected. A rolled-in vermilion border is evidence of inadequate lip support and has

historically characterized denture wearing. If the problem appears to be that the anterior teeth are set too far lingually or palatally, then the lack of support can be tested by adding wax to the labial surfaces of the prosthesis. If this improves the appearance of the lip, plans can be made to place the new teeth more labially and thus provide the necessary support to help eliminate the wrinkles. It is important to recognize that while the presence of skin creases can be indicative of inadequate lip support, which may be amenable to correction, the prostheses are not in themselves tools for modifying the visual impact of the aging process irrespective of functional criteria for tooth positioning. Patients should be warned about this before a treatment plan has been agreed upon so as to avoid subsequent disappointment.

Questions about the prominence of the natural upper anterior teeth may reveal that the residual alveolar ridge was surgically reduced when the teeth were removed "to get rid of the buck teeth I never liked." Similarly the anterior maxillary denture teeth may have been set excessively palatally to reduce the overjet. Such procedures usually lead to a lack of lip support, producing vertical wrinkles later in life as tissue tone deteriorates. If this is to be corrected, then patients should be told that for a short time their mouths might appear to them to be too full because of the sudden increase in lip support. The danger insofar as the dentist is concerned is that excessive labial support might be provided in an attempt to eliminate the vertical wrinkles in the upper lip, resulting in an inappropriate appearance and denture instability. The apparent fullness of the lip is directly related to the support provided by the teeth and alveolar bone or denture base. Lip fullness should not be confused with lip thickness, which involves the intrinsic structure of the lip. A denture with an excessively thick labial flange may make the lip appear to be too full rather than displaced. Excessively thick denture bases also can make the lip appear thick or short. The latter effect results from the increased bulk raising the labial margin. The converse also occurs when inadequate labial support results in the teeth appearing to be "too short"—a problem usually best corrected not by lowering the occlusal plane but by increasing lip support. An obliterated philtrum or mentolabial fold suggests excessive support. The problem with lip fullness is in the patient's reaction to changes. If the existing dentures have the teeth set too far palatally, the patient may feel that the new and corrected tooth arrangement makes the lip too full. Extra time will be needed at the try-in of the wax dentures to ensure that the patient is comfortable with the agreed design.

Although the dentist can modify the apparent "length" of the anterior teeth by modifying anterior tooth positions, the situation is further complicated by lip length. Where a patient has short or incompetent lips, they may ask for a less-than-natural show of teeth while individuals with long lips may request the opposite. Awareness of these problems can help the dentist to manage them. A patient with a short upper lip may expose all the anterior maxillary teeth when properly set and much of the labial flange of the denture base as well. Patients with thin lips present special problems. Any slight change in the labiolingual tooth position makes an evident change in the lip contour. This can be so critical that even overlapping of teeth may distort the surface of the lip. Both the arch form and the individual tooth positions are involved. Thick lips give the dentist a little more opportunity for variations in the arch form and individual tooth arrangement before the changes are obvious in the lip contour.

INTRAORAL EXAMINATION

The surface quality and contours of the soft and hard tissues are the objects of a careful visual examination of the mouth. The dentist should adopt a routine order for this examination to avoid omissions. Patients will frequently direct the clinician to their chief complaint, which can distract the dentist from a comprehensive evaluation. It is wise to explain to patients what the value of the complete examination is and how this allows for setting the chief complaint in the context of their overall oral and general health concerns.

Our primary data-gathering sense is vision. In daily life, vision is taken for granted and used unconsciously. In a dental examination, it must be used consciously with conditions designed for optimal effectiveness. Adequate lighting is essential for making correct visual observations with both quality and quantity being important considerations. Dentists routinely use task lighting to supplement ambient room light. To avoid eye strain, the gradient between the two must not be too great. The ambient light should be diffuse to prevent the production of high-contrast shadows and the task lighting should not produce glare. Visual acuity diminishes with age, and higher levels of lighting are required. Color balance is important not only for shade selection but also for the correct evaluation of soft tissue. Aids to vision are also helpful. The mouth mirror has been the symbol of dentistry's diagnostic responsibilities for many years, since it allows for comfortable viewing angles. It also enables the dentist to direct light to structures and recesses of interest.

Magnification is a simple aid to vision. A handheld lens will serve in some instances, but many dentists find loupes convenient for most tasks. Beyond magnification, loupes can improve the viewing distance and, with more sophisticated optics, can adjust the viewing angle. The latter features enable the dentist to work using a less stressful posture than might be possible with unaided vision.

Complete dentures are entirely dependent for support on soft tissue (mucoperiosteum) and underlying hard tissue (bone). The health and quality of these tissues are therefore very important determinants of success in the wearing of complete dentures.

MUCOSA (FIGS. 5-2 AND 5-3)

The dentures are surrounded by the cheeks and lips, which are covered by lining mucosa. This mucosa moves in intimate contact with the dentures during the functioning of the related facial and masticatory muscles. The lining mucosa of the lips and cheeks and floor of the mouth is relatively thin and easily traumatized. It is also the site of a variety of pathoses. The lingual and palatal surfaces of the dentures are in intimate contact with the tongue and its specialized mucosa. The specialized mucosa covering the tongue is often regarded as a possible "window" on systemic disorders—arguably an overstatement, but still a relevant consideration. All these tissues must be examined in detail for individual anatomy and for abnormalities, irregularities, and pathoses. The term masticatory mucosa has been applied to the mucosa covering the residual alveolar ridges and palate. It is usually attached to the underlying periosteum; however, when it is not, denture instability can be a problem. The area of attachment diminishes with ridge resorption, which is more severe in the mandible. A total loss of attachment is often first seen above the mandibular

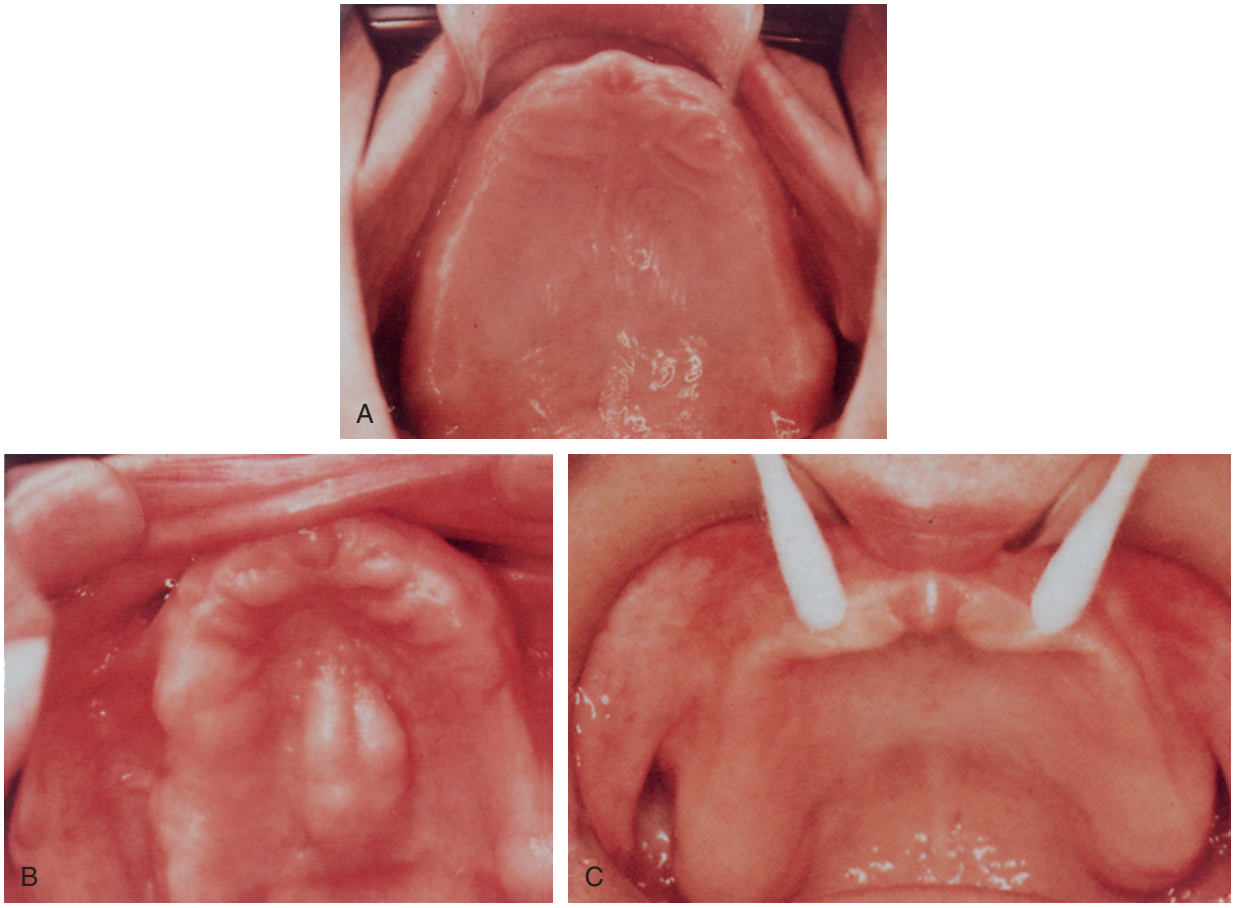


Figure 5-2 An extensive range of morphological tissue health variables must be diagnosed before treatment planning is finished and complete denture fabrication is started. Six different edentulous maxillae underscore some of the frequently encountered variables. **A,** This residual ridge shows minimal resorption and is covered by firm, healthy, soft tissues. Hamular notches are well defined, and no tissue adhesions are present. This maxillary basal seat area offers an excellent morphological prognosis. **B,** This residual ridge, though substantial, is irregular, with bony undercuts and small exostoses present. The left tuberosity is pendulous and mobile, and a large torus is present. A denture can be built on these foundations, but surgical considerations also should be addressed to optimize the basal seat area. **C,** Anterior localized ridge resorption has occurred and been replaced by hyperplastic tissue. This tissue usually is excised before impression making. When a patient's health precludes this option, a modified impression technique is employed.

Continued

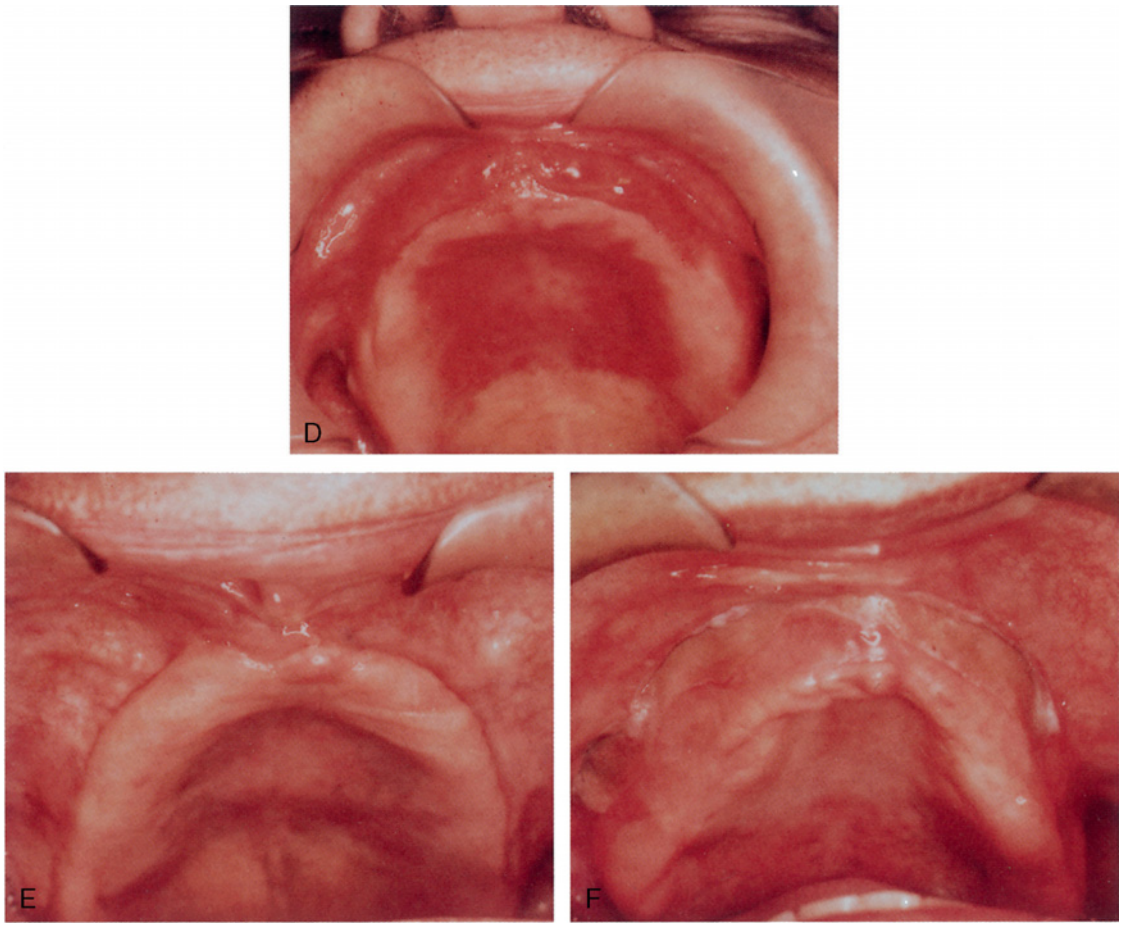


Figure 5-2, cont'd **D,** Home care and a regular recall program were not instituted for this patient. Consequently, the basal seat area became inflamed and an epulis resulted. Tissue rest, massage, and the prescription of a treatment liner should precede a surgical assessment in this patient. **E,** Advanced residual ridge resorption is evident, with low mobile peripheral tissue attachments and obliteration of the hamular notches. As a result, compromise in both peripheral and posterior palatal seals will not improve the diagnosis for a retentive and stable denture. **F,** A morphological picture similar to the one in **E** has been rectified by preprosthetic sulcus deepening with skin graft placement. This prescription used to be frequently employed in the mandible but has been virtually eclipsed by implant treatment.

symphysis and can be demonstrated by tensing the lower lip, which causes the floor of the mouth to move.

Diagnosis of abnormalities of the mucosa requires the recall of the normal appearance. Shape, color, and texture are significant characteristics. Some variations occur frequently with no significance and are therefore accepted as normal. These include Fordyce's granules in the buccal fat pads and varicosities in the floor of the mouth of elderly patients. Initially, knowledge of normal appearance is learned from anatomy texts and the study of surface anatomy. However, the required mental picture becomes well developed only through careful examination of many healthy mouths.

The color of the mucosa reveals much about its health. The differences in appearance between a healthy, pink mucosa and red, inflamed tissue will be apparent. The cause of any inflammation must be determined. Is it the result of trauma from an old denture or a sign of infection? Abrasions, cuts, or other sore spots may be found in any location under the basal seats of the existing dentures or at the borders. They may be the result of overextended or even underextended borders (Fig. 5-4). Incorrect occlusion is also a major source of tissue trauma. Sharp or overextended denture borders produce red lines of inflammation or ulcerations. Evidence of cheek biting appears at the level of the occlusal plane and often presents as a white scar tissue line indicating a mucosa that has been traumatized and is now healing. Sometimes soreness results from something as simple as a small fruit seed lodged under the denture. At the time of the examination, the causes

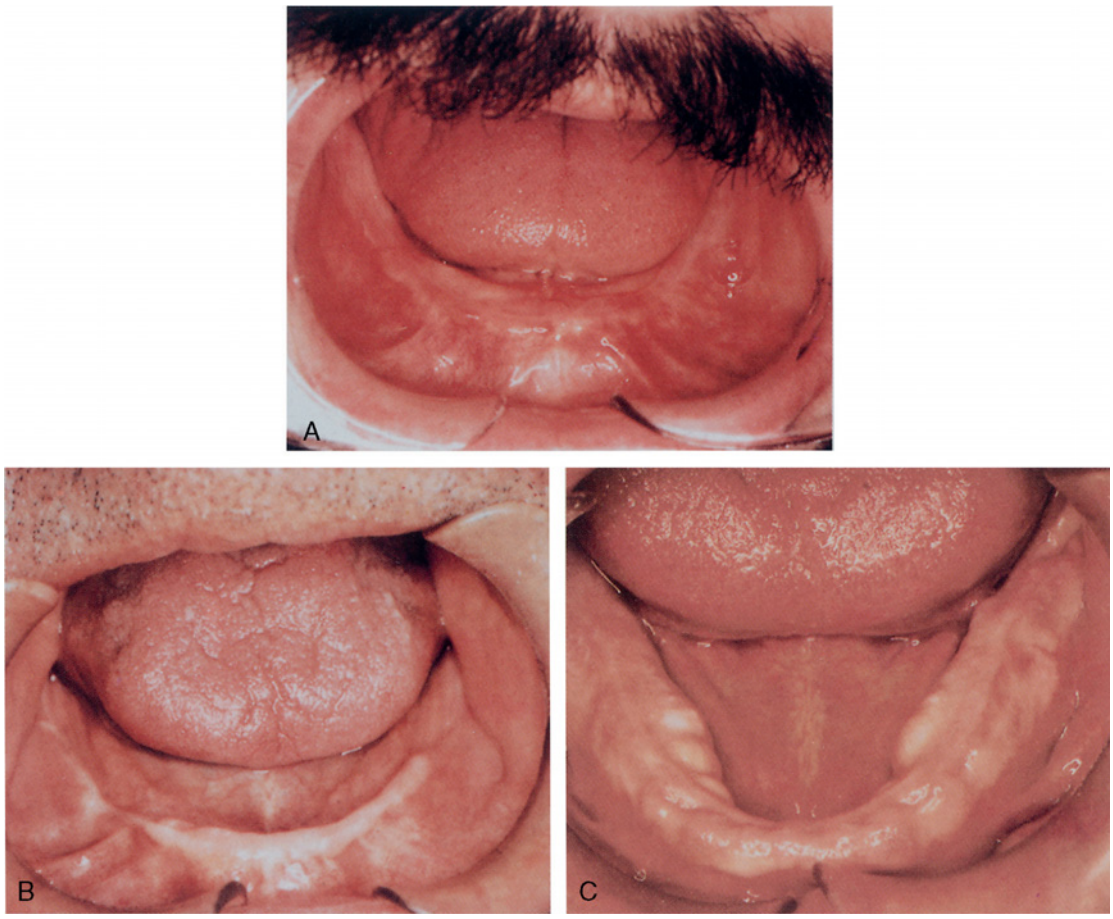


Figure 5-3 Six diverse edentulous mandibular morphological outcomes. **A,** A firm, broad, and well-developed ridge accompanied by a favorable tongue size and position suggests a good prognosis. **B** and **C,** Alveolar ridge undercuts are present, though ridge size differs substantially. Surgical removal of the undercuts can be readily avoided by prudent relief of the denture base. However, tender areas over the exostoses and/or the tori in **C** may have to be treated surgically to ensure a comfortable prosthetic experience.

Continued

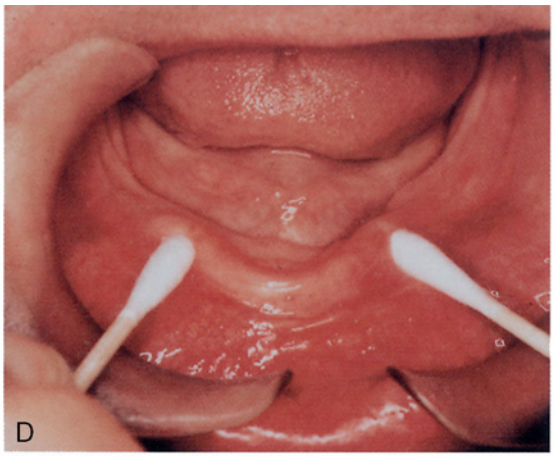
should be determined to allow correction before impressions are recorded.

INFECTION (FIG. 5-5)

Although infections may arise from a variety of sources, *oral fungal infections* are common in edentulous patients, particularly in maxillary denture-related stomatitis. Concomitant inflammation of the corners of the mouth—angular cheilitis—should raise suspicions of *Candida albicans* infection. A cytosmear may be made easily and examined for pseudohyphae. Smears also may be cultured to confirm the clinical diagnosis (see Chapter 4).

Soft tissue hyperplasia (see Figs. 5-2 and 5-3) associated with ill-fitting dentures is a common finding and is observed in relation to edentulous ridges and border tissues as a reaction either to trauma or to the resorption of supporting bone. A decreased vertical dimension of the jaws associated with posterior tooth wear often results in occlusal trauma being concentrated in the anterior regions and contributing to this problem. Border tissues may be chronically traumatized by flanges that were originally overextended or have become so as a result of lost ridge support, producing a reactive hyperplasia that has commonly been referred to as epulis fissuratum. Similarly, tissue will proliferate inside a loose-fitting flange, commonly in relation to the labial surface of the maxillary residual alveolar ridge.

Papillary hyperplasia is cauliflower-like in appearance and tends to occur on the anterior region of the palate in long-term denture wearers. Often this tissue is inflamed when it is referred to as inflammatory papillary hyperplasia. The deep crevices of papillary hyperplasia are prone to infection, frequently with C. *albicans*. Although the infection must be treated before new dentures are made, recurrence is likely unless the hyperplastic tissue is removed.





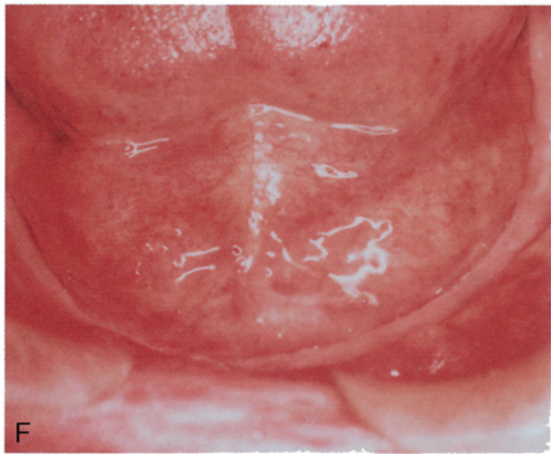


Figure 5-3, cont'd **D** to **F,** Hyperplastic replacement of the entire residual ridge does not usually provide a firm denture-bearing area. However, surgical excision may result in a significantly reduced basal area, as in **E.** Extension of the denture's posterior lingual flanges usually will allow for a stable denture in **E.** This objective may not be fulfilled in **F** because of the unfavorably high attachment of the floor of the mouth. Also notice the virtual continuity of mobile mucosa in the floor of the mouth and the labial/buccal vestibule. They are separated by a thin, mobile, fibrous band. From a morphological point of view, this does not provide a favorable prognosis. Preprosthetic surgery for placement of osseointegrated implants is likely to be needed in these situations.

TONGUE (FIG. 5-6)

The tongue plays an important role in determining denture success or failure, with its size and activity being the main concerns. The tongue will expand into any edentulous space(s) by a reorientation of its intrinsic musculature and become habitually active within its extended boundaries. The introduction of a new denture will then be met with dislodging competition from the tongue. An edentulous patient who has not been wearing a mandibular denture often uses the tongue as an antagonist for the maxillary arch during mastication. In these situations, the tongue can become enlarged (see Figs. 5-2 and 5-3) and also very strong, making prosthetic treatment and subsequent denture use challenging for the dentist and the patient, respectively. Examination of the floor of the mouth includes examination of deep sublingual structures. The surface contours are important but can change as a result of underlying activity. Contraction of the mylohyoid muscles raises the floor of the mouth. This will dislodge a complete denture made from an impression that did not record the position of the floor of the mouth with the mylohyoid muscles in a contracted state. The visual examination also requires that the depths of mucosal folds be exposed to make sure that hidden lesions are not missed

Tongue position and coordination are significant in functioning with a mandibular denture. Normally, the tongue should be expected to rest in a relaxed position on the lingual flanges, which, if properly contoured, will allow the tongue to help retain the denture. A retruded tongue position deprives the patient of a border seal for the lingual flange in the sublingual crescent; it also may produce

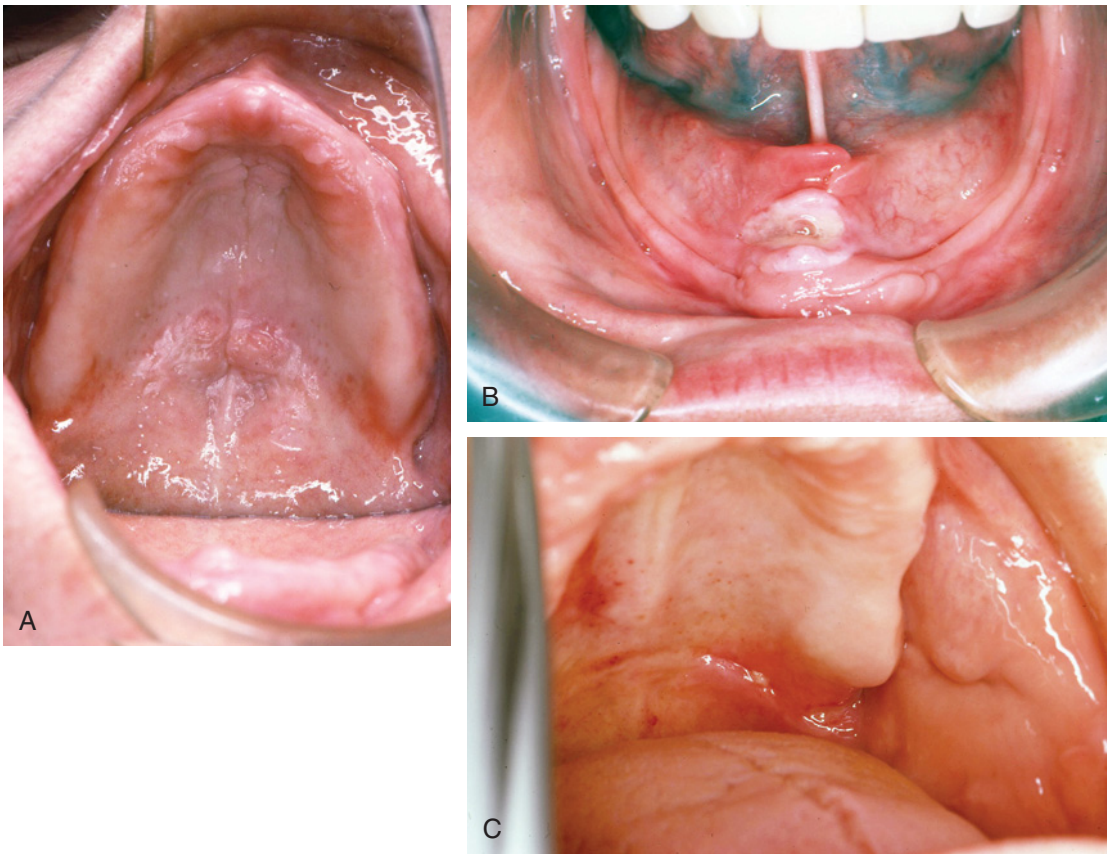


Figure 5-4 Traumatic lesions associated with denture peripheral overextensions and patient failure to seek immediate clinical adjustment. **A,** A chronic response to an incorrectly designed posterior palatal seal. **B,** Severe irritation of a lingual frenum. **C,** Ulceration in a left hamular notch area.

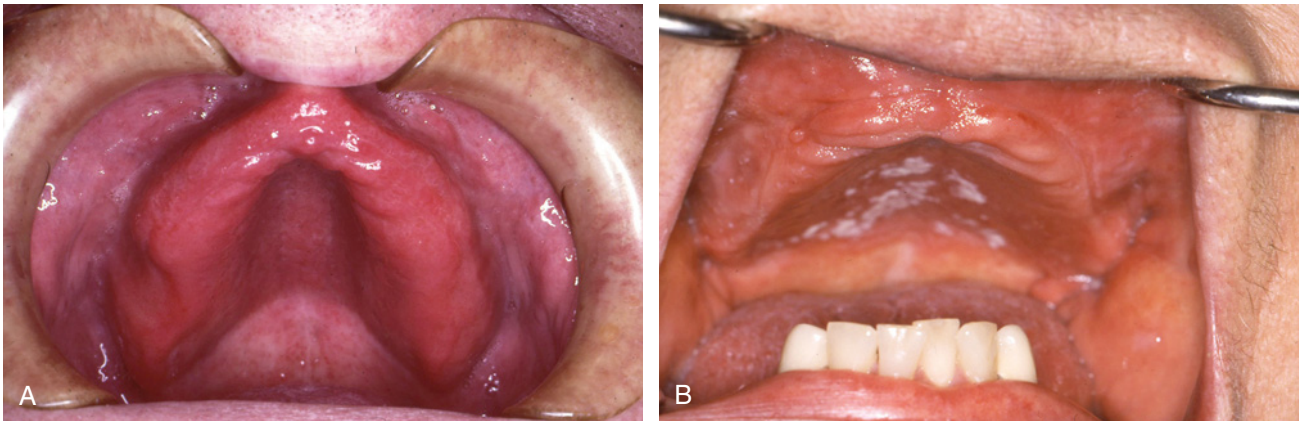


Figure 5-5 Clinical examples of palatal trauma resulting from prolonged wear of ill-fitting maxillary dentures. **A,** Generalized stomatitis with a superimposed *Candida* infection. **B,** A more overt fungal infection plus anterior ridge hyperplastic replacement.

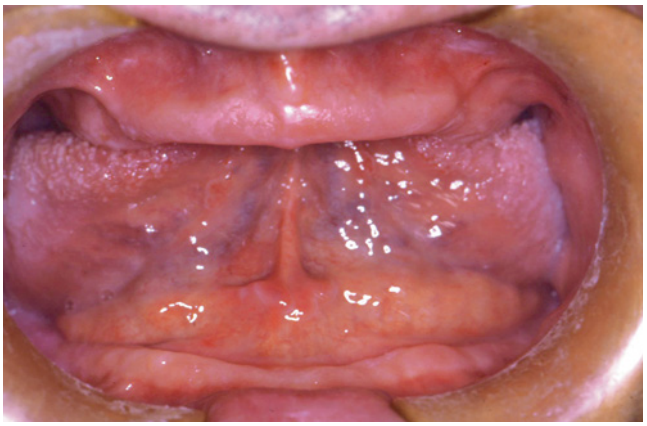


Figure 5-6 A prolonged experience of not having an entire, or even a partial posterior mandibular dentition present, allows the intrinsic musculature of the tongue to spread out to fill in the extra available space. This may pose management and adaptation problems, both during prosthesis fabrication and the patient's subsequent adaptation to the space restriction imposed by the presence of the new prosthesis.

dislodging forces on the distal regions of the lingual flanges. On the other hand, a habit of protruding the tongue tends to dislodge a lower complete denture by raising the floor of the mouth and, in so doing, lifting the lingual flanges. Attempts at tongue retraining may not be very successful but will at least make patients aware of the problem and help them to understand encountered adverse effects.

SALIVA (SEE ALSO CHAPTER 2)

The secretions comprising saliva often do not receive the attention they deserve. The quality and quantity of saliva are crucial factors in a patient's ability to tolerate dentures since both the flow rate and the viscosity are important to denture success. Normal resting salivary flow is about 1 mL/min. A flow of medium viscosity at this rate lubricates the mucosa and assists retention of complete dentures. The patency of the Wharton duct and the production of saliva by the submandibular glands should be demonstrated by watching for the expression of saliva from a duct orifice as the gland and duct are gently squeezed. The patency of the submandibular ducts also should be checked via bidigital palpation in an effort to express saliva from the duct. This technique may help identify abnormalities such as sialoliths in the submandibular duct, fibrosed glands, and enlarged lymph nodes.

Many factors can affect the flow rate, but aging is no longer considered to be a primary factor in diminished flow. Many patients of denture-wearing age, however, take medications that can reduce salivary flow. Patients who have received radiation therapy in the region of the salivary glands usually have glandular tissue destruction with a resulting reduction in salivary flow. In the absence of a history of radiation or antisialagogue drugs to explain diminished flows, further investigation is warranted. The glands themselves may be diseased or ducts blocked, although the latter would usually produce acute distress. Often the palatal glands are destroyed in patients who have worn a complete maxillary denture for many years. The cause is pressure atrophy resulting from lost residual alveolar ridge support of the denture.

Thick, ropey saliva tends to dislodge dentures, and thin saliva or low salivary flows tend to provide an insufficient film for their retention or lubrication of the mucosa. Although these factors are unlikely to be modified for prosthodontic purposes, an explanation of their effects can help patients understand related problems and thereby increase their willingness to accept the associated limitations on treatment success.

BONE RIDGE MORPHOLOGY

Bone provides firm, yet physiologically dynamic, support for teeth and prostheses. It is primarily a collagenous matrix impregnated with mineral salts, and its external form and internal structure are influenced by both systemic and local factors. While it is subject to constant remodeling, its stability is partly dependent on good nutrition and an appropriate hormone balance. Residual ridges are best examined visually and by palpation, an assessment that should extend to the adjacent structures. A sensitive finger will detect abnormalities such as displaceable structures, discontinuities, and enlargements of structures. It can reveal textural differences and unusual contours and although a light touch should be used for most of the examination, the patient's response to pressure also can be helpful (see Figs. 5-2 and 5-3).

A routine pattern of intraoral palpation should be followed to avoid omissions. Typically, one might start with lips and cheeks, moving to the denture-supporting areas, the floor of the mouth, and the tongue. Aside from noting the features of each area, it is important also to identify any asymmetries with the contralateral structures. Certain areas, such as sharp residual alveolar ridges and mylohyoid ridges, are typically tender; so before patients are palpated, they should be told to expect pressure. They should be assisted in distinguishing the normal sensation of pressure from pain and tenderness, the presence of which in apparently normal areas may indicate underlying pathoses that should be investigated radiographically.

Both primary and secondary denture support areas also should be checked. The sides of residual alveolar ridges should be palpated in addition to the ridge crest and irregularities and patient reactions noted. The contents of the floor of the mouth are best palpated with one finger from one hand inside the mouth and two fingers of the other hand applied extraorally. The outside fingers prevent the displacement of the structures during palpation by the intraoral finger.

Many variations in residual ridge morphology will be found. Some will present no special problems, others will require accommodation in impression making while still others may require surgical correction. Sharp and spiny residual alveolar ridge crests can be products of preextraction bone destruction, trauma during extractions, or postextraction resorption. Crestal bone irregularities and increasing radiolucency toward the ridge crest suggest this in radiographs showing the ridge in profile. Palpation usually will reveal the tenderness of the mucoperiosteum over the crest. Because of this, spiny ridge crests cannot contribute much to the support of a denture. While surgical reduction is tempting and sometimes indicated, the reduction in ridge height adversely affects the stability of a denture. It may therefore sometimes be preferable to retain the ridge for its contribution to denture stability if it is relieved of direct pressure by using a selective pressure impression technique that gains support for the denture from other areas. Severe resorption frequently results in the mental foramina coming to lie superficially near to or on the crest of the mandibular residual alveolar ridge. This may be seen radiographically (Fig. 5-7). In these situations the mental nerve lies exposed to pressure from the tissue surface of the denture, and the patient may consequently report a sporadic shooting pain in the area of distribution of the nerve. Palpation will produce the same pain. Relief of the denture over the nerve must be provided but is not always completely effective because of denture movement in function. However, the predictable stabilization of dentures that results from implant support has effectively overcome this problem.

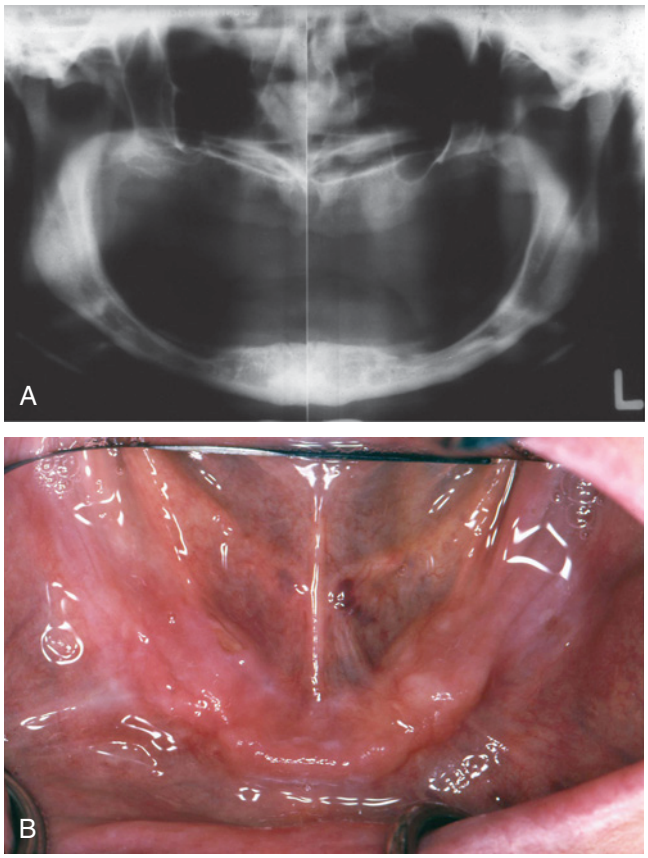


Figure 5-7 Time-dependent residual ridge resorption will frequently compromise the available support area for the denture's intaglio surface **(A)** and render the now superficially located mental foramina **(B)** quite vulnerable to painful contact with the denture's periphery.

The location and size of the mandibular canals are only important if surgery for the placement of implants is contemplated. Enlarged maxillary sinuses preclude, or at least complicate, reduction of maxillary residual alveolar ridge height such as might be needed to allow correct orientation of the occlusal plane. Placement of implants in the region of the maxillary sinuses will usually require the grafting of bone to the inner wall of the sinus by a procedure referred to as a sinus lift.

TORI (SEE FIGS. 5-2 AND 5-3)

These are benign bony enlargements found in some patients at the midline of the hard palate or on the lingual aspect of the mandible in the premolar region. They vary in size. Small ones may be accommodated by relief of the denture base. Others are so large that their interference with denture design warrants consideration for their surgical removal. Tori are covered with a thin mucoperiosteum; consequently, they are very hard and sensitive to pressure. A torus palatinus is found in the midline of the maxillary arch and can vary in size from an apparently prominent midline suture to a mass so large as to fill the palate to the level of the occlusal plane. Generally, surgical removal of a torus palatinus should be avoided, but if it is so large as to extend beyond the vibrating line and over part of the soft palate, then it should be removed or reduced in size. When a torus extends very far posteriorly, it can interfere with the development of a posterior palatal seal.

Mandibular tori occur singly or in rows just above the floor of the mouth. It is often difficult to provide adequate relief for them within a denture without breaking its border seal. If adequate accommodation through relief of the acrylic resin flange cannot be achieved, surgical removal is indicated. Since a torus has a thin covering of cortical bone, the interior cancellous bone will be exposed by surgery. The formation of a new cortical plate usually takes 2 to 6 months.

BONY UNDERCUTS (FIG. 5-8)

These can be found on maxillary and mandibular residual alveolar ridges. They are significant only if the denture base cannot be manipulated into place over them, which usually requires opposing undercuts. Typical examples are posterolingual mandibular undercuts and lateral posterior maxillary ones. Maxillary buccal undercuts are frequently the result of exostoses and may need to be surgically removed if they

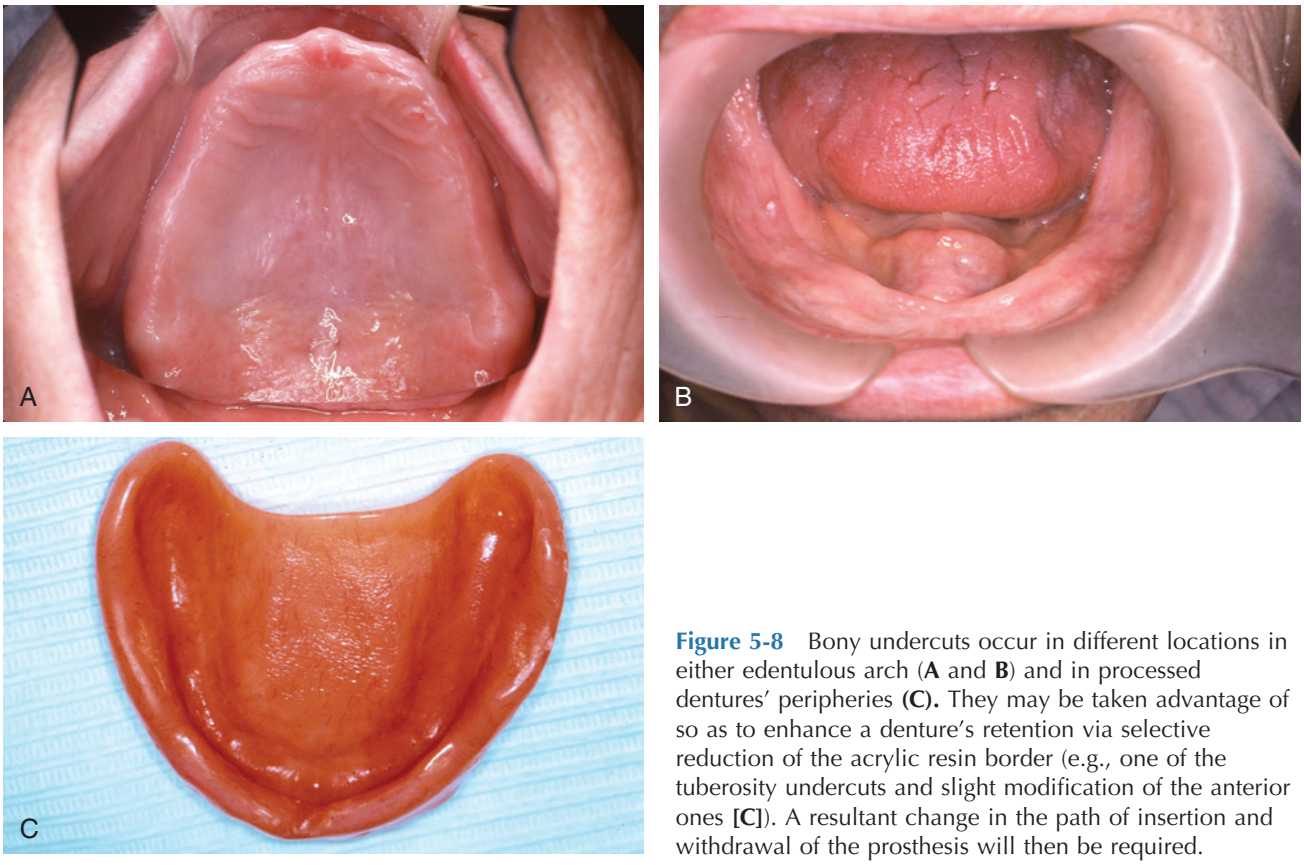


Figure 5-8 Bony undercuts occur in different locations in either edentulous arch (**A** and **B**) and in processed dentures' peripheries **(C).** They may be taken advantage of so as to enhance a denture's retention via selective reduction of the acrylic resin border (e.g., one of the tuberosity undercuts and slight modification of the anterior ones **[C]**). A resultant change in the path of insertion and withdrawal of the prosthesis will then be required.

cannot be accommodated by suitable relief areas in the overlying acrylic flanges.

ARCH RELATIONS

The available amount of support for complete dentures is directly related to the size of the residual ridges in both the mandible and the maxillae. The arch forms, as demonstrated by the edentulous ridges as they appear from an occlusal viewpoint, should be noted since arch form can be used as a factor in tooth selection. It also may assist in decisions on the arrangement of teeth. If the arches are asymmetric, problems of tooth arrangement and occlusion may occur. Harmony in size and form between maxillary and mandibular jaws allows for the use of an occlusal scheme similar to that of an Angle class I occlusion. However, some patients have large maxillary arches and small mandibular ones, or vice versa. These conditions arise from genetic factors and from imbalance in growth and development. When the natural teeth were present, these patients would have had naturally occurring malocclusions, which may have been treated orthodontically. It should not therefore be assumed that every edentulous patient must be provided with an artificial class I occlusion. Where the sizes of the jaws and the anatomy and activities of the perioral muscles so permit, a more natural appearance and function may be achieved by placing the artificial teeth in positions closer to those of their natural predecessors. Nevertheless the replacement of teeth for people who had a class II or class III malocclusion presents some special problems, and the occlusion will need to be planned in relation to the disharmony. The modifications from an ideal occlusion to a crossbite occlusion or one with an excessive overjet will require time to develop. These difficulties should be recognized and anticipated when the diagnosis is made.

The cross-sectional contour of a residual alveolar ridge radically changes after the removal of teeth because of resorption. When the teeth are first removed, the ridge is broad at its occlusal surface, but as resorption occurs, the residual ridge becomes progressively narrower and shorter. The ideal ridge has a broad top and parallel sides. As the ridge becomes narrower, it becomes sharper and consequently is less able to withstand as much occlusal pressure as a broader ridge. The relationship between the maxillary and mandibular support areas also changes because of resorption after teeth have been lost. The bone of the maxillae resorbs primarily from the occlusal, buccal, and labial surfaces. Thus the maxillary residual ridge loses height, and the maxillary arch becomes narrower from side to side and shorter anteroposteriorly.

On the other hand, the mandibular ridge resorbs primarily from the occlusal surface. Because the mandible is wider at its inferior border than at the residual alveolar ridge in

the posterior part of the mouth, resorption, in effect, moves the distal ridges progressively farther apart. The mandibular arch thus appears to become wider and the maxillary arch narrower. The cross-section shrinkage in the molar region is downward and outward, while in the anterior region it is at first downward and backward. As shrinkage continues, the anterior part of the basal seat for the mandibular denture moves forward. These changes must be noted at the time of the examination so as to plan for the resultant problems of leverage, occlusion, and tooth positioning for esthetics and function. Where treatment with dental implants is to be considered, note must be made of the intrabony space available for implant placement (the surgical envelope) and of its relationships with the prosthetic envelope, which defines the boundaries of the superstructure. Denture stability is enhanced by parallelism of the primary denture-bearing areas. When natural teeth contact in centric occlusion, the surfaces of the maxillary and mandibular arches are, in effect, parallel which makes for a very stable relationship. Even though denture teeth will be set to contact evenly in centric occlusion, the surface of the arches that support the dentures may not be parallel because of bone resorption. This diminishes the stability of the dentures because vertical loads will acquire a horizontal component due to ridge angulation. The problem can be severe where the ridges offer little resistance to horizontal denture displacement and must be identified at examination for consideration in denture design. (It should be noted here that implant-supported dentures permit an especially suitable solution for this problem.)

The relationship also will be obvious on mounted diagnostic/study casts, which will readily reveal the interarch separation. This is important information because a lack of space can lead to denture failure from improperly positioned teeth. Excessive space usually is related to severe ridge reduction with a resulting instability that also limits denture success. Even when severe ridge reduction indicates excessive interarch separation in the anterior region of the mouth, the posterior regions should be examined to determine if there is sufficient space. If some teeth are present, they must not interfere with the placement of the occlusal plane. Extraction may be indicated if a tooth is so extruded that its occlusal surface is above the desired occlusal plane, unless it can be reduced sufficiently to be on the same plane as the other teeth in that dental arch.

ENLARGED MAXILLARY TUBEROSITIES (FIG. 5-9)

When the maxillary tuberosities are so large that they prevent the correct location of the occlusal plane, require the omission of some teeth, or prevent the correct distal extensions of the denture bases, then they could be surgically reduced. The fact that a patient may have been wearing dentures does not rule out these difficulties. Denture-base wear on old dentures over the retromolar pads and the maxillary tuberosities suggests an interarch space deficiency. Radiographs will show whether large tuberosities are bony or composed of fibrous connective tissue. Where possible, the reduction should be limited to the fibrous tissue. The resulting closed soft tissue wound heals quickly and predictably. Should bone have to be removed, remodeling is initiated, making the result less predictable and prolonging the healing. Very rarely, slight additional space can be gained by dissecting out nonessential contents from larger retromolar pads.

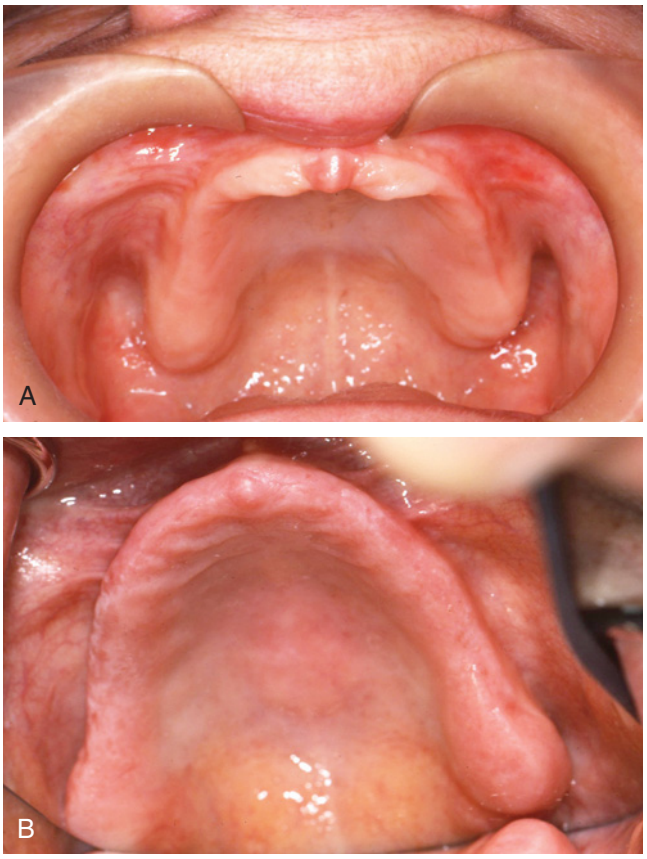


Figure 5-9 Enlarged tuberosities (**A** and **B**) also may be associated with the so-called Kelly's syndrome, wherein the anterior part of a maxillary complete denture rotates into an upwards position, while the posterior tuberosity part appears to grow downwards. This morphological predicament is usually associated with an untreated Kennedy class 1 type of mandibular dentition, and the associated enlarged tuberosities may need to be surgically reduced to accommodate the replacement mandibular posterior dentition.

EXISTING DENTURES (FIG. 5-10)

The patient's existing dentures can convey a wealth of information and should be carefully examined both outside and inside the mouth. The objective is to determine the



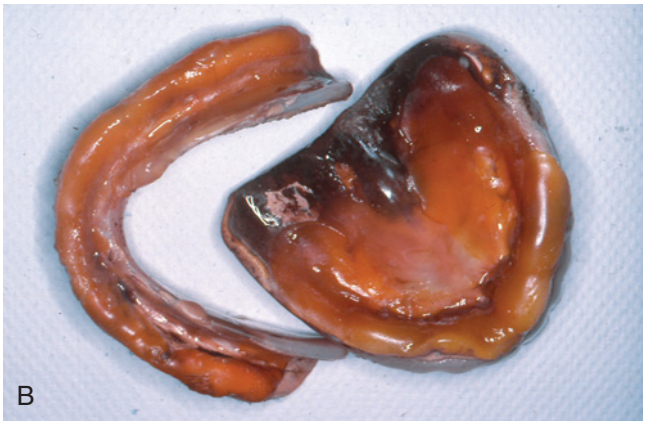




Figure 5-10 **A** to **C,** Materials used to fabricate a patient's current dentures are usually easy to identify. However, additional information about the patient's home care and hygiene considerations also may be gleaned from studying old prostheses.

effects of time-dependent functional "wear and tear" on the denture base and artificial teeth, as well as evidence of denture hygiene procedures and chemical staining. The presence of reinforcing metallic components also should be noted because this may reflect a history of repairs before denture breakages. Visual inspection or light scratching with a metal instrument will help differentiate between acrylic resin and porcelain teeth. The exercise also can be facilitated by the use of transmitted light because it will reveal the retentive pins of porcelain teeth. Set against the age of the denture and the material of the opposing occlusion, some estimates of patient use and abuse of the prostheses can be made. For example, porcelain teeth are more wear resistant than acrylic resin ones and will show less wear over the same period of use. However, porcelain teeth are more brittle and will often be chipped if the patient has not been careful, especially when cleaning them. Chipping also may be the result of a lack of harmonious occlusion. Furthermore, different degrees of wear of the prosthetic dentition—acrylic resin ones in particular—may reflect parafunctional activity and provide insights into supporting tissue tolerance.

Examination of old prostheses, coupled with discussion with the patient, also can reveal much about what the patient likes and dislikes and can or cannot tolerate. It is important to note characteristics such as the arch form of the teeth relative to the arch form of the residual alveolar ridge, the orientation of the occlusal plane, the relationship of the anterior teeth to the lips, denture base extensions, the thickness and contours of the flanges, and wear patterns. An evaluation of the esthetic merits of existing dentures—specifically teeth arrangement, size, and color— also can be made with the dentures outside the mouth, more especially if other dentures and old photographs are provided by the patient.

The occlusion can have a profound effect on denture stability, lack of which is often ascribed to errors in the fitting surfaces. Tissue trauma and a patient's inability to successfully use dentures can frequently also be traced to errors of an inadequate occlusion. This must therefore be assessed, in particular, its harmony with the patient's jaw relations. Large discrepancies will be obvious immediately if the patient is guided into centric relation as the patient brings the teeth together and subsequently is guided into eccentric contacts. Small discrepancies may only be suggested by tooth wear patterns. The level and orientation of the occlusal plane must also be assessed, as must the tooth-to-tooth and tooth-to-ridge relationships. The length of the plane relative to the size and shape of the denture-bearing area also should be considered. Denture teeth set over the slope of the mandibular ridge as it approaches the retromolar pad are recognized as a source of denture instability.

An intraoral evaluation of a denture's fit will determine its adaptation to the denture-bearing area, how well the flanges fill the sulci, the correctness of the border extensions, and the location of the posterior palatal seal. Dentures with flanges that are deficient in extent or thickness fail to achieve their potential for support, stability, and retention. A variety of proprietary products can be applied to the tissue surface of the denture before seating that will reveal the distribution of tissue contact. These products include pressure-indicating pastes, special formulations of silicone impression materials, or even a thin mix of irreversible hydrocolloid impression material. An additional clue to a poor denture-base fit is the finding of plaque on selected

sites of the tissue surface of the denture. The tissue surface of the labial flange is a typical location. Retention of a complete denture is partially dependent on an effective border seal, which is created by closely adapting the denture to its surrounding tissues. The tissues that will surround the denture flanges and the spaces that will accommodate them should therefore be examined thoroughly. Noting their specific anatomical characteristics and dimensions during the diagnosis will help in designing the denture, in determining the size and shape of a custom tray, and in evaluating impressions. Chapter 8 describes in detail the recording of denture-bearing tissues' morphological features that need to be recruited into intaglio surface recordings. Consequently only a very concise descriptive introduction to these features is presented here.

The labial sulci anterior to the buccal frenula are often obliterated by the lips resting against the residual alveolar ridges, while severe ridge resorption usually results in the lingual boundary being undefined. An estimate of the functional depth and labiolingual width of each sulcus will help in setting objectives for impression recording and ultimately for the height and thickness of the labial flanges. The goal is to provide a denture flange that correctly supports, but does not distort the lip, while also creating a border-sealing contact with the boundary tissues without impingement on their functional movements. Essentially the same can be said of the buccal sulci, which are located distal to the buccal frenula. However, some related structures must be examined for their influence on the space. Lateral jaw movement will advance the contralateral coronoid process of the mandible toward the maxillary tuberosity. In so doing, it may significantly narrow or even obliterate the sulcus, indicating that a very thin denture flange will be needed. This diminished space will have to be recorded during impression stage. The masseter muscle, when contracting, can act through the buccinator muscle and impinge on the buccal sulcus, an effect that usually is much more pronounced in the mandibular buccal sulcus. The external oblique line of the mandible defines the lateral boundary of the buccal shelf and frequently also the buccal boundary of the mandibular buccal sulcus. However, sometimes the tissues of the cheek are easily displaced and will allow a wider mandibular buccal flange.

The alveolingual sulcus lies between the tongue and the residual alveolar ridge and body of the mandible. The mylohyoid muscle underlying its floor modifies its depth and functional shape. The sulcus should therefore be observed during movements of the tongue. Having the patient lick the lower lip from side to side with the tip of the tongue can raise the floor of this sulcus to a suitable level. The retromylohyoid fossa is the pouch forming the posterior terminus of the alveolingual sulcus on each side. The few mylohyoid muscle fibers in this region are usually weak and displaceable; however, the posterior wall of the fossa is formed by the retromylohyoid curtain, which contains the superior constrictor muscle of the pharynx. Contraction of this muscle alters the shape of the fossa, as does protrusion of the tongue. When estimating usable space in this region, it can be helpful to ask the patient to place the tongue tip in the opposite buccal sulcus. It also may be necessary to use a mouth mirror to control the tongue to permit observation.

The posterior border of the maxillary denture should ideally be placed as far distally as possible while remaining on tissues that do not move to such an extent in function as to break the border seal. This position is determined by the anatomy of the soft palate. Where this turns down abruptly, then the maximum distal extension of the denture is clearly defined, while a soft palate that slopes down gradually allows more discretion in locating the denture border. The area of transition from immovable palatal tissue to the movable soft palate, or vibrating line, is used as a guide to this location. Observation of the palate with the mouth open and the patient attempting to say the letter "k" usually will reveal the vibrating line and the degree of palatal movement. The extent to which the tissue anterior to the vibrating line can be displaced will determine the depth of the posterior palatal seal. The hamular notches, which lie between the maxillary tuberosities and the hamular processes of the medial pterygoid plates, should be identified. Even though these bony boundaries are covered by soft tissue, they usually can be palpated. Between them, the soft tissue is quite displaceable, thus affording a location for the posterior palatal seal of the maxillary denture in these regions. However, the pterygomandibular raphe originates in this area and must not be encroached upon by the denture.

If the patient's protective gag reflex is readily elicited, the optimal location of the posterior palatal seal's location becomes even more significant, since an uncontrolled gag reflex can compromise treatment. A patient's protective gag reflex can compromise dental treatment. A thorough history and oral examination will reveal the presence of an overly active reflex early in the patient/dentist relationship. The dentist can then assess the possible cause of the problem, which may be attributable to biomechanical inadequacies of existing prostheses; anatomical anomalies; or maybe even iatrogenic factors, organic disturbances, or psychological factors. Effective management of gagging tends to be based on clinical experience and anecdotal management techniques, with combinations of distraction methods and occasional medication. Usually, counseling, reassurance, and kind handling of the patient prove to be useful therapeutic adjuncts. However, patients whose chronic gagging cannot be controlled via a chairside approach may need the services of a psychologist.

The various sulci are traversed by frenula (Fig. 5-11). Some contain muscles, while others are fibrous but moved by neighboring muscles. If frenula are displaced by the denture base, then the prosthesis will be dislodged by muscular activity. Excessive adjustment of the denture base to accommodate the frenula should however be avoided because it can prevent the creation of a peripheral seal, which reduces denture retention and acts as a stress focus in the acrylic resin. The potential for these problems must



Figure 5-11 Most frenula need to be accommodated in dentures' peripheral extensions. Both the anterior labial maxillary frenum and the mandibular lingual one can be prominent and particularly active. They have to be looked out for when making final impressions and at the time of finalizing the fit of the processed denture bases.

be estimated at the diagnosis. If it is determined that the location, size, or activity of the frenula will adversely affect denture retention, then surgical repositioning or removal should be considered. Each labial and buccal frenulum must be examined to make specific determinations. The lingual frenulum also must be examined, although surgical correction often has to involve the floor of the mouth, making it uncomfortable for the patient and hence less desirable. An important consideration is interaction between the lingual frenulum and the mandibular labial frenulum. If there is insufficient attached mucosa on the ridge between the frenula to prevent movement of one causing displacement of the other, then the area of attachment must be improved surgically, otherwise the mandibular denture will be unstable as a result of the mobility of its mucosal support.

ADDITIONAL CONSIDERATIONS WITH THE PARTIALLY DENTATE PATIENT

Some patients seeking denture treatment will have a number of remaining teeth in one or both arches and are unsure about the outcomes of the different therapeutic possibilities available to them. They will require diagnosis and treatment planning that offers considered alternative options to complete dentures. While management of such potentially edentulous patients is also discussed in Chapter 6, brief reference to their treatment options (Box 5-2) includes the following considerations for either arch should retaining such patients' entire or partial dentitions be indeed feasible:

- Using traditional dental interventions—periodontal, restorative, prosthodontic, and surgical—the health of the dentition may be restored.

Box 5-2 A Primer on Treatment Options

Adjunctive Care

Elimination of infection
Elimination of pathoses
Surgical improvement of denture support and space
Tissue conditioning
Nutritional counseling

Prosthodontic Care

The patient destined to become edentulous
- Removable partial denture
  - Conventional
  - Interim
  - Hybrid complete denture/removable partial denture
  - Transitional
- Complete denture
  - Immediate or conventional
  - Definitive or interim
  - Tooth, implant, or soft tissue support

The edentulous patient
- Complete denture
  - Soft tissue supported
  - Implant supported
  - Fixed
  - Removable

Box 5-3 Clinical Conditions That Suggest Need for Teeth Extractions

- Advanced periodontal disease with severe bone loss around the teeth
- Severely broken-down crowns with subgingival residual tooth tissue that cannot be adequately restored
- Fractured roots
- Periapical or periodontal abscesses that cannot be successfully treated
- Unfavorably tipped or inclined teeth that pose problems for their use as abutments for fixed or removable prostheses
- Extruded or tipped teeth that interfere with the proper location of the occlusal plane and are not amenable to prosthodontic modification.

- Those teeth that are regarded as having poor or dubious prognoses (Fig. 5-12 and Box 5-3) may be extracted while retaining others that offer a good prognostic outcome. When assessing which teeth should be removed, consideration also must be given to their potential role in improving the stability of any intended prostheses. Removable partial dentures or



Figure 5-12 **A** to **E,** The six clinical examples shown underscore the challenge of selecting a best individual treatment option when confronted with partial or complete dentitions that reflect neglect and disease plus their consequences, as well as dental care attitudes on any patient's part.

implant-supported/retained fixed or removable prostheses may then be prescribed to compensate for the missing dentition.

- Alternatively, specific teeth can be selected as potential abutments for overdenture treatment with or without adjunctive implant support. Where implant treatment is not contemplated at this stage, consideration also should be given to the retention of endodontically treated roots not only to provide overdenture support but also to minimize bone resorption on an interim basis before eventual implant placement.
- Extraction of all remaining teeth with immediate denture replacement is another option.

The remaining teeth should be examined and evaluated carefully. It must be recalled at all times that the loss of all of one's teeth can be a terrible psychological shock to patients, even though some of them may not admit it. Consequently, the dentist should be empathetic to patients facing potential removal of their remaining teeth and every possibility for saving them should be explored. When patients recognize that the dentist would in principle prefer to retain teeth, a necessary feeling of confidence can be developed. Even patients who say that they cannot wait to get rid of their teeth to avoid further dental care rarely do, in fact, wish to do so. Often they are only trying to prepare their defenses against future difficulties they do not understand. If the dentist removes teeth without adequate reason, physical, mental, and even legal problems may arise. The clinician must therefore avoid a premature decision to extract the remaining teeth until all the facts and possible treatment alternatives have been considered. And above all the dentist must be prepared to provide all the alternative treatment options that may reconcile patients' needs and expectations with prudent clinical judgment as to what is most likely to provide a successful outcome with the minimal risk of morbidity.

The number and location of remaining teeth must be carefully noted. Perception sometimes fulfills expectations, as was mentioned earlier. Drifted teeth can masquerade as missing neighbors. Each tooth should be identified and notations should be made of drifted or malaligned teeth. The coronal structure of remaining teeth should be examined for the quality of both the natural components and any restorations. The fracture or ditching of restorations, the extent of caries, and the presence of cracks, especially vertical cracks extending into the root, should be determined. The questions to be answered include the following: Is this tooth satisfactory to survive on its own? Can it support a removable partial denture? Can it be restored? Can it be used as an overdenture abutment? Periodontal support is another major factor in the decision to preserve teeth or render a patient edentulous. If significant periodontal disease is found, its extent and the prognosis for treatment become factors in deciding on retention or extraction of the affected teeth.

RADIOGRAPHS, PHOTOGRAPHS, MEASUREMENTS

RADIOGRAPHIC IMAGES (FIG. 5-13)

Radiographs are important aids in the evaluation of submucosal conditions in patients seeking prosthodontic care. Although they reduce the three-dimensional oral structures to two-dimensional shadow pictures, somewhat enlarged and perhaps distorted, they do show very useful information. They first and foremost provide information about the presence or absence of pathoses or abnormalities, as well as insights into the quantity and, to a limited extent, the quality of bony tissues. The presence of abnormalities in edentulous jaws, or in the edentulous segments of partially edentulous jaws, may be unsuspected because of the absence of clinical signs or symptoms, but they do occur and can be seen on radiographic examination. These may be foreign bodies; retained tooth roots; unerupted teeth; or various pathoses of developmental, inflammatory, or neoplastic origin. Radiographs also aid in determining the depth of periodontal pockets and can provide information about the bone surrounding the apices of pulpless teeth. They can show the amount of bone lost around the remaining teeth and in the edentulous regions. They also can show the relative thickness of the submucosa covering the bone in edentulous regions, the location of the mandibular canal, and the mental foramina in relation to the basal seat for dentures. They can give an indication of the quality of the bone that supports residual teeth and, eventually, the dentures. Unfortunately, this information is not always reliable because of variations in radiographic techniques, exposure times, and developing procedures. However, the denser (radiopaque) the bone appears to be, the better the bony foundation. Sharp spicules of bone on ridge crests and spiny ridges also may be detected on dental radiographs. These are findings that may affect decisions about impression techniques and denture-base design that will be planned.

Local bone disease and anatomy can be significant factors in prosthodontic care. Retained roots of teeth, abscesses, cysts, and other pathoses have to be identified and differentially diagnosed. Appropriate treatment must then be planned. Some retained roots will be partially resorbed and difficult to distinguish from surrounding bone. Attempts to remove these surgically often are frustrating and only partially successful. If such roots are asymptomatic and apparently covered completely in bone, they are usually best left undisturbed. The patient should be made aware of their presence and the rationale for leaving them. Roots covered only by mucosa and roots with clearly defined periodontal ligaments, associated cysts, or abscesses should be removed.

Intraoral radiography is the most frequently used format in dentistry, with the periapical approach considered

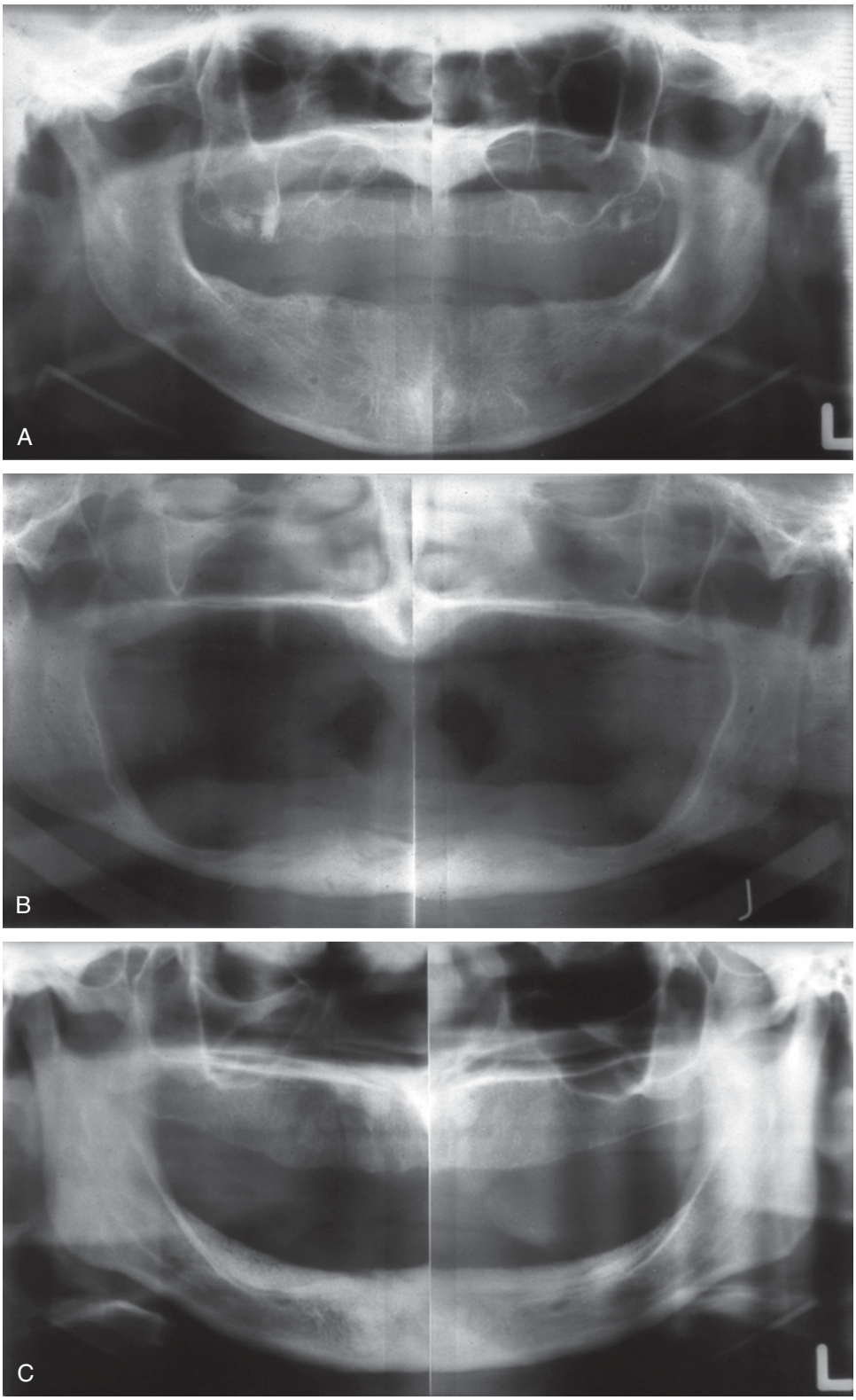


Figure 5-13 Radiographic images are necessary to ensure that abnormalities and pathoses are identified, and if needed, addressed before complete denture management is undertaken. Fig. 5-7 identifies the superficial position of the mental foramina, while **A** shows favorable ridge morphology and tooth roots in posterior maxillary regions. Compromised ridge morphology is quite clear in **B** together with superficially located mental foramina. Both the two-dimensional quantity of bone support, size, and location of maxillary sinuses, plus presence of an alloplastic-only graft in the mandible, are clearly shown in **C.** This is a typical example of the sort of "scout" view for selecting implant host sites before more sophisticated imaging is undertaken.

essential for caries detection and the evaluation of periodontal support. The small film size allows placement close to the structures of interest, resulting in less magnification than panoramic radiography. Similarly, the small films can be kept flat and thus avoid distortion of the image. Although these features suggest the value of this format when teeth are present, this format should not be overlooked in edentulous patients. Maxillary tuberosities, for example, often are not clearly seen in panoramic radiographs but can be clearly seen in profile on periapical films. In fact, this format should be used to further explore any suspicious areas not clearly seen on large-format films. Although the word *film* has been used here, the same comments will apply to this format when recorded by means of direct digital radiography. Occlusal format films are designed to be held on the occlusal surface of the teeth and exposed appropriately from above or below the jaws to provide a view of a whole arch. Like the periapical approach, it captures all structures in the path of radiation. The profile it provides is particularly helpful for diagnosing apparent expansion of the bone buccally or lingually, such as may occur with cysts or retained roots. Panoramic dental radiography provides a general survey of a patient's denture foundation and surrounding structures and is readily available for the convenient examination of both dentulous and edentulous patients. The dentist must be aware that such radiographs incorporate inaccuracies resulting from the tomographic principles of this type of radiograph. Modern machines have adjustments to compensate for some of these problems, but they do not produce precisely accurate pictures of the bony anatomy. Magnification of structures is common with this technique and is of the order of 25%. Because the machines are programmed to capture a predetermined anatomical "slice," structures outside that slice can be missed. This can happen most easily for small structures such as ectopic root tips. Knowledge of the location of anatomical structures, as they are normally projected on panoramic radiographs, is an essential prerequisite for reading panoramic radiographs. Suspicious areas should be examined in more detail with intraoral radiographic techniques.

Recent technical developments are increasingly providing the profession with computerized radiographic systems capable of generating three-dimensional images of the jaws. Such devices are of considerable value when planning implant procedures.

PHOTOGRAPHIC IMAGES

Preextraction photographs can be useful for determining teeth selection and arrangement. Observations on face form and jaw relations also can be made. Frequently, patients can supply nonstandardized photographs that reveal much of the same information. Age is not a major factor when selecting teeth from preextraction information. The presence of natural teeth is important even if the patient's mouth is closed because some information on circumoral support and smile lines may be usually gleaned from a series of old pictures. When asking patients for such photographs, it helps to explain how they will be used (i.e., for background information and not necessarily as a blueprint for new dentures).

MEASUREMENTS

Both specific intraoral and extraoral measurements may be of clinical help, have been outlined earlier in this chapter, and are described in more detail later in this text as an integral part of clinical protocols. The clinical determination of the vertical dimension of occlusion (VDO) and the rest vertical dimension (RVD) is an imprecise procedure because use must be made of soft tissue landmarks that are not always easy to identify with precision and are frequently displaced as part of the measuring process or patient movement. A variety of techniques has been proposed; however, it has been recommended that the clinician use more than one to better estimate the vertical dimension. Where anatomical landmarks such as the menton and the columella of the nose are used, then note of this should be made in the patient's chart to facilitate subsequent determinations. Consistency of the dentist's technique will foster improved reliability of these repeated measurements.

Other extraoral measurements that are sometimes made relate to specific procedures such as tooth selection. For example, the patient's true interpupillary distance can be compared with the interpupillary distance measured on a full face photograph; a ratio can then be calculated and used to determine a replacement tooth size from the patient's own tooth as depicted on the photograph.

DIAGNOSTIC/STUDY CASTS

Diagnostic or study casts are invaluable because they offer a versatile and three-dimensional analogue of both available denture-bearing areas and currently used prostheses. They provide accurate information on tooth size and arrangement, and when articulated, also can reveal jaw relationships and interarch tooth relationships. Diagnostic casts are both a convenience and a necessity. Moreover, arch size and symmetry; interarch space; arch concentricity; anteroposterior jaw relationship; and lateral jaw relationships, especially posteriorly where an occlusal crossbite might be indicated, can be more readily visualized. Measurement and a determination of relationships to other structures will assist in making decisions on preprosthetic surgery. Undercuts may be observed unaided or their significance determined more precisely with the aid of a dental surveyor. Even soft tissue disease may be more obvious on a cast than intraorally when saliva and color may obscure information. Tissue displacement from the pressure of an old ill-fitting denture also may be more obvious on a dry cast than in the mouth.

FINANCIAL IMPLICATIONS

Both dentist and patient also must consider the financial implications of any selected treatment plan. An optimal treatment plan is useless if the patient cannot afford it, or his or her funding, whether it is insurance or state-based, is inadequate. The diagnosis must therefore determine the significance of the identified problems and prioritize the need for treatment to permit the development of a treatment plan that balances the patient's needs and ability to pay. The diagnostic findings should be evaluated to allow consideration of interim care, deferred treatment, and alternative treatment

DEVELOPMENT OF THE TREATMENT PLAN

After all the intraoral and general physical and dental conditions have been recorded and radiographs, casts, and other visual aids are in hand, they can be interpreted and the treatment plan developed (Fig. 5-14). The details of the specific observations determine the details of the treatment required. If teeth are present, this includes which ones are to be saved and how, which teeth are to be extracted, the tooth-removal sequence, the type and extent of oral surgery that might be required, and the type of prosthesis that is indicated. Should it be an overdenture, an immediate overdenture, a conventional immediate complete denture, or an interim immediate denture, or even a transitional denture? Is the situation an unusual one in which all the teeth should be removed and an interim period for tissue healing provided before new dentures are made? If preprosthetic surgery is required, the specific type of intervention must be selected and explained to the patient as an integral part of the treatment protocol, and if so, in which capacity? Are implants to be recruited for prosthesis stability? Will the ultimate goal be an implant-supported fixed prosthesis or an overdenture one? These questions are addressed specifically in the next chapters.

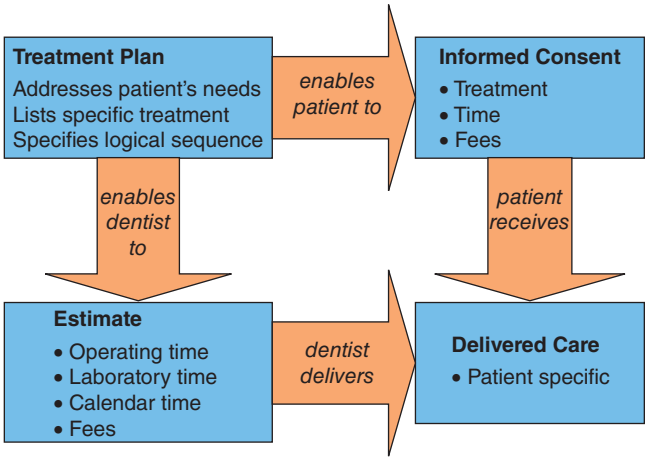


Figure 5-14 Why treatment plan.

SUMMARY

Treatment planning is the process of matching possible treatment options with patients' needs and systematically arranging the treatment in order of priority but in keeping with a logical or technically necessary sequence. The process requires a broad knowledge of treatment possibilities and detailed knowledge of patient needs determined by a careful diagnosis. A dentist approaching treatment planning with a deficiency in either of these categories of knowledge places the patient in jeopardy of receiving inadequate or inappropriate care. The dentist also must resist the natural tendency to include in a treatment plan only that treatment that they feel competent to deliver. Patients requiring treatment beyond the competency of the treatment planner should be referred to more experienced colleagues or specialists. When presented with adequate explanations, patients appreciate referrals as expressions of the dentist acting in their best interests. Failure to make such referrals is unethical and can lead to litigation. The consequences of providing or not providing active treatment must be considered. Treatment planning must have a parallel process of developing a prognosis. Although it is driven by the diagnosis, other factors such as a prognosis, patient health, and education also must be taken into account (Fig. 5-15).

IMPROVING DENTURE-BEARING FOUNDATIONS FOR EDENTULOUS PATIENTS

The vast majority of patients for whom complete denture therapy is prescribed have already been using dentures and frequently demonstrate adverse supporting tissue changes. This is the so-called biologic price inherent in wearing removable prostheses and is often manifested as one or more of several conditions that should be corrected or treated before denture treatment is started. This part of Chapter 5 reviews the more commonly encountered changes that lend themselves to both nonsurgical and surgical management protocols.

Treatment methods to improve the patient's denture foundation and ridge relations are usually either nonsurgical or surgical in nature but can be a combination of both methods.

PREPROSTHETIC NONSURGICAL METHODS

Dentures can apply excessive forces to the supporting tissues because of poor fit or occlusal errors. These loads may be localized or generalized and can cause accelerated bone resorption, inflammation, and hyperplasia. The latter soft tissue conditions must be treated before denture

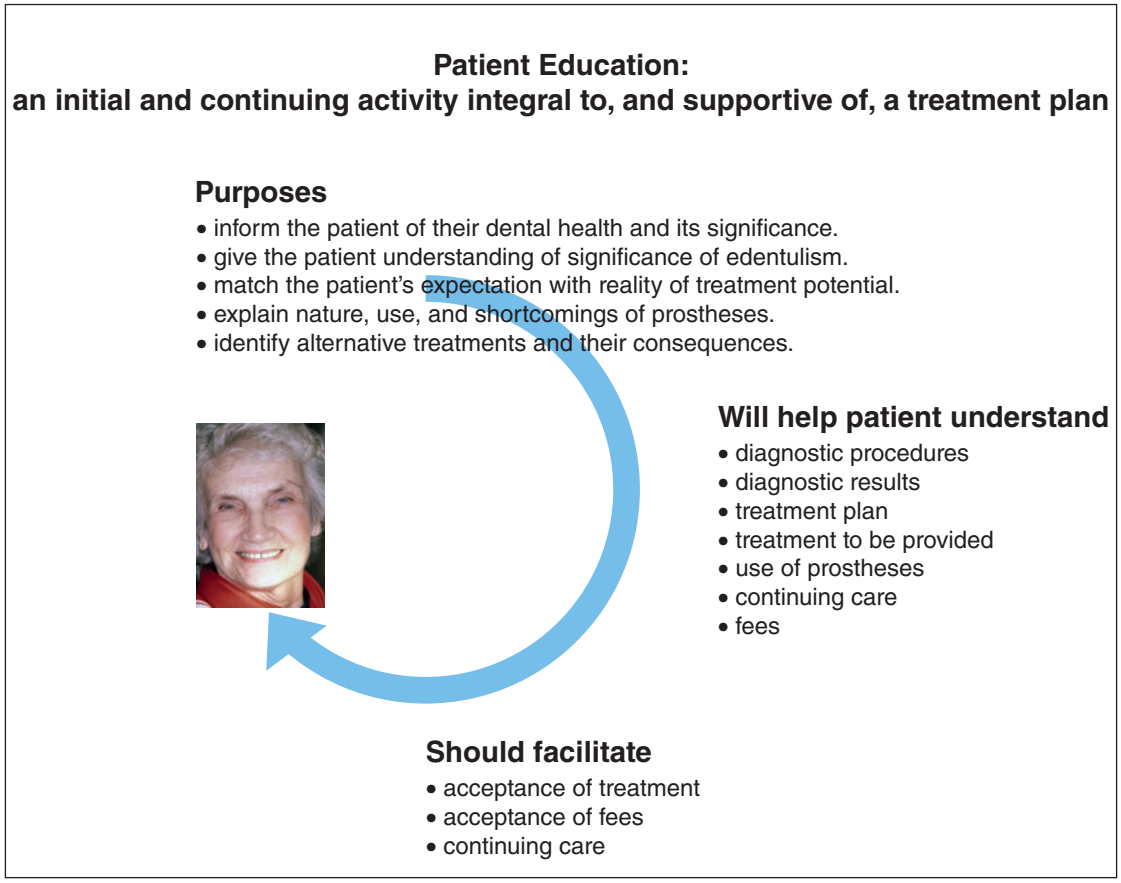


Figure 5-15 Patient education.

construction and can often be improved significantly by nonsurgical procedures such as those subsequently described.

MANAGING TRAUMATIZED TISSUES

Rest for the denture-supporting tissues can be achieved by removal of the dentures from the mouth for an extended period or the use of temporary soft liners inside the old dentures. Both procedures allow deformed tissue of the residual ridges to return to normal form (Fig. 5-16). However the latter overcomes the problem of appearing edentulous in public for an extended period. Clinical reports and experience also support the merits of regular finger or toothbrush massage of denture-bearing mucosa, especially of those areas that appear edematous and enlarged.

It also has been demonstrated that tissue abuse caused by improper occlusion can be corrected by (1) withholding the faulty dentures from the patient, (2) adjusting/correcting the occlusion and refitting the denture by means of a tissue conditioner, and (3) substituting properly made dentures once the denture-bearing tissues have recovered. This usually can be readily achieved by removing the dentures for 48 to 72 hours before the impressions are made for the construction of new dentures. However, this protocol is rarely feasible and treatment with so-called "tissue treatment or conditioning materials" is usually employed. These temporary lining materials consist of a polymer powder and an aromatic ester ethanol mixture and are both elastic and plastic. Consequently they provide an interim cushioning stage and allow the tissues to recover their unstressed shape. Their softness is maintained for several days while the tissues recover, and they have been widely used in dentistry for many years. They offer expanded scope for *short-term* resolution of patients' problems in removable prosthodontics.

Additional uses of these soft-lining materials include their use as liners for surgical splints and trial denture-base stabilizers. They also have been used as an adjunctive technique for optimal arch form or neutral zone determination. Clinical experience also indicates that soft liners may be used as functional impression materials when relining or refitting complete dentures provided that due regard is made of their physical properties (see Chapter 7).

It is well recognized that denture-bearing tissues demonstrate microscopic evidence of inflammation, even if they appear clinically normal. Consequently, tissue rest for at least 24 hours plus the additional use of tissue conditioners are regarded as essential preliminaries to each prosthetic

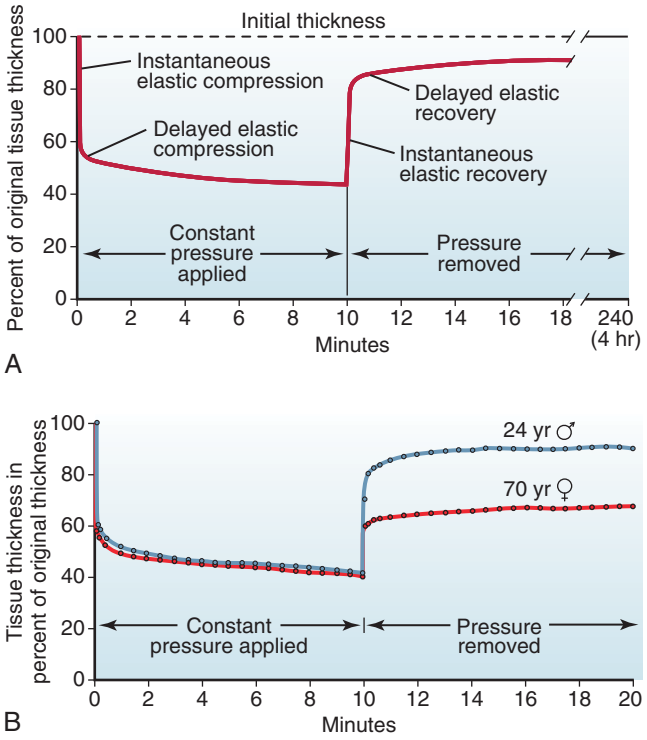


Figure 5-16 **A,** Typical behavior of tissue under a constant load for 10 minutes. Notice the 90% recovery within 8 minutes after removal of the pressure. Total recovery requires 4 hours. **B,** Comparison of responses to tissue loading and removal of the load in an elderly adult and a young adult. The compression curve is essentially the same. However, the removal of load shows definite differences in rate of recovery. The load was 11 g/mm^2. *(Redrawn from Kydd WL, Daly CH, Wheeler JB: The thickness measurement of masticatory mucosa in vivo,* Int Dent J *21[4]:430-441, 1971.)*

appointment. Tissues recover rapidly when the dentures are not worn or when treatment liners are used. The method of achieving optimal health of the denture-bearing tissues is not as important as the result (the tissues being made healthy). Many dentures fail because the impressions or registrations of the relations are made when the tissues are distorted by the old dentures. The same error is frequently committed when dentures are relined without adequate denture-bearing tissue rest or tissue treatment.

OCCLUSAL CORRECTION OF THE OLD PROSTHESES

Interim use of temporary liners is invaluable in the restoration and determination of an optimal VDO for the dentures presently worn by the patient. This step helps the dentist predict the amount of vertical facial support that the patient can tolerate and also allows any deformed tissues to recover. The decision to create room inside the denture for the addition of the tissue conditioner depends on its fit and the condition of the tissues; however, the liner material is frequently just added to the denture's intaglio surfaces. The material also permits some movement of the denture base, so its position tends to some extent to become compatible with the existing occlusion, apart from allowing the displaced tissues to recover their original form. Consequently, ridge relations are improved, and this improvement facilitates a preliminary occlusal adjustment, as well as the dentist's eventual relation registration procedures. It must however be emphasized that although the lining material will alter the occlusion, this is not its prime purpose other than to change the VDO. Its use must therefore be accompanied by an assessment of the occlusion and any necessary alterations to the occlusal surfaces of the teeth. This may involve grinding or the addition of material to the teeth.

It also may be necessary to correct the extent of tissue coverage by the old denture base so all usable supporting tissue is included in the treatment. This correction can easily be achieved by use of one of the resin border–molding materials combined with a tissue conditioner.

Box 5-4 Objectives of Preprosthetic Surgical Prescriptions

1. Correcting conditions that preclude optimal prosthetic function
   - Localized or generalized hyperplastic replacement of resorbed ridges
   - Epulis fissuratum
   - Papillomatosis
   - Unfavorably located frenular attachments
   - Pendulous maxillary tuberosities
   - Bony prominences, undercuts, and ridges
   - Discrepancies in jaw size relationships
   - Pressure on mental foramen
2. Enlargement of denture-bearing area(s)
   - Vestibuloplasty
   - Ridge augmentation
3. Provision for placing tooth root analogues by means of osseointegrated dental implants

PREPROSTHETIC SURGICAL METHODS

Infrequently, certain conditions of the denture-bearing tissues require surgical interventions. These conditions may be the result of unfavorable morphological variations of the denture-bearing area, or more commonly, they result from long-term wear of ill-fitting dentures. The objectives of prescribing a preprosthetic surgical procedure are listed in Box 5-4. It must be emphasized that these interventions are infrequently mandatory. It is often far easier to accommodate the morphological conditions by making alterations

in the prosthetic techniques and materials used than to subject the patient to a surgical intervention. The key consideration is whether a good prosthodontic prognosis will result from the surgical outcome.

SURGICAL CORRECTION OF CONDITIONS THAT PRECLUDE OPTIMAL PROSTHETIC FUNCTION

Hyperplastic Ridge, Epulis Fissuratum, and Papillomatosis (Fig. 5-17)

The premise underscoring surgical intervention is that mobile tissues (e.g., a hyperplastic ridge) that interfere with optimal seating of the denture, localized enlargement of peripheral tissues (an epulis), or tissues that readily harbor microorganisms (a papillomatosis) are not conducive to firm, healthy foundations for complete dentures. Whenever possible, these tissues should be rested, massaged, or treated with an antifungal agent before their surgical excision. This often results in a considerable reduction in the edema, making the surgical procedure simpler and less extensive. Healing is faster, scarring reduced, patient comfort improved, and a better prosthodontic result achieved. If the patient's health or a personal choice precludes surgical intervention, then the impression technique and design of the denture base have to be modified to accommodate the mobile tissue and minimize its distortion.

Frenular Attachments and Pendulous Maxillary Tuberosities

Frena are fibrous bands of tissue attached to the bone of the mandible and maxillae and are frequently superficial to muscle attachments. If the frenum is close to the crest of the bony ridge (Fig. 5-18, *A*) it may be difficult to obtain the ideal extension and border of the flange of the denture. The upper labial frenum in particular may be composed of a strong band of fibrous connective tissue that attaches on the palatal side of the crest of the residual ridge. This tissue usually should be removed surgically. Frena often become prominent as a result of reduction of the residual ridges. If muscle fibers are attached close to the crest of the ridge when frena are removed, the muscles usually are detached and elevated or depressed to expose the amount of desired ridge height. The frenectomy can be carried out either before prosthetic treatment is begun or at the time of denture insertion when the new prosthesis can act as a surgical template. The former is preferred because the patient will not have to contend with postoperative discomfort along with adjustment to the dentures.

Pendulous fibrous maxillary tuberosities (Fig. 5-18, *B*) are frequently encountered. They occur unilaterally or bilaterally and may interfere with denture construction by excessive encroachment on or obliteration of the interarch space. Surgical excision is the treatment of choice (see Fig. 5-20), but occasionally maxillary bone must be removed. Care must be used to avoid opening into the maxillary sinus. In those instances in which the sinus dips down into a pneumatized and elongated tuberosity, it may be possible to collapse the sinus floor upward without danger of opening into it. This technique also is used when a bony undercut exists on the buccal side of the tuberosity and the sinus has pneumatized into the undercut.

Bony Prominences, Undercuts, Spiny Ridges, and Tori

Bony prominences, undercuts, spiny ridges, and tori may have to be removed to avoid painful denture flange impingement and to achieve a border seal beyond them against the floor of the mouth (Fig. 5-19). They may occur so close to this structure that a border seal cannot be achieved on the denture's periphery. On the other hand, maxillary tori are rarely removed because satisfactory dentures can be made over most of them by careful relief of the palatal denture-base material. The following are indications for the removal of maxillary tori:

- An extremely large torus that fills the palatal vault and prevents the formation of an adequately extended and stable maxillary denture
- An undercut torus that traps food debris, causing a chronic inflammatory condition; surgical excision is necessary to create optimal oral hygiene
- A torus that extends past the junction of the hard and soft palates and prevents the development of an adequate posterior palatal seal
- A torus that causes the patient concern

Exostoses may occur on both jaws but are more frequent on the buccal sides of the posterior maxillary segments (Fig. 5-20). They may create discomfort if covered by a denture and usually are excised. It must be emphasized that routine excision of all mandibular exostoses is rarely recommended. Frequently the denture can be easily relieved to accommodate the exostosis, or a so-called permanent soft liner can be used.

Sometimes the genial tubercles are extremely prominent as a result of advanced ridge reduction in the anterior part of the body of the mandible (Fig. 5-21). If the activity of the genioglossus muscle has a tendency to displace the lower denture or if the mucosa over the tubercle cannot tolerate the pressure or contact of the denture flange in this area, then it may have to be removed and the genioglossus muscle detached. Should it be clinically necessary to deepen the alveololingual sulcus in this area, then the genioglossus muscle is sutured to the geniohyoid muscle below it.

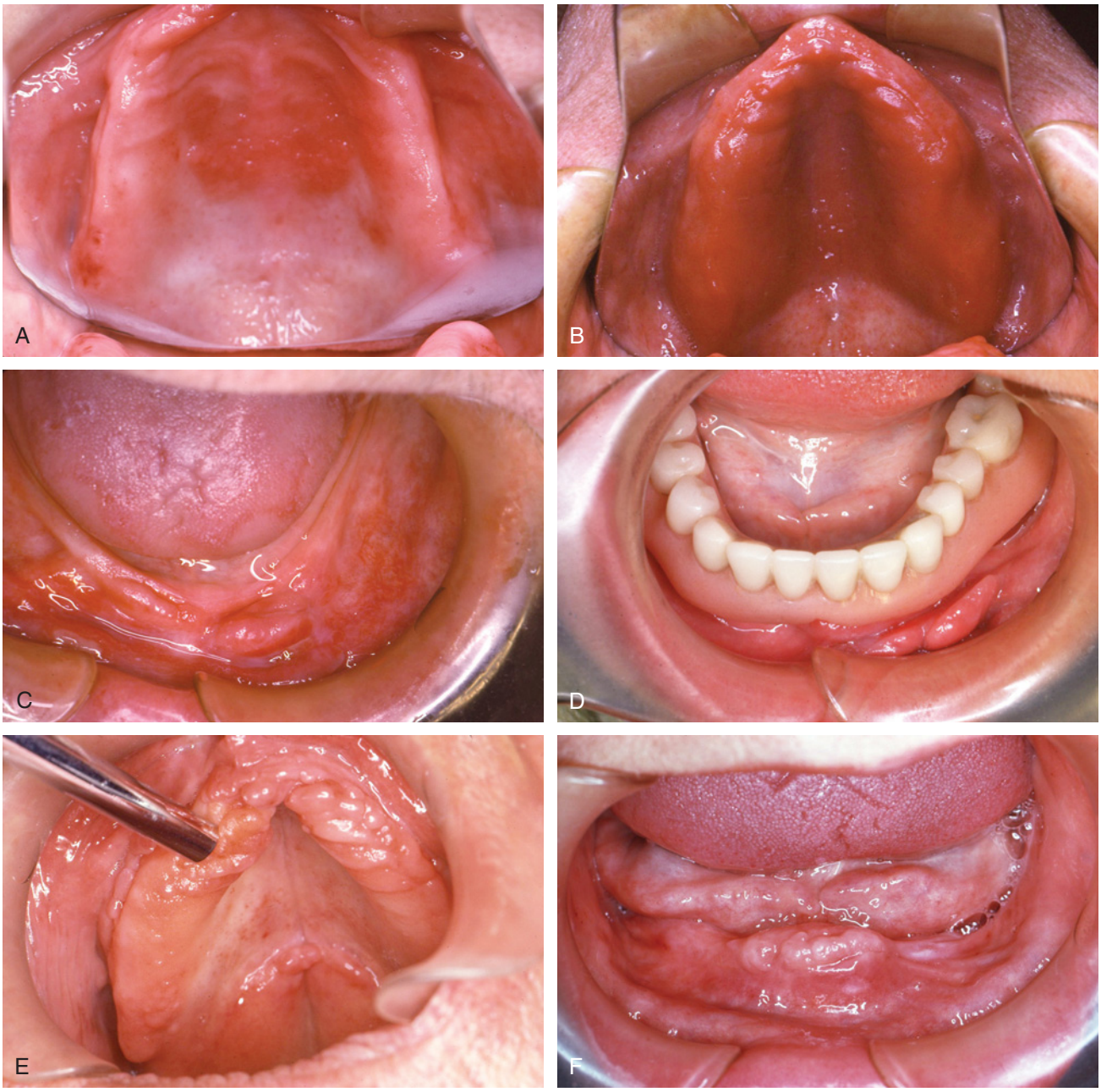


Figure 5-17 **A,** Mild and restricted palatal hyperplasia that contrasts with a severe example seen in **B,** which is accompanied by an overt stomatitis. An epulis fissuratum and its cause are shown in **C** and **D**, with hyperplastic ridge replacement in **E** and **F**.

Residual alveolar ridge undercuts (Fig. 5-22) are rarely excised as a routine part of improving a patient's denture foundations because considerable evidence exists that any residual ridge surgery causes excessive bone resorption. Moreover, a path of insertion and withdrawal of the prosthesis can be readily determined together with careful adjustment of a denture flange, which enables the dentist to use the undercuts for extra stability. However, the dentist may choose to remove a severe undercut that occurs opposite the lingual side of mandibular second and third molars and is tender to palpation. Such an undercut is caused by a sharp mylohyoid ridge that is usually covered by very thin mucosa. Diagnostic casts can be surveyed as a guide in the assessment of the minimal amount of tissue to be removed. It must be emphasized not all prominent mylohyoid ridges are tender on palpation and that undercuts frequently occur

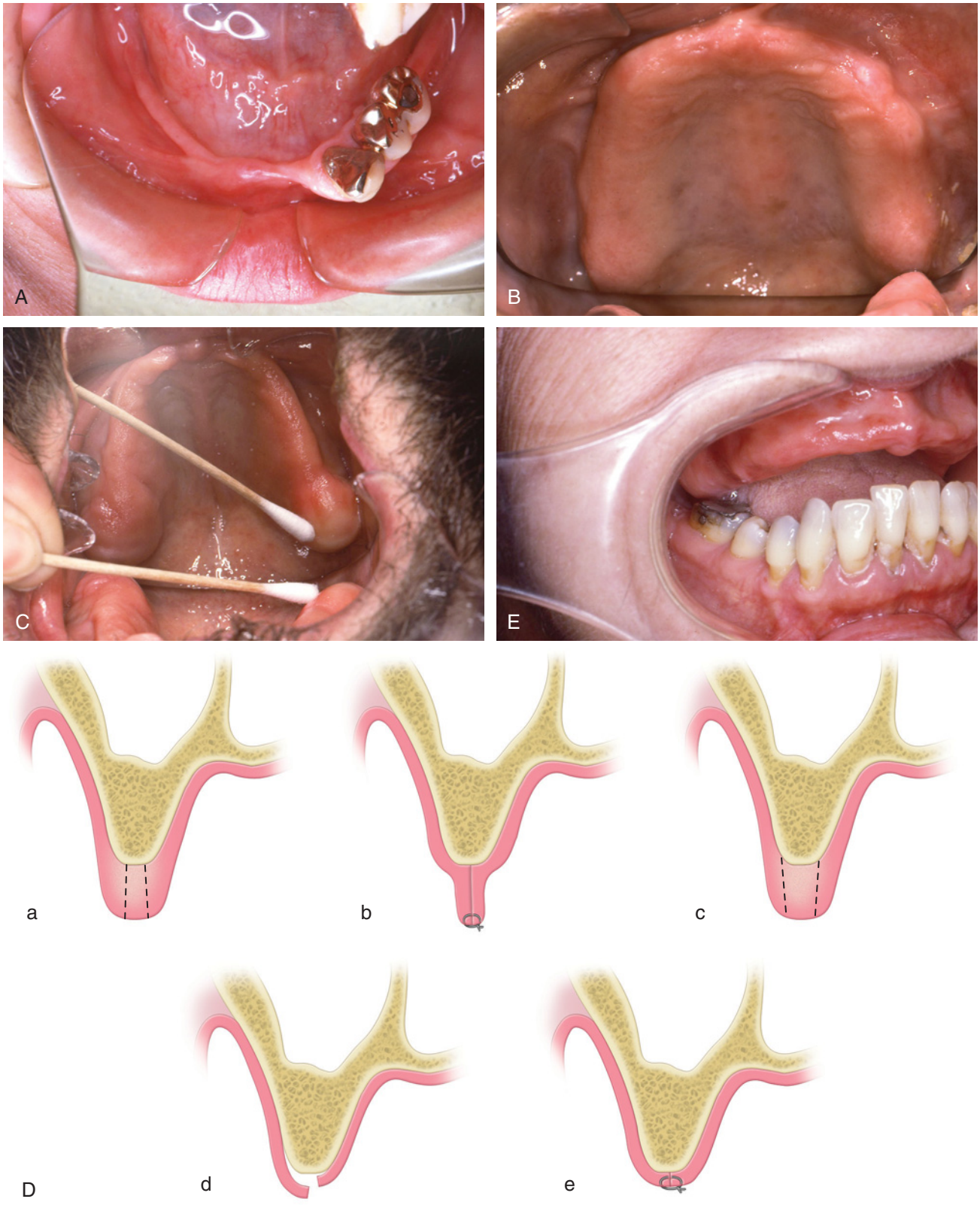


Figure 5-18 Mandibular **(A)** and maxillary **(B)** frenula that may undermine prosthesis retention may need to be surgically corrected. **C,** Flabby, mobile tuberosity should be excised as shown in part **D** (*a,* incisions made in fibrous tuberosity; *b,* wedge of fibrous tissue removed; *c,* incisions made under the mucosa for removal of all unwanted fibrous connective tissue; *d* and *e,* thin mucosal flaps fitted, trimmed, and sutured). In part **E,** the compromised vertical space challenge may be approached surgically, or better still, by reducing the height of the mandibular molar to accommodate the opposing acrylic resin base but without a prosthetic tooth.

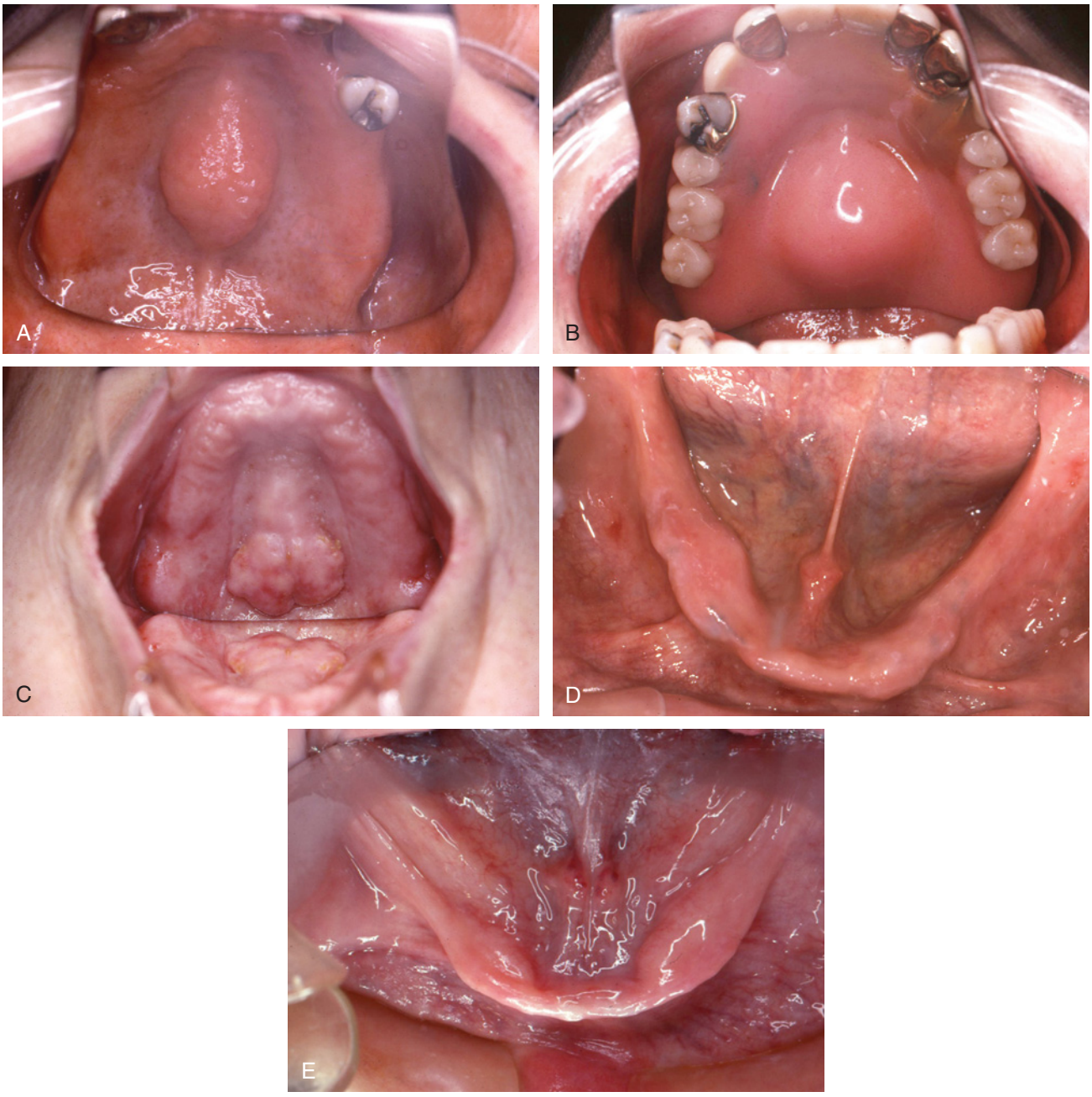


Figure 5-19 Different sized and located maxillary and mandibular tori (**A** to **E**) may be managed by relief design in the acrylic resin denture bases (shown in part **B**), or else by surgical excision. The latter is indicated if the tori are particularly large, extend distally in the maxilla so as to compromise the efficacy of the posterior palatal seal, or else preclude the desired basal seat coverage for a mandibular prosthesis.

in this area and can often provide added stability for the denture. The path of insertion in such a situation is altered to allow for distal placement of the lingual flanges with a downward and forward final seating movement. Alternatively, one undercut area can be relieved in the denture to permit engagement of the remaining undercut area for retentive purposes.

Pressure on the Mental Foramen

If bone resorption in the mandible has been extreme, the mental foramen may open near or directly at the crest of the residual bony process (Fig. 5-23). When this happens, the bony margins of the mental foramen usually are more dense and resistant to resorption than the bone anterior

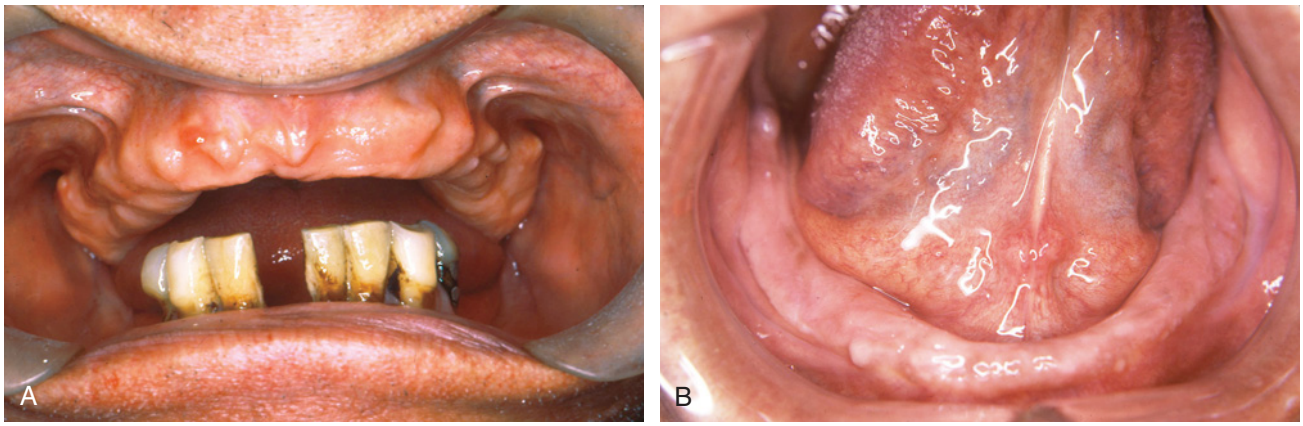


Figure 5-20 Different sized and located exostoses (**A** and **B**) may interfere with comfortable and convenient wearing of dentures and their insertion/withdrawal.

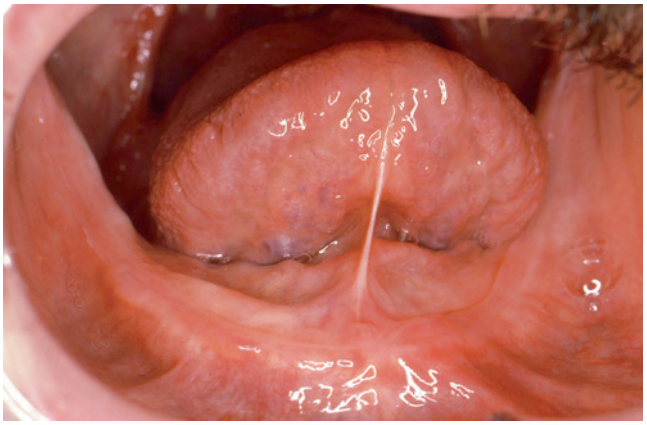


Figure 5-21 Enlarged genial tubercles that encroach on the available potential denture-bearing area in the mandible are infrequently encountered but may still have to be surgically reduced if denture stability is compromised. The problem can now be readily avoided by relying on implant abutments for the desired retention and support.

or posterior to the foramen. This causes the margins of the mental foramen to extend and have very sharp edges, typically 2 to 3 mm higher than the surrounding mandibular bone. Pressure from the denture on the mental nerve exiting the foramen and over this sharp bony edge will cause pain and sometimes paresthesia in its area of distribution. Pain also can occur in the oral mucosa overlying the sharp bone as it is pinched by the denture. The most suitable way of managing this is to adjust the denture to relieve the pressure. However, in rare instances, it may be necessary to reposition the mental foramen more inferiorly. This allows the mental nerve to exit the bone at a lower level, thereby relieving the pressure.

Occasionally, the anterior part of the residual ridges becomes so resorbed that it is extremely thin labiolingually, and it may have a sharp knife-edge from which protrude small spicules of bone (Fig. 5-24). Careful denture relief in these areas frequently overcomes this problem. If, however, constant irritation develops as a result of the soft tissue being pinched between the denture and the bone, then the spicules and the knife-edged ridge must be surgically reduced.

Ridge Parallelism

A lack of parallelism between the maxillary and mandibular ridges can be encountered and, on occasion, may require surgical correction. This lack of parallelism may be caused by failure to trim the tuberosity and ridge behind the last maxillary tooth when it was removed or may be the result of jaw defects, unequal ridge reduction, or abnormalities of growth and development. Most clinicians favor parallel ridges for their denture foundations because the resultant forces generated are directed in a way that tends to seat the dentures rather than dislodge them. Also, the height of the occlusal plane of the upper denture can be elevated posteriorly to improve the denture esthetically.

Virtually all the surgical procedures described necessitate the use of a surgical template. The patient's old dentures usually can be modified and lined with a tissue conditioner to function as such. The use of a soft-lined prosthesis protects the operated area from trauma and enables the patient to continue wearing the dentures. All the surgical interventions mentioned in this chapter must be considered in the context of their potentially harmful effects on residual ridge resorption and recognition that extensive surgical preparation of the edentulous mouth is rarely necessary. In fact, clinical experience indicates that careful prosthetic technique and design frequently can preclude a surgical intervention. The obvious exception to this observation is the use of implants, which have significantly improved treatment outcomes for patients with a maladaptive denture experience.







Figure 5-22 Alveolar ridge undercuts are shown in parts **A** and **B**. These bony morphological variations may be regarded as a clinical nuisance. However, they also may be readily recruited into a denture's retention objectives via planned modification of the acrylic resin flanges **(C)**.



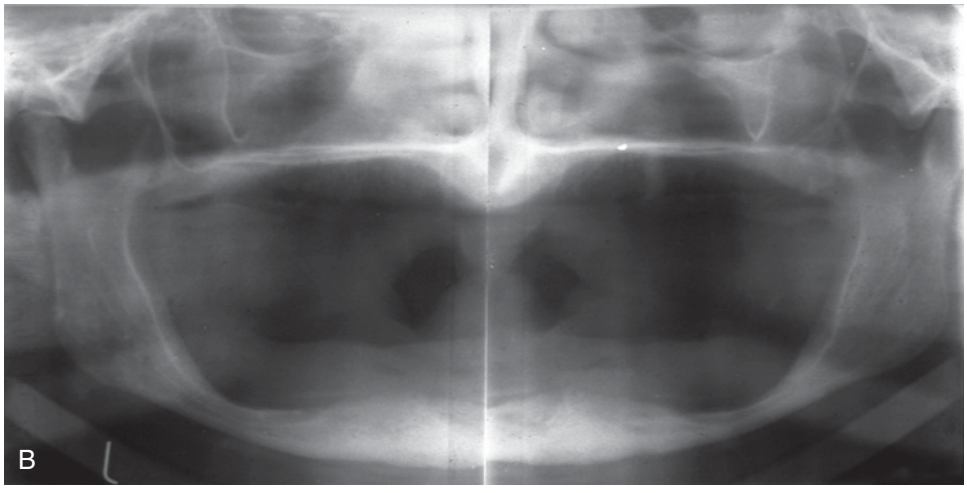


Figure 5-23 Advanced residual ridge resorption **(A)** almost invariably leads to palpable and often painful superficially placed mental foramina **(B).**

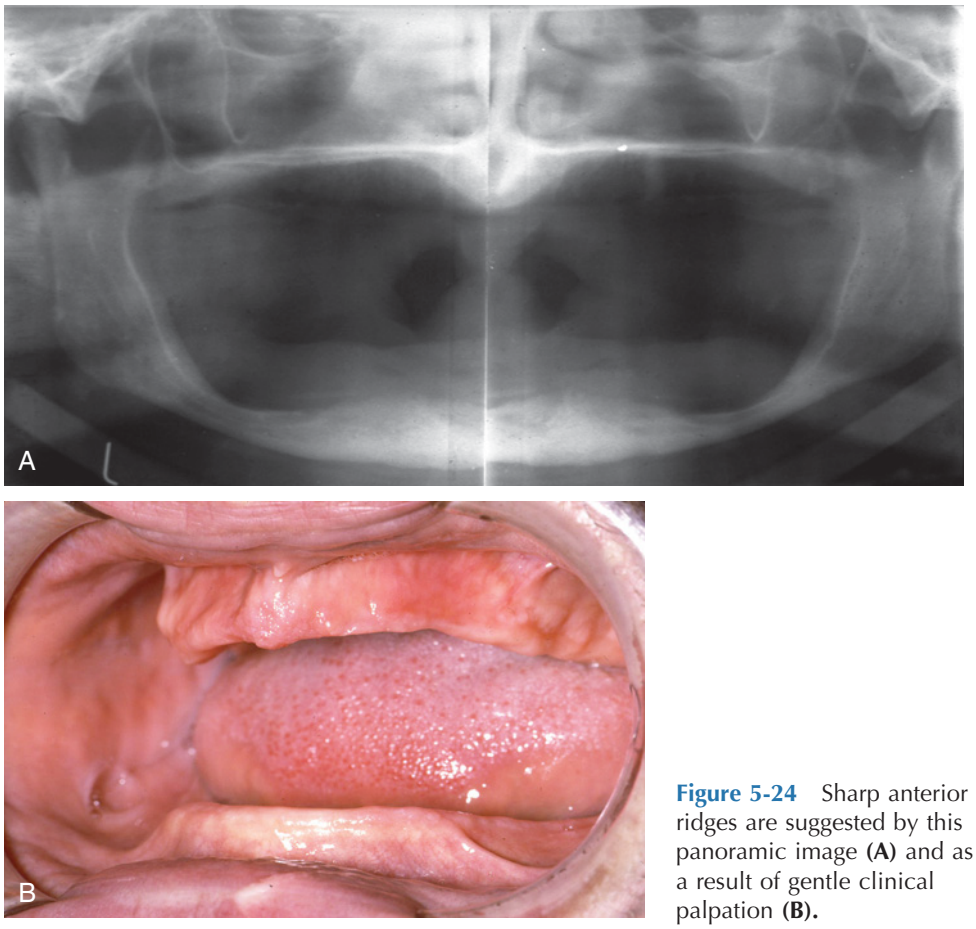


Figure 5-24 Sharp anterior ridges are suggested by this panoramic image **(A)** and as a result of gentle clinical palpation **(B).**

ENLARGEMENT OF DENTURE-BEARING AREAS

For many years, heavily resorbed alveolar ridges and the associated shallow sulci were considered major causes of difficulties in the use of complete dentures. While such unfavorable anatomy certainly contributes to denture problems, it is but one of many systemic and local issues that may be involved.

Nonetheless it has been tempting for some clinical educators to develop classifications of residual ridge morphology that should be used as a diagnostic guide to reconcile morphological features with treatment choice and prognosis. One popular one was published in 2004 by McGarry et al (Box 5-5).

Over the years, an expanding interest in preprosthetic surgery led to the development of techniques designed to enlarge the denture-bearing areas. These involved either extending the sulcus (vestibuloplasty) or enlarging the ridge by bone grafting. The former technique also sometimes involved the use of skin or mucosal grafts to maintain the patency of the newly acquired sulcular depth. Although the techniques did not always provide benefit to the anticipated degree and were frequently accompanied by varying degrees of morbidity, they did contribute to a broader understanding of surgical/prosthodontic synergies that have now become such an integral part of implant prosthodontics.

Vestibuloplasty

The reduction of alveolar ridge size is frequently accompanied by an apparent encroachment of muscle attachments on the crest of the ridge. These so-called high (mandibular) or low (maxillary) attachments serve to reduce the available denture-bearing area and to undermine denture stability. The anterior part of the body of the mandible is the site most frequently involved with the labial sulcus virtually obliterated, and the mentalis muscle attachments appearing to "migrate" to the crest of the residual ridge (Fig. 5-25). This usually results in the dentist's arranging the teeth in a position more lingual than the position of the former anterior teeth. This lingual encroachment may not be tolerated

Box 5-5 Classifications of Residual Ridge Morphology

Class I: This classification level describes the stage of edentulism that is most apt to be successfully treated by conventional prosthodontic techniques with complete denture prosthesis.

Defined by:

- Residual bone height of 21 mm or greater measured at the least vertical height of the mandible
- Class I maxillomandibular relationship

Class II: This classification level distinguishes itself with the noted continuation of the physical degradation of the denture-supporting structures and in addition is characterized by localized soft tissue factors and patient management/lifestyle considerations.

Defined by:

- Residual bone height of 16 to 20 mm measured at the least vertical height of the mandible
- Class I maxillomandibular relationship
- Residual ridge morphology that resists horizontal and vertical movement of the denture base

Class III: This classification level is characterized by the need for surgical intervention (implant therapy or preprosthetic surgery) to allow for adequate prosthodontic function.

Defined by:

- Residual bone height of 11 to 15 mm measured at the least vertical height of the mandible
- Class I, II, and III maxillomandibular relationship
- Residual ridge morphology has minimum influence to resist horizontal or vertical movement of the denture base
- Location of muscle attachments with moderate influence on denture-base stability and retention

Class IV: This classification level depicts the most debilitated edentulous condition. Surgical reconstruction is almost always indicated but cannot always be accomplished because of the patient's health, desires, past dental history, and financial considerations.

Defined by:

- Residual bone height of least vertical height of the mandible
- Class I, II, and III maxillomandibular relationships
- Residual ridge offers no resistance to horizontal or vertical movement
- Location of muscle attachments with significant influence on denture-base stability and retention

Data from McGarry TJ, Nimmo A, Skiba JF, et al: Classification system for complete edentulism. The American College of Prosthodontics, *J Prosthodont* 8(1):27-39, 1999.

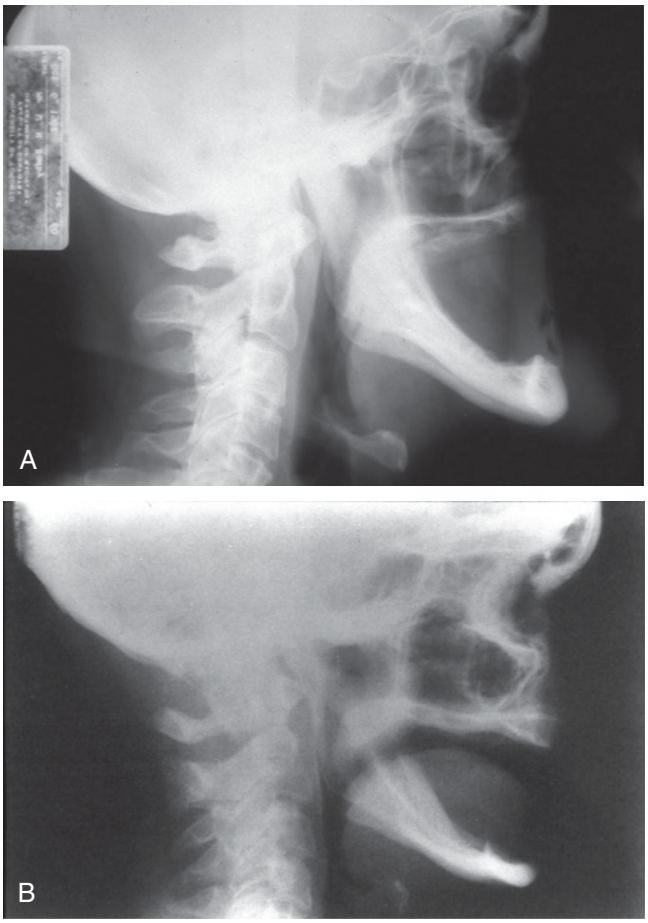


Figure 5-25 Advanced anterior mandibular residual ridge reduction (RRR) leads to the mentalis muscle's origin ending up close to the ridge crest. In part **A,** the residual vertical height would lend itself to a sulcus-deepening procedure to allow scope for an enlarged acrylic resin base at this site. Part **B,** on the other hand, would be a candidate for an onlay graft given the short height of the residual mandibular site.

by the patient, especially when the absent sulcus is accompanied by little or no attached alveolar mucosa in this area, making it virtually impossible to control the lower denture. Myoplasty accompanied by sulcus deepening was proposed as a method of extending the denture-bearing area and improving denture retention. The operation involves detaching the origins of muscles on either the labial or lingual, or both, sides of the edentulous residual ridges. This allows for an increase in the vertical extensions of the denture flanges. When horizontal bony shelving is present in the mentalis muscle region, the surgical procedure is less successful, and its relative efficacy is attributable to the modification of the powerful mentalis muscle's activity. Recognized problems include altered lower lip and chin sensation and an altered chin profile, or "witch's chin," due to repositioning of the mentalis muscle.



Figure 5-26 **A** to **C,** A sulcus-deepening procedure requires surgical detachment of labial and buccal muscle attachments followed by placement of a mucosal or skin graft . While this approach yields a larger available area for acrylic resin coverage **(D)**, it also risks a so-called "witch's chin" appearance as a result of localized altered morphology and muscle function **(E).** This outcome is equally evident when a more extensive sulcus deepening is carried out (**F** to **H**).The procedure is less frequently prescribed for the edentulous maxilla (**I, J,** and **K**). All of these preprosthetic surgical procedures have now been virtually eclipsed by routine implant placement and advances in bone grafting combined with implant prescriptions.

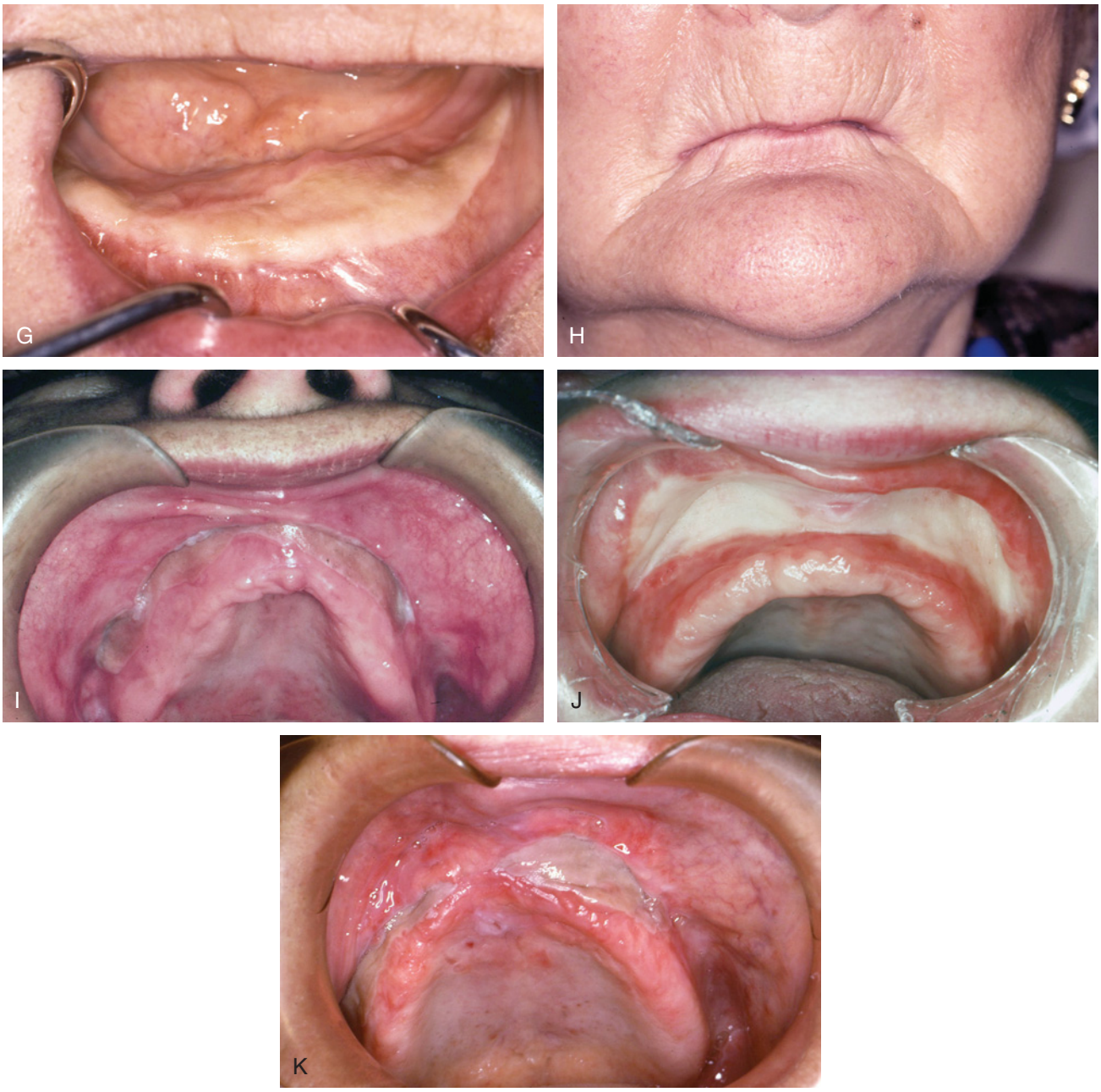


Figure 5-26, cont'd.

Experience has shown that a wide and deep sulcus is not essential for success. The vestibuloplasty can be restricted to the interpremolar region because the buccinator muscles are not the major cause of the problem (Fig. 5-26, *D*). Displacement of the mentalis muscle and adjacent muscle slips allows for the production of a looser lower lip, along with a low wound margin down in the sulcus and an increase in both stability and extension of the labial flange. The situation varies in the maxillae, where a muscle comparable to the action of the mentalis in its unstabilizing potential is not encountered. A broader vestibuloplasty is indicated here.

Where coverage requires the use of a skin or mucosa graft, the latter is preferred because free skin grafts lose resiliency, develop nuisance crinkling, and suffer from parakeratosis, producing a soggy surface in the moist environment. They also seem to exhibit poor cohesion and adhesion qualities with acrylic resin when compared with mucosa.

The use of customized acrylic resin templates or the modified previous denture to support vestibuloplasty in the mandible is essential. These templates may have to be fastened to the mandible with circummandibular wires for 1 week or longer. This protocol ensures the patency of most of the recovered vestibular depth. However, alternative approaches such as constantly wearing the denture/template also have been explored. The surgical prosthesis is then removed exclusively for hygiene purposes and for very short periods of time. Carefully designed surgical splints will reduce inflammation, reduce postoperative scarring, and maintain muscles in the desired position, thereby improving the result.

Another result of excessive alveolar bone loss or reduction is obliteration of the hamular notch. This "anatomical cul-de-sac," with its potential for displacement that contributes to a posterior palatal seal makes it an important part of the maxillary denture's periphery. Its absence can severely undermine retention of the denture, and a small, localized deepening of the sulcus in this area can sometimes be attempted. The patient's old denture or a surgical template is used after the surgery to help retain the patency of the newly formed, yet small sulcus, or notch.

Ridge Augmentation

For many years oral and maxillofacial surgeons have attempted to restore advanced jaw residual ridge resorption by placing onlay bone grafts, or inserting synthetic materials (Fig. 5-27). These procedures are rarely preferable alternatives to implant placement, principally because of their surgically extensive nature and uncertain outcomes and benefits. Nevertheless, current surgical developments and reports suggest promise for combining some types of grafts with implants to rectify serious residual ridge resorption problems, particularly in the maxillae.

DISCREPANCIES IN JAW SIZE

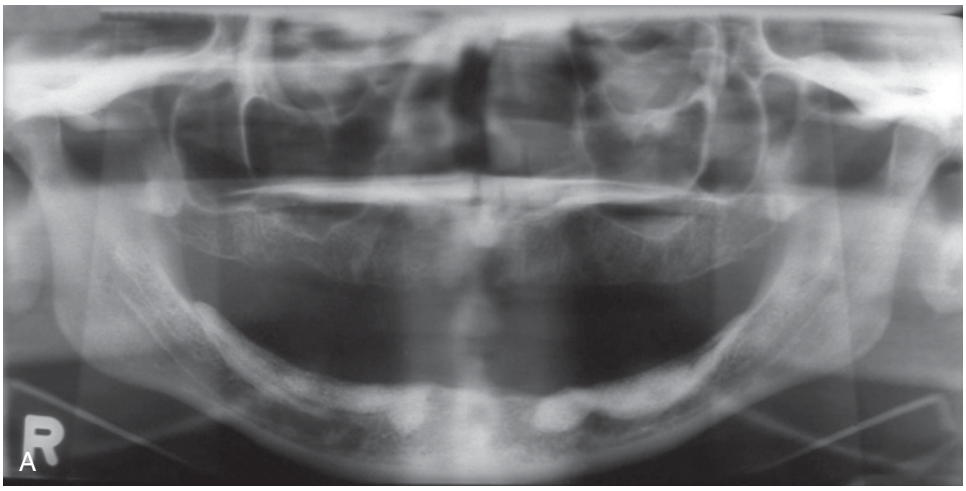
Impressive advances in surgical techniques of mandibular and maxillary osteotomy have enabled the oral and maxillofacial surgeon to create optimal jaw relations for patients who have discrepancies in jaw size. The patient with prognathism frequently places considerable stress and unfavorable leverages on the maxillary basal seat under a complete denture. This may cause excessive reduction of the maxillary residual ridge. Such a condition is even more conspicuous when some mandibular teeth are still present. A mandibular osteotomy in very carefully selected cases can create a more favorable arch alignment and also improve the appearance. However, changes in the soft tissues of the face tend to be accentuated by such a procedure and may require an adjunctive face-lifting procedure for optimal results. A more logical and simple approach here is to counter the adverse loading risk by providing an implant-supported maxillary overdenture (see Fig. 14-4, *C* to *I*). Although the previously described surgical procedures are a tribute to surgical skills and versatility, they are now rarely prescribed for edentulous patients given their invasive nature and the dramatic improvement in denture stability that can be obtained using implant-supported or retained dentures with their less extensive surgical procedures. They cannot, however, directly address issues of jaw size disparity but may enable this to be partly masked with an implant-stabilized prosthesis. Although the implant approach is far more practical, its outcome is still determined by host bone site and esthetic considerations and above all a prosthodontically driven team approach to managing a patient's needs.

REPLACEMENT OF TOOTH ROOTS WITH OSSEOINTEGRATED DENTAL IMPLANTS

Dissatisfaction with tooth loss and the prostheses used to manage edentulism is as old as dentistry. It is not therefore surprising that the notion of skeletal fixation with an implanted device has a very long history. This was, however, rather checkered until the latter half of the twentieth century when scientifically sound research provided the underpinnings of modern implant dentistry. Three decades of extensive and rigorous studies about treatment outcomes with osseointegration have provided irrefutable evidence to support this type of treatment. Scientific advances have ushered in a new era of efficacy and effectiveness in preprosthetic surgery. The denture-bearing area is no longer the prime or exclusive source of support, and the focus has now shifted to an endosseous one. While dental implant treatment is not limitless in its applicability, it has greatly extended the range and quality of prosthodontic interventions. For the edentulous patient this often means the option of treatment with implant-stabilized fixed or removable prostheses using various numbers and locations of dental implant bodies. Implant management of edentulous jaws is described in depth in Part V.

SUMMARY

Patients are often unaware that their oral tissues have been damaged or deformed by the presence of old prostheses and must be informed of these problems before the construction of new complete dentures. A logical explanation by the dentist, supplemented with radiographs and, where required, diagnostic casts, usually satisfies the patient as to the basis of the suggested treatment, which also may require preprosthetic surgery that includes implant placement. The combination of osseointegrated implants and complete denture fabrication skills have now expanded patient management scope and enhanced favorable outcomes in a very compelling manner.





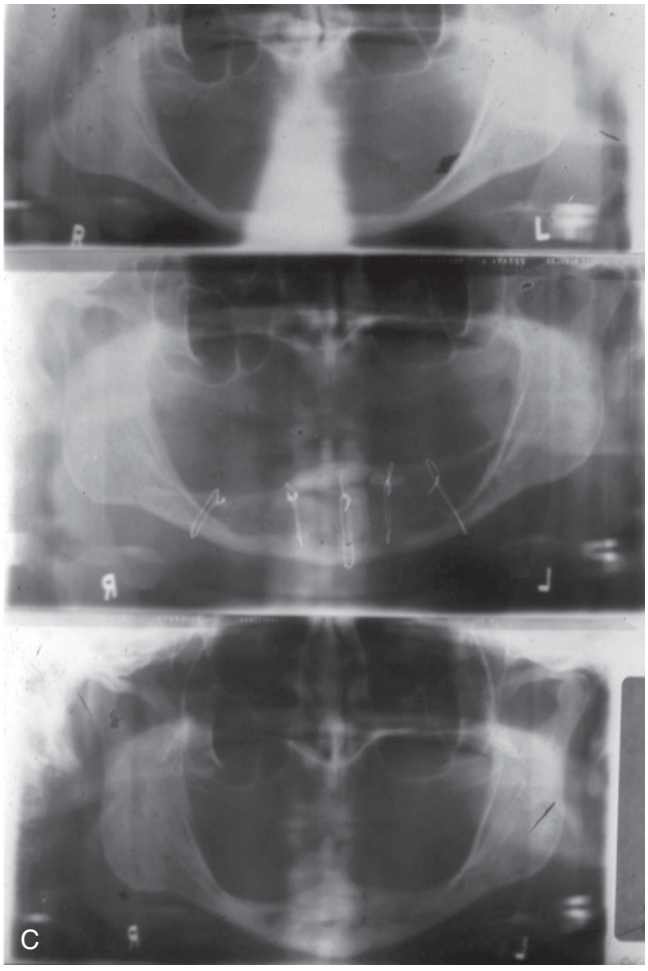


Figure 5-27 Ridge augmentation by means of an alloplastic material (**A** and **B**) or a homologous graft **(C)** also has been eclipsed by combinations of autologous bone grafting and implant placement.

Bibliography

On History Taking and Treatment Planning for Edentulous Patients

Bohay NB, Stephens RG, Kogan SL: A study of the impact of screening or selective radiography on the treatment and postdelivery outcome for edentulous patients, *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 86:353-359, 1998.

Cooper LF: The current and future treatment of edentulism, *J Prosthodont* 18(2):116-122, 2009.

Dickinson CM, Fiske J: A review of gagging problems in dentistry: 2. Clinical assessment and management, *Dent Update* 32(2):74-76, 78-80, 2005.

Hall WB, Robert WE, LaBarre EE: *Decision making in dental treatment planning*, St Louis, 1994, Mosby-Year Book.

Kydd WL, Daly CH, Wheeler JB: The thickness measurement of masticatory mucosa in vivo, *Int Dent J* 21:430-441, 1971.

Little JW: *Dental management of the medically compromised patient*, ed 7, St Louis, 2008, Mosby Elsevier.

MacEntee MI: *Oral health care and the frail elderly—a clinical perspective*, 2010, Wiley Blackwell.

Masood F, Robinson W, Beavers KS, et al: Findings from panoramic radiographs of the edentulous population and review of the literature, *Quintessence Int* 38:e298-305, 2007.

McCord JF, Grant AA: Identification of complete denture problems: a summary, *Br Dent J* 189:128-134, 2000.

NIH Consensus Development Panel: Osteoporosis prevention, diagnosis and therapy, *J Am Med Assoc* 285:785-795, 2001.

Owall B, Kayser AF, Carlsson GE: *Prosthodontics: principle and management strategies*, London, 1996, Mosby-Wolfe.

Petersen PE, Yamamoto T: Improving the oral health of older people; the approach of the WHO Global Oral Health Programme, *Community Dent Oral Epidemiol* 33:81-92, 2005.

Slagter KW, Raghoebar GM, Vissink A: Osteoporosis and edentulous jaws, *Int J Prosthodont* 21:19-26, 2008.

United States Pharmacopeial Convention: *Drug information for the health care professional*, ed 6, Rockville, Md, 1996, The United States Pharmacopeial Convention, Inc.

White SC, Pharoah MJ: *Oral radiology: principles and interpretation*, ed 6, St Louis, 2009, Mosby Elsevier.

Improving Denture-Bearing Foundations for Edentulous Patients

Carlsson GE: Clinical morbidity and sequelae of treatment with complete dentures, *J Prosthet Dent* 79:17-23, 1998.

Cawood JI, Howell RA: Reconstructive preprosthetic surgery. I. Anatomic considerations, *Int J Oral Maxillofac Surg* 20(2):75-82, 1991.

Kelly E: Changes caused by a mandibular removable partial denture opposing a maxillary complete denture, *J Prosthet Dent* 27(2):140-150, 1972.

McGarry TJ, Nimmo A, Skiba JF, et al: Classification system for complete edentulism. The American College of Prosthodontics, *J Prosthodont* 8(1):27-39, 1999.

McCord JF, Grant AA: Identification of complete denture problems: a summary, *Br Dent J* 189:128-134, 2000.

Owall B, Kayser AF, Carlsson GE: *Prosthodontics: principle and management strategies*, London, 1996, Mosby-Wolfe.

Wood NK, Goaz PW: *Differential diagnosis of oral and maxillofacial lesions*, ed 5, St Louis, 1997, Mosby-Year Book.

CHAPTER 6

Additional Treatment Planning Options for Both Edentulous and Potentially Edentulous Patients

George Zarb, Steven E. Eckert, Rhonda F. Jacob, John P. Zarb

CONSIDERATIONS FOR IMPLANT PROSTHODONTIC TREATMENT

George Zarb, Steven E. Eckert

The combination of optimal clinical skills and patient compliance does not guarantee a successful denture-wearing experience. This clinical reality is compounded by time-dependent local and systemic health concerns, as well as patient-mediated psychological and behavioral ones. The search for adjunctive, in fact superior, forms of prosthesis stability and retention eventually led to titanium implants that are surgically placed in selected edentulous host bone sites and allowed to heal and osseointegrate, followed by connection to a fitted superstructure screwed onto transepithelial abutments that are joined to the buried implants. As a result, the management of edentulism has now become an exciting new therapeutic era of applied biotechnology.

The vast majority of edentulous patients around the world are managed satisfactorily using a range of clinical protocols for making complete dentures, as well as using a range of prosthetic materials. Given the global context of the edentulous state, the treatment is understandably performed at various levels of health professional educational backgrounds. Consequently, although successful outcomes are claimed routinely by most dentists for a wide range of technique protocols, the absence of any robust science to back up such claims underscores the importance of specific common denominator clinical success determinants. These include a good patient-dentist relationship, patients' favorable oral and systemic health, professional skills, and the use of a clinical protocol that integrates the key principles described throughout this text. The entire process also depends on a continuum of steps that reconciles qualities of care and compassion with diagnostic and professional skills. But ultimately, any patient's potential to adapt to and accept the challenge of wearing dentures remains a complex issue. In fact, it has precluded statistically significant relationships between patient satisfactory adaptation and age, gender, oral variables, personality, esthetics, or even the denture's technical merits. It must be recognized that there are patients who do not tolerate complete dentures. This is neither an indictment of professional skills nor a criticism of the patient's response to the dentist's efforts. It is a realistic acceptance of the fact that many patients who wear complete dentures either do not like the experience or encounter difficulty adapting. Other patients may have adapted to dentures for several years but may become maladaptive as a result of local regressive tissue changes or systemic health-related considerations. Still others may be perfectly adaptive but continue to regret and even resent the fact that wearing dentures is their only treatment option, while others simply cannot wear dentures at all. The quality of life of all such individuals may be profoundly affected by their predicament since their management usually entails considerable efforts of both the clinical-technical and the emotional-supportive variety, albeit with unpredictable results. The dentist may even be tempted to dismiss such patients as having difficult or "impossible" mouths or, worse, as lacking motivation or learning skills. These clinical interpersonal situations can be very frustrating, especially when it becomes clear that conventional complete denture therapy is not the solution for the patient's edentulism.

MALADAPTIVE DENTURE BEHAVIOR

Diverse reasons are presented in the dental literature to explain the etiology and frequency of chronic inability to wear dentures. In the past, it was tempting for clinicians to regard the maladaptive problem as resulting mainly from adverse anatomical changes in the denture-bearing surface. However, clinical experience and some research also have identified physiological and psychological contributions to

such a response. Apart from the extensive anecdotal evidence favoring optimized denture construction techniques, the major adjunctive treatment proposed for such patients has been preprosthetic surgery. The goal of this approach is to enlarge the denture-bearing area by deepening the buccal or labial vestibules, detaching muscles that impinge on denture borders, or augmenting the residual ridge area as described in Chapter 5. Implicit in this prescription is the conviction that an enlarged denture-bearing surface will significantly increase the chances of denture stability and therefore patient adaptation. Apart from the inherent morbidity risks associated with such surgical procedures, longitudinal assessment of such preprosthetic surgical approaches has failed to produce compelling and predictable therapeutic outcomes.

Some dentists understandably have pioneered other methods, such as endosseous dental implants, in an effort to treat or preclude maladaptive denture behavior. The premise in prescribing dental implants has always been the predictable and safe provision of alloplastic tooth root substitutes to stabilize and retain prostheses. The originally used implants were made out of a variety of presumed biocompatible alloplastic materials and consisted of diverse designs (Fig. 6-1). The very mixed reported successful

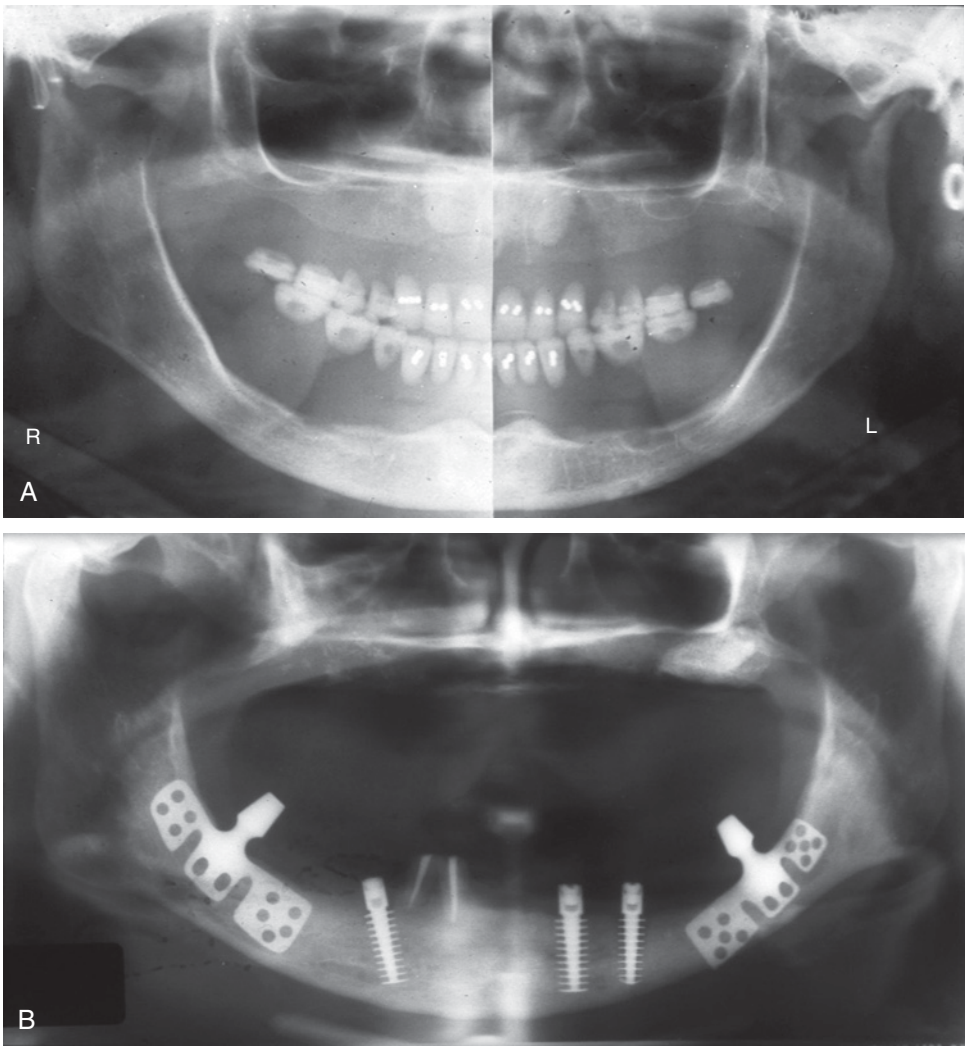


Figure 6-1 Treating the edentulous state with complete dentures presumes that acrylic resin is a reasonable substitute for the absent periodontal ligament and its participation in the maintenance of its surrounding alveolar bone. The space between the prosthetic teeth and the underlying bony support in part **A** reflects the reduced and profoundly changed support for a prosthetic occlusion. Attempts to compensate for this inherently compromised support mechanism have included a diversity of implant designs as shown in the clinical examples in parts **B, C,** and **D.** Regrettably, the resultant induced mechanical anchorage is characterized by a poorly differentiated connective tissue interface whose longevity is quite unpredictable.

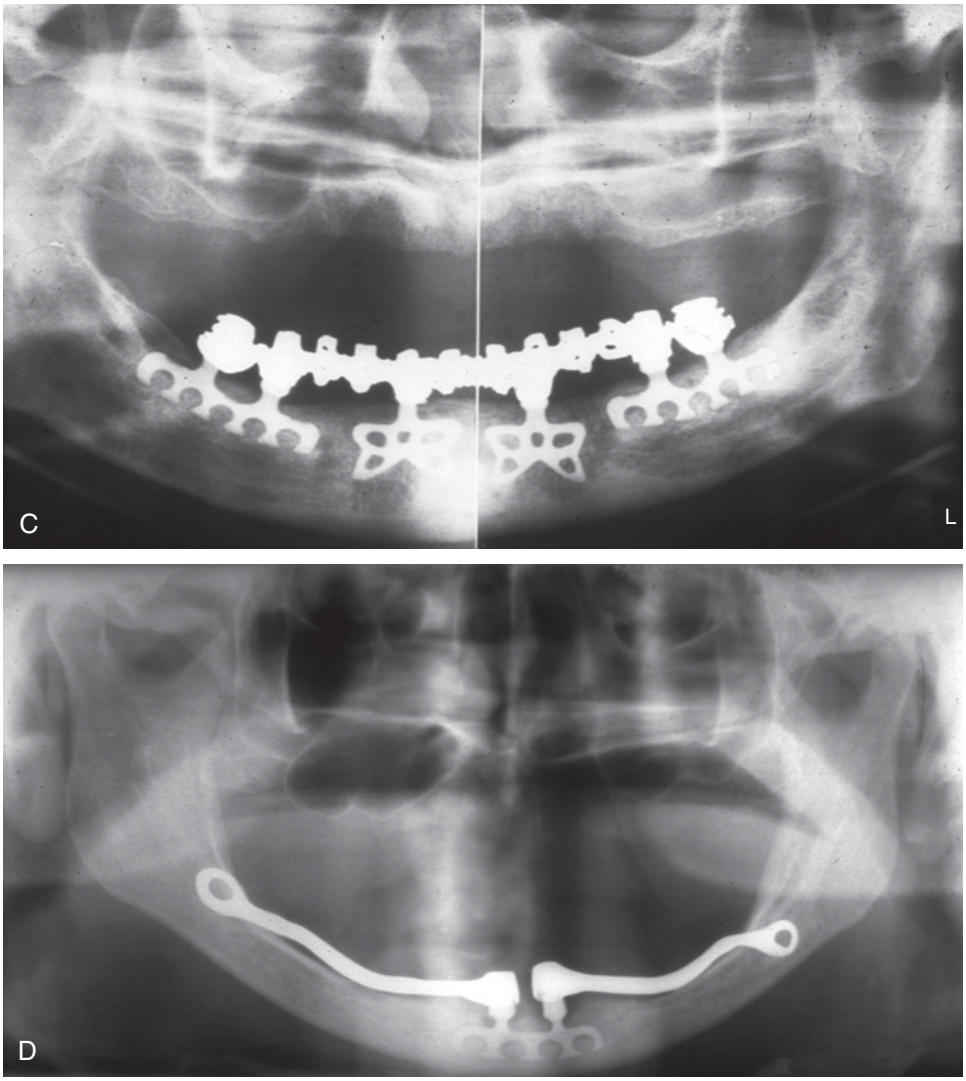


Figure 6-1, cont'd.

outcome rate seemed to depend on three-dimensional mechanical stabilization as opposed to a biologically acceptable and predictable interfacial response. It was not until the concept of osseointegration was advanced some 30 years ago, that the predictability of an induced interfacial healing response was demonstrated.

THE SCIENTIFIC ERA IN IMPLANT PROSTHODONTICS

The required evidence-based clinical application of dental implants was ushered in by the publication of osseointegration research work of Per Ingvar Brånemark and his colleagues during the late 1970s and first presented to the scientific dental community at the 1982 Toronto Conference. This led to several clinical researchers (including several of this book's contributors) embarking on clinical trials that involved variations on a theme of inserting machine-turned and -threaded cylindrical titanium implants into mandibular and maxillary edentulous sites and using them as abutments to support a variety of prostheses designs. The original commercially pure (CP) titanium implants were inserted with a meticulous technique that aimed at creating a direct contact between the implant material and living bone. The first human trials were conducted in Sweden beginning in 1965 and subsequently in various teaching centers around the world.

Although some authors had hypothesized that an interfacial osteogenesis could be induced with any type of implant placement, it was Brånemark who first produced laboratory and clinical results that demonstrated a close spatial relationship between titanium and living bone, an interface he described as "osseointegration." The term suggests a highly differentiated interfacial bone response to the careful and relatively atraumatic placement of CP titanium tooth root analogues (Fig. 6-2). Brånemark's clinical technique has now been replicated in several teaching centers



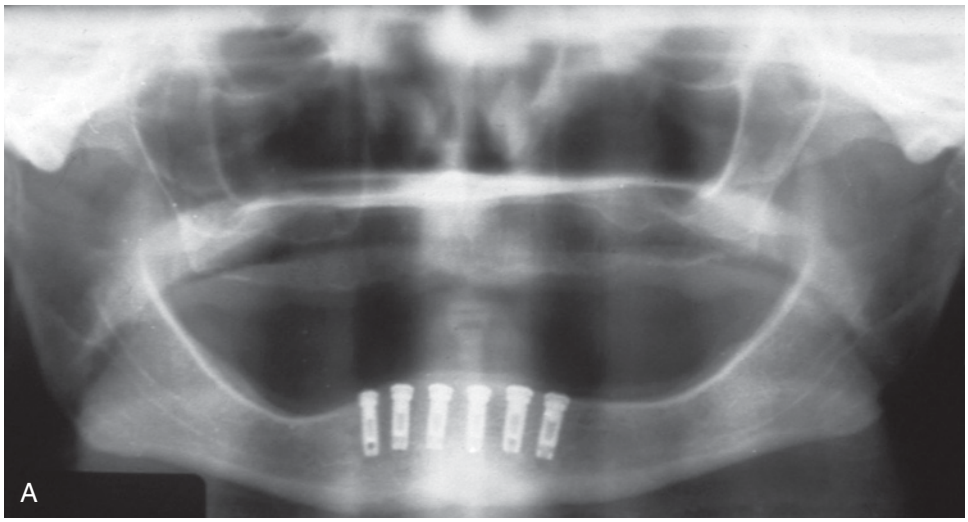
Figure 6-2 **A** to **D,** Brånemark's now classical osseointegration technique in an edentulous mandible. This method led to compellingly documented and long-lasting interfacial osteogenesis for implant abutments, with favorable functional outcomes irrespective of location in different host bone sites, age, or gender considerations.

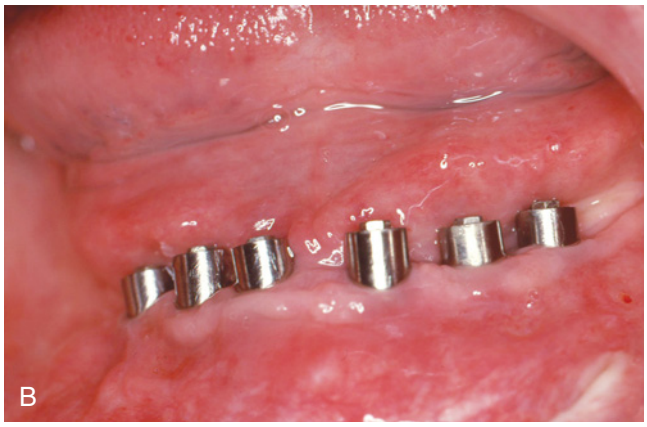
in well-designed longitudinal trials and marks a very important advance in the entire field of prosthodontics.

In fact, the technique of osseointegration has virtually solved the predicament of maladaptive denture behavior. It also has addressed the needs of those patients who would prefer wearing a fixed prosthesis or a relatively immobile overdenture one. This is achieved in one of two ways since most edentulous patients can, as well as should, now be routinely offered the following:

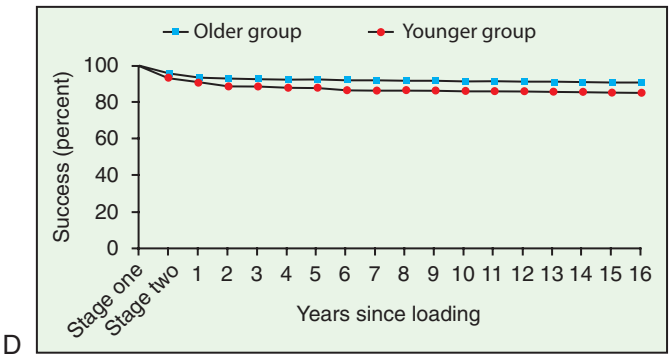
- A fixed implant-supported prosthesis that may be legitimately regarded as a "cure" for edentulism (Fig. 6-3)
- An overdenture supported by one or more implants with significant convenience and economic implications, plus enhanced scope for soft tissue support as esthetic clinical considerations (Fig. 6-4)

Currently, numerous commercial and scientific initiatives also have yielded diverse implant macroscopic and microscopic surface designs and materials that have dramatically expanded the scope of the technique. As a result, the technique also has been successfully recruited for both single and multiple teeth replacement. This is therefore a professionally rewarding time to be managing both partially and completely edentulous patients given currently available treatment options (Fig. 6-5). However, the dramatic swing towards considering the inclusion of implants in every treatment plan also has introduced the risk of ignoring the merits (functional, esthetic, and financial) of traditional treatment modalities in the management of most forms of partial or complete edentulism. For example, an exclusive surgically driven treatment plan is often proposed without efficacy and effectiveness outcomes reconciled with prosthodontically directed treatment. This current clinical practice reality reflects a subtle yet profound shift away from the required emphasis on what best addresses patient-mediated concerns. As a result, it may be stated that commercial explosion in implant system production has risked a regression in the scientific rigor required to select scientifically acceptable clinical protocols. Few controlled clinical studies are available to compare results of different implant designs, materials, or surfaces. In fact, too many reports claiming improved outcomes are often based on short-term studies that are assumed to equate with long-term clinical success. Although historical controls are thought to be useful, study designs are so different that the utility of such controls is limited.









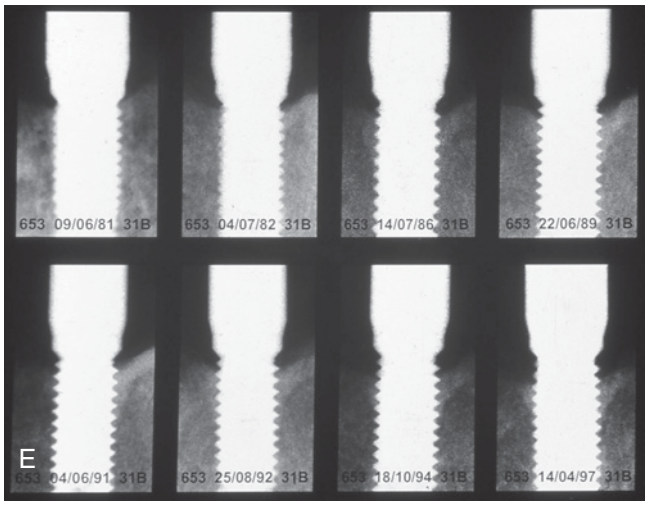
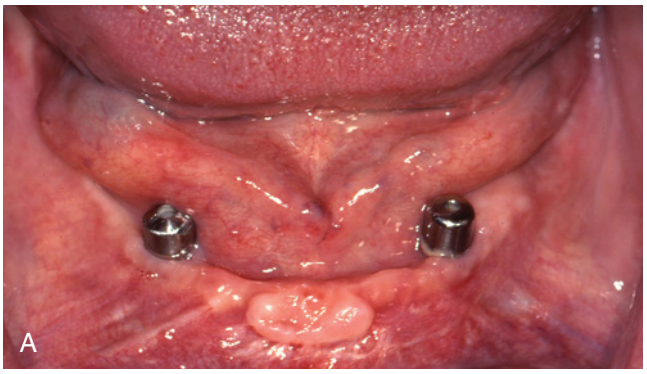


Figure 6-3 **A** to **C,** An elderly patient's annual recall examination appearance of successful management of long-standing maladaptive mandibular edentulism with a fixed prosthesis. **D,** Bryant's data underscore the comparable cumulative survival rates in older and younger groups of patients. **E,** The impressive bone maintenance levels around implants over a prolonged observation period can be noted.





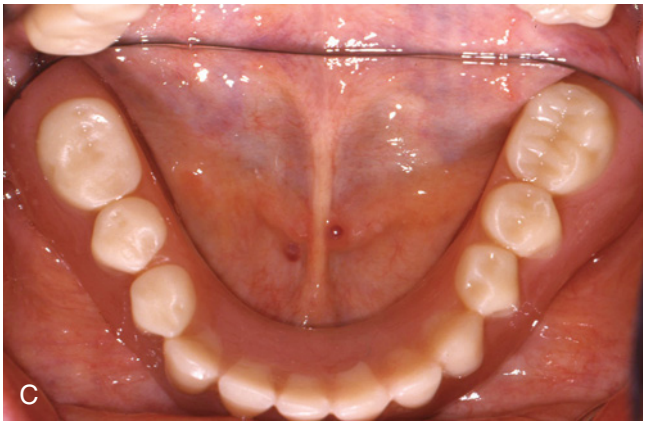


Figure 6-4 **A** and **B,** Clinical and laboratory examples of two abutments that are used to retain and support a mandibular overdenture **(C).** A diversity of retentive design features are employed (see Chapter 17 and Fig. 6-10, *B* and *C*).

The risk of this state of a quasiscientific anarchy is a return to an anecdotally driven era in implant prosthodontics; thus our preference is to prescribe implant systems that reflect scrupulous multicenter and long-term endorsement. Our preferred choices remain the Nobel Biocare, Straumann, and AstraTech implant systems.* All three are made from CP titanium with different macroscopic and microscopic surface features and are designed to be used as one-stage or two-stage surgical procedures. The implants

*Nobel Biocare, Zurich, Switzerland. Straumann AG, Basel, Switzerland. AstraTech Inc–Dental Division, Waltham, Mass.

Box 6-1 Patients' Signs and Symptoms That Frequently Preclude an Adaptive Complete Denture Experience

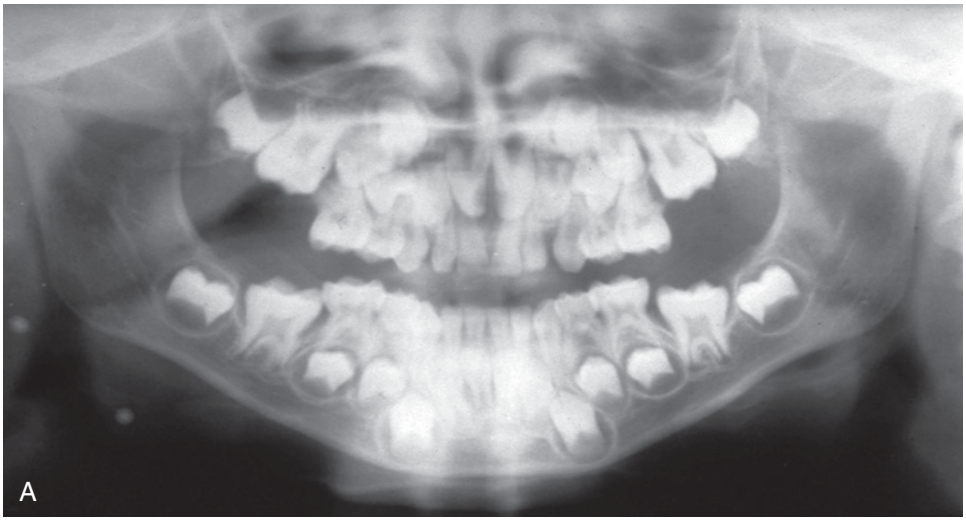
- Severe morphological compromise of the denture-supporting areas that significantly undermines denture retention
- Poor oral muscular coordination
- Low tolerance of the mucosal tissues
- Parafunctional habits leading to recurrent soreness and instability of the prosthesis
- Unrealistic functional prosthodontic expectations
- Active or hyperactive gag reflex elicited by a removable prosthesis
- Psychological inability to wear a denture, even if adequate denture retention or stability is present

either can be immediately attached to a healing abutment or can be buried submucosally until the time-dependent osseointegration is achieved. The latter will then permit a secondary surgical exposure for prosthetic abutment attachment and subsequent screw-retained or cemented prosthesis loading. Current, short-term outcome-based research even suggests the feasibility of immediately loading implants in specific location for edentulous patients, most particularly the anterior edentulous mandible.

PATIENT CONSIDERATIONS

The psychological reactions to various forms of bodily organ loss have been investigated in patients who have undergone procedures such as hysterectomies and mastectomies. However, remarkably little interest has been shown in the psychological reaction to tooth loss. This apparent lack of interest is probably attributable to the prevalence of edentulism and the impressive success enjoyed by the dental profession in treating the condition. Furthermore, edentulism will neither result in death nor likely elicit profound sympathy in a society preoccupied with youthful appearances. The sense of shame and inferiority that many edentulous patients feel is rendered even more poignant by the inability of some of them to tolerate a denture at all.

Patients who cannot wear dentures or who wear them with varying degrees of difficulty usually have one or more of the features listed in Box 6-1. Such patients are candidates for an implant prosthodontic prescription. Also, even the most successful denture wearer frequently regrets his or her dependence on a removable prosthesis and the attendant sequelae associated with its long-term wear. These patients also could be added to the list of treatment candidates because compelling longitudinal research confirms the safety and predictability of implant procedures. It



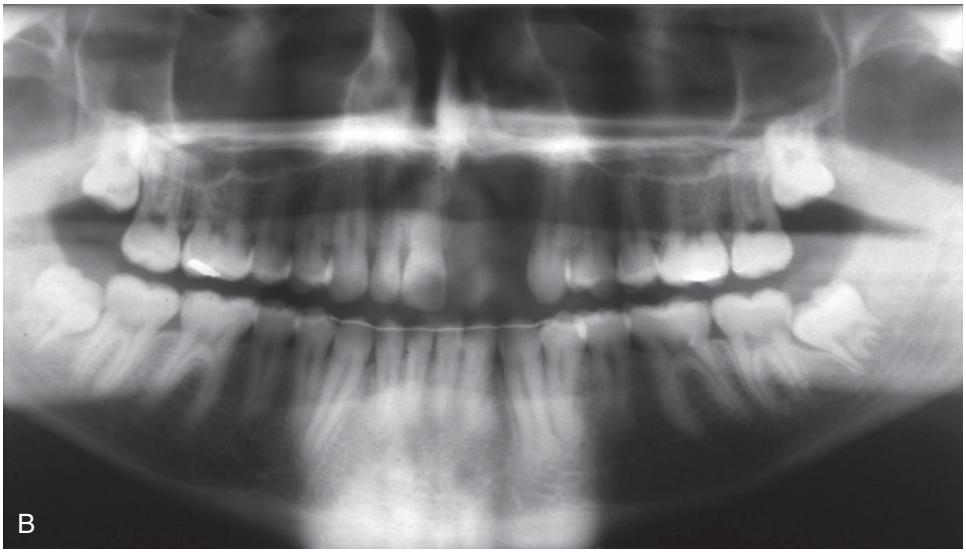




Figure 6-5 The profound and significant differences that exist between the natural dentition's biologically determined eruptive process (**A** and **B**) as compared with the induced healing response that results in osseointegration **(C)** has changed the traditional approach to managing partial and complete edentulism.

Box 6-2 Differences Between Teeth and Implants

Teeth

- Attachment mechanism (periodontal ligament) is the result of evolution and has not been replicated
- Variable mobility is present; increased mobility may be reversible
- Can be intruded, extruded, or moved
- In young patients, teeth continue to erupt
- Proprioception
- Has a rich plexus of blood vessels and nerves in the periodontal ligament
- Data present to show progress of mucosal inflammation to periodontal disease

Implants

- Interfacial osteogenesis (ankylotic-like) is an induced healing response that is readily replicated
- Immobile (ankylotic-like)
- Cannot be intruded, extruded, or moved (ankylotic-like)
- In young patients, implants are "left behind" while surrounding tissues change
- So-called osseoperception
- A relative absence of such a sophisticated circulation and probably innervation
- Similar data are not present

is expected that this advance could very well lead to therapeutic strategies in prosthodontics that considerably reduce the conventional role of removable prostheses.

The objective in prescribing implants is to provide the patient with an analogous attachment mechanism for the lost periodontal ligament (PL) without the latter's inherent vulnerable qualities. The resulting availability of dentist-placed abutment(s) can then be used to support diverse prosthetic superstructure designs. This is achieved through:

1. Selection of patients whose systemic health does not preclude a minor oral surgical procedure. Furthermore, the quality and quantity of the selected edentulous host bone sites must be carefully assessed by a careful and comprehensive radiographic evaluation.
2. Meticulous surgical protocol. The predictability of a favorable healing response as manifested by subsequent interfacial tissue differentiation must not be compromised. Surgical judgment and skills have been shown to be successful outcome determinants.
3. Use of a biocompatible alloplastic material, preferably CP titanium, because it has been shown to yield the best long-term results reported to date. However, titanium alloys and different surface treatments appear to offer equally good prognosis, at least in the short-term.
4. Implant design that ensures immediate stability and excellent stress distribution. The screw's cylindrical design appears to be the optimal one; however, preliminary evidence indicates that implants with alternative macroscopic and microscopic design features may be equally successful. Rough surface implants have also been proposed as providing an increased surface contact area, which may be critical during the early phases of the osseointegrated response.
5. Unloaded healing of the implant could be routine protocol, although good evidence supports merits of immediate loading for a number of situations. The latter objective is encouraged given research outcome results with roughened surface implants. Critical to a satisfactory final result, whether with traditional loading protocols or immediate loading protocols, is the avoidance of high-magnitude forces or prosthetic designs that could result in excessive movement of the implant prior to its achievement of osseointegration.
6. Optimal occlusal stress control via a passive fit of the prosthetic superstructure and correct occlusal relationships is ensured.

The last item in the list is a standard objective in traditional prosthodontics, but the absence of resilient PL support in implant prosthodontics indicates a need for technical accuracy that may very well exceed what is required when using tooth abutments to support cast fixed prostheses.

It should be recalled that the PL's qualitative and quantitative determinants are arguably the gold standard for a dentist-induced attachment mechanism. It is now obvious that the osseointegrated interface is a worthy functional substitute for the PL, even if the area of interfacial attachment is significantly less. On the other hand, a subtle yet profound difference lies in their behavioral nature, given the origins of either interface (Box 6-2).

The PL is the result of a developmental phenomenon, whereas osseointegration is the result of a carefully planned and, to a larger extent, controlled healing response. This profound difference accounts for the different pathogenesis of attachment mechanism failure—periodontal disease or loss of osseointegration. Because an induced "ankylotic-like" response is unlikely to be vulnerable to periodontal pathogens, we strongly suspect that implants fail only when the induced healing response is an imperfect one. This is reflected in the fact that most implant failures occur during the prescribed healing interval. Other failures may occur a few months after healing, but the presumption then is that a variable period of relative traumatic occlusal loading leads to an overload of the imperfectly healed interface. Infection then becomes the secondary superimposed insult to the failed or failing interface. This chain of events has

regrettably been misunderstood by many dentists who often bring a PL mind-set to the fascinating debate on the infrequently encountered postloading, or late biological, osseointegration failure.

TREATMENT OUTCOME CONSIDERATIONS

The most important reason for establishing criteria of success in any treatment method is to safeguard the oral health of the public. Each patient who receives implant prosthodontic treatment has the right to know the potential benefits and risks and to receive an accurate prognosis of the method. These criteria protect the patient, whose informed consent before undertaking implant therapy should include an awareness of the highest standard of service currently available.

A clinical working definition for osseointegration is "the time-dependent healing process whereby clinically asymptomatic rigid fixation of alloplastic materials is achieved and maintained in bone during functional and parafunctional loading." The definition implies a short list of determinants—asymptomatic, immobile, and time-dependent functions—that underscore treatment outcome criteria reflecting the method's efficacy and effectiveness. These criteria are still regarded as less than perfect in clinical research circles because they are partially based on fallible resolution levels (e.g., office radiographic imaging) and they do not lend themselves to a range of so-called success norms that are quantifiable. On the contrary, they support a dichotomous, all-or-none diagnosis (e.g., mobile or immobile implant, absent or present interfacial radiolucency, painful or painless). The criteria, however, reflect the outcome of numerous international, scrupulously monitored scientific investigations and have proven to be useful and reliable in the formulation of a yardstick to measure clinical success. Box 6-3 sums up the recommendations of a Consensus Conference on Treatment Outcome Criteria held at the University of Toronto in 1998. We acknowledge their merits and endorse the guiding scope of the proposed and described clinical yardstick package, although we recognize that determinant 4 may also manifest itself at different rates. It is important to note that these determinants were mainly an outgrowth of the experience with edentulous patients. Subsequent applications to other jaw sites led to the realization that vertical bone loss may indeed be variable. However, this does not preclude successful long-term outcomes.

Box 6-3 Determinants of Treatment Outcome in Implant Prosthodontics (Toronto Consensus Conference, 1998)

The Following Considerations for Successful Outcomes with Implant-Supported Prostheses Were Proposed:

1. Implant therapy is prescribed to resolve prosthodontic problems and permit diverse prosthodontic treatments, which in turn may have an impact on the economics of the service. Such prostheses should meet the clinically evolved standards of function, comfort, and esthetics. They also should allow for routine maintenance and should permit planned or unplanned revisions of the existing design. Criteria of treatment outcome success for implant-supported prostheses should be assessed in the context of time-dependent considerations for any required retreatment.
2. Criteria for implant success apply to individual endosseous implants and include the following:
   - At the time of testing, the implants have been under functional loading.
   - All implants under investigation must be accounted for.
   - Because a gold standard for mobility assessment is currently unavailable, the method used must be specifically described in operative terms.
   - Radiographs to measure bone loss should be standard periapical films with specified reference points and angulations.

The Success Criteria Comprise the Following Determinants:

1. The resultant implant support does not preclude the placement of a planned functional and esthetic prosthesis that is satisfactory to both patient and dentist.
2. There is no pain, discomfort, altered sensation, or infection attributable to the implants.
3. Individual unattached implants are immobile when tested clinically.
4. The mean vertical bone loss is less than 0.2 mm annually after the first year of function.

SUMMARY

Traditional edentulous patient management with complete dentures has rapidly morphed into an entirely new and diverse treatment paradigm. It is therefore tempting to regard variations on a theme of implant prosthodontics as the logical and eventually even optimal choice for treating virtually all forms of complete and partial edentulism. Part VI of this text seeks to take stock of the profession's challenge to reconcile clinical scholarship in all aspects of understanding and managing the edentulous predicament.

THE POTENTIALLY EDENTULOUS PATIENT TO BE TREATED WITH OVERDENTURES

George Zarb, John P. Zarb

Relatively short-term favorable outcomes using natural teeth to support overdentures endorse routine prescription of the technique. However, the method's inherent risk is that the longevity of overdentured teeth abutments is quite likely to be compromised by caries and periodontal disease. Furthermore, the recent introduction of the osseointegration technique created the possibility of converting patients with maladaptive complete dentures into ones with adaptive overdentures when implants are used to stabilize "offending" prostheses. The twin techniques (traditional complete denture fabrication with natural teeth abutments or with implants) continue to offer dentists and patients a new standard of prosthodontic therapy (see Part IV).

Dentists have long recognized the difference that the presence of teeth makes to the preservation of alveolar ridge integrity (Fig. 6-6). It appears that a healthy PL helps maintain alveolar ridge morphology, whereas a diseased PL, or its absence, is associated with variable but inevitable time-dependent reduction in residual ridge dimensions. Complete denture replacements for extracted entire dentitions used to be promoted as an inexpensive and permanent solution for oral health care. Regrettably, the legacy of this approach became a major oral morphological problem as advanced residual ridge resorption (RRR) evolved into a virtual epidemic for edentulous patients.

The ongoing and frequently rapid reduction in edentulous ridge bulk appears to be multifactorial and is imperfectly understood. However, clinical experience and compellingly documented research have underscored the practical merits of retaining natural teeth to serve as vertical support abutments under a complete denture and distal extension areas of removable partial dentures. The premise is that occlusal forces of a functional and parafunctional nature that exert an adverse influence on denture-supporting tissues need to be attenuated or reduced and that attempts to clinically address this problem are an important part of the RRR paradigm under the dentist's control. Hence the technique of designing overdentures, which also have been described as overlay, hybrid, teeth-supported, or teeth-assisted complete dentures. The retained teeth abutments may be few or numerous, coronally modified or restored, frequently endodontically prepared, and often site-specific. The overall objective is to distribute stress concentration between retained teeth abutments and denture-supporting tissues (Fig. 6-7).

The overdenture technique was originally introduced to reconcile a need for maximum prosthesis support in morphologically compromised dental arches, with a desire to improve equally compromised esthetic appearance resulting from undersupported circumoral and facial tissues. Consequently, patients with congenital anomalies such as cleft palates, or those with sequelae of maxillofacial trauma, were frequent candidates for the service. Eventually, the merits and ingenuity of the technique encouraged dentists to prescribe it for patients who had severely worn dentitions, or else anomalies that included missing teeth, and particularly

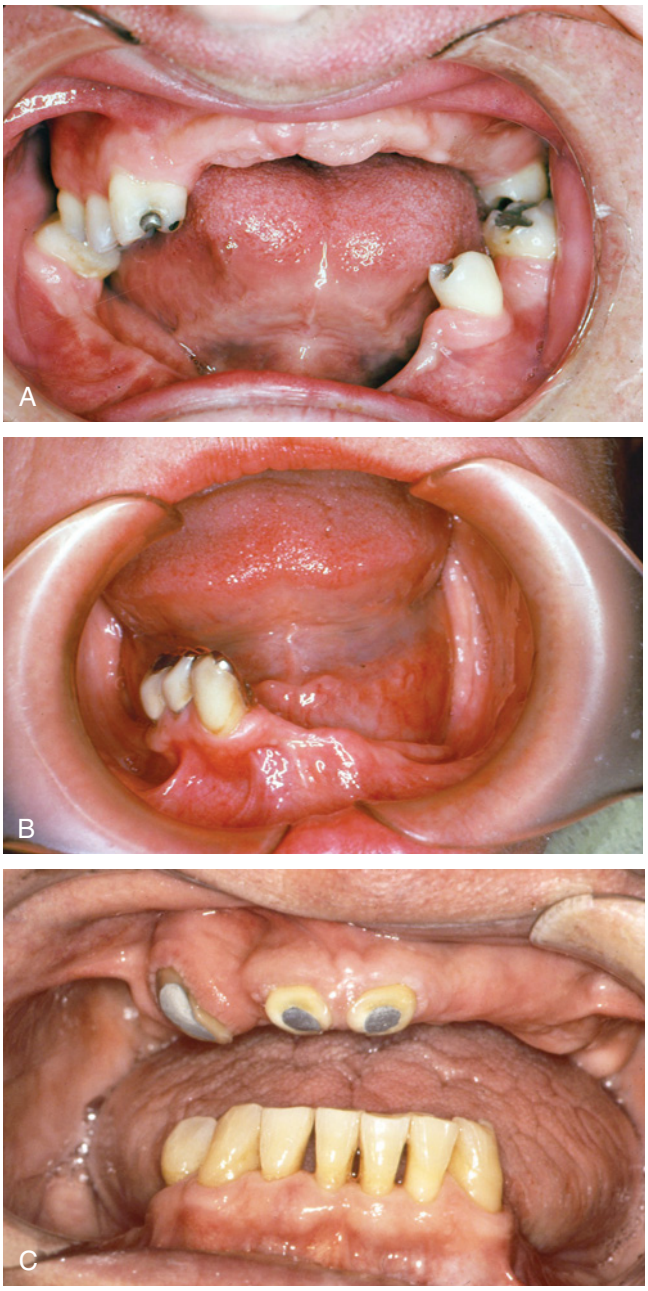


Figure 6-6 **A** to **C,** Dramatic residual ridge reduction (RRR) of the edentulous segments contrasts sharply with integrity of the alveolar ridge where the residual natural teeth are present. This predicament is even more severe in part **A,** where a traumatic teeth avulsion compromised the RRR process even further.

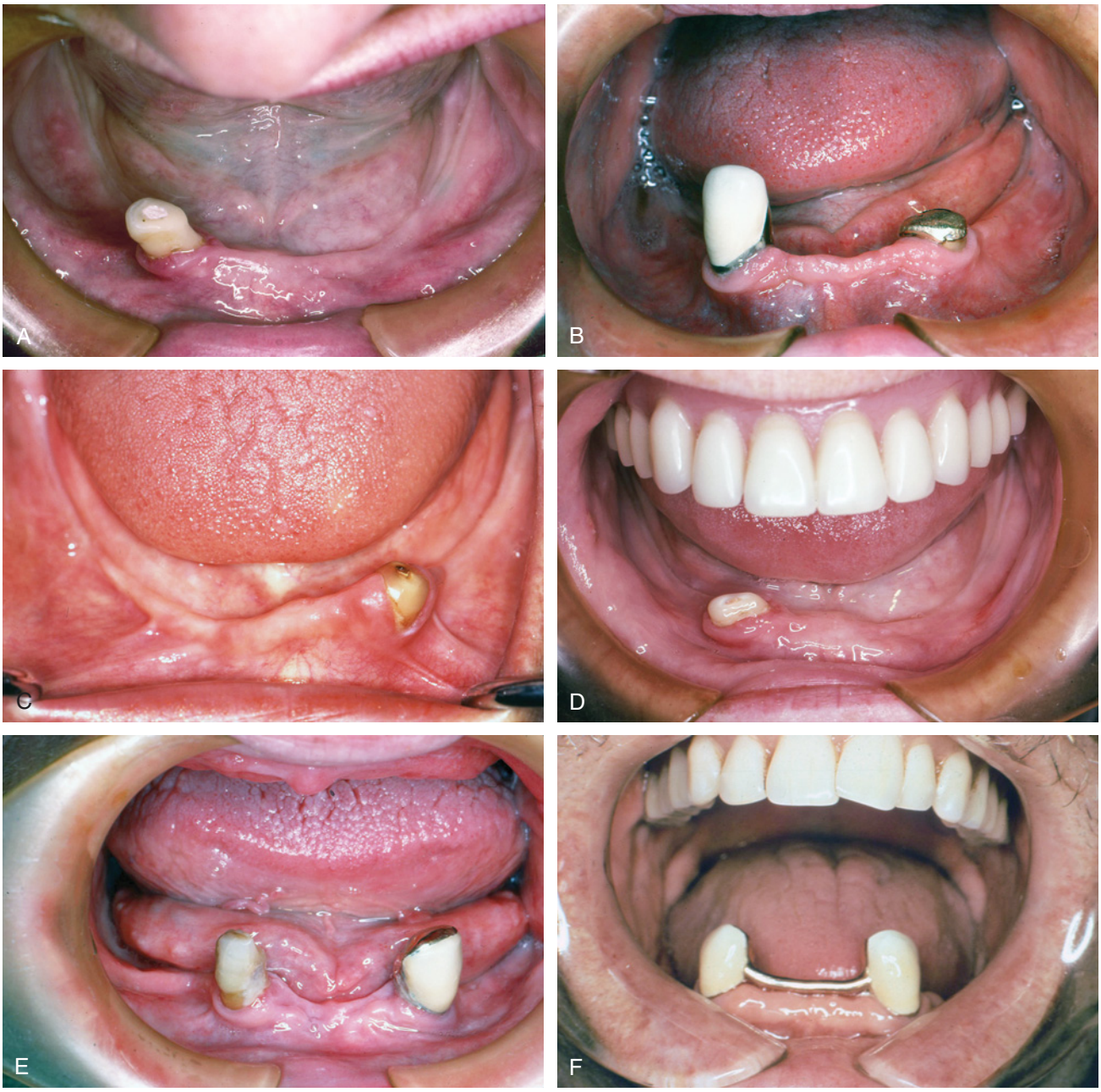


Figure 6-7 **A** to **F,** The notion underscoring the benefits of the development of the "classic" overdenture technique. Dentists had long recognized the merits of recruiting one or more teeth—often irrespective of overall integrity—to enhance the retention and support of mandibular removable prostheses, as well as to retard additional and ongoing RRR. Clinical experience culminated in recurrent efforts to aim at preferably retaining two mandibular canines that are morphologically altered after root canal therapy and extraction of adjacent teeth that demonstrated advanced periodontal disease (**G** to **J**). The resulting overdenture abutments ensure dentogingival support for complete dentures and an expected reduction in RRR, at least around and between the abutments. Overdenture treatment planning reconciles clinical decisions regarding number and location of potential abutments, their restorative and endodontic status, and their use for retention and support. The logical extension of the above examples culminated in the routine placement of two or more abutments when employing the implant overdenture technique **(K),** although preliminary short-term evidence suggests that even one mandibular implant can be of benefit (**L** and **M**). A management strategy for any abutment's health status is, of course, also a required consideration.

Continued



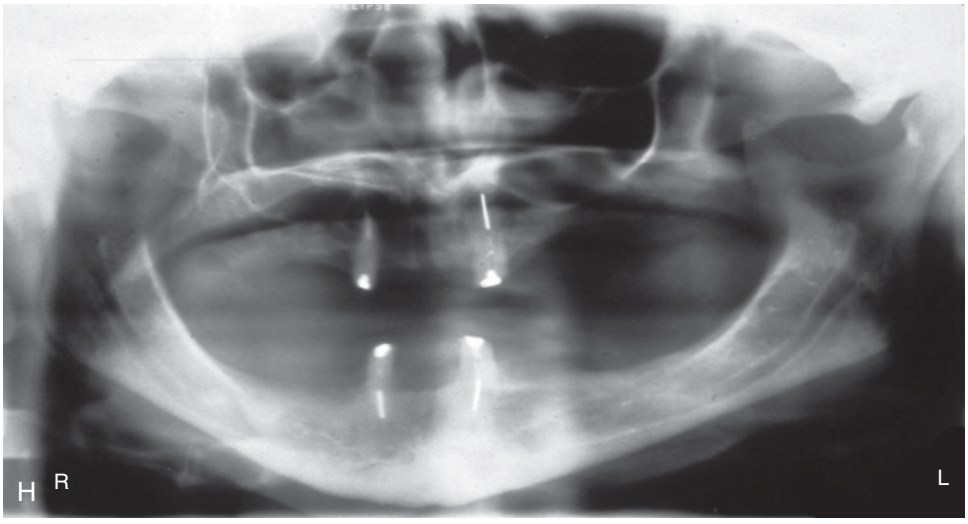






Figure 6-7, cont'd.

when unfavorable jaw size or position could not be rectified by orthognathic surgery (Fig. 6-8).

The technique was readily incorporated into the management of patients with partial or terminal dentitions, especially when complete dentures seemed inevitable. In fact, in today's dental practices, it is unlikely that immediate dentures are ever prescribed without diligent efforts made to retain abutment teeth—even if provisionally—for an immediate overdenture service. This approach helps reduce the compromising impact of some unavoidable complete denture-wearing consequences: RRR, loss of occlusal stability, undermined esthetic appearance, risks of soft tissue







Figure 6-7, cont'd.





Figure 6-8 **A** to **F,** Congenitally missing maxillary teeth and severe crowding of the residual dentition undermined both the appearance and the functional efficiency of this patient. A maxillary overdenture supported by abutments with gold copings resolved both clinically challenging concerns. **G** to **I,** The natural dentition was initially left virtually unaltered when the maxillary overdenture was made. It was managed by the patient with regular fluoride gel application and relatively conscientious home care. At a recall appointment, the teeth's rough edges would obviously require some modification and minor restorative touch-up.

Continued

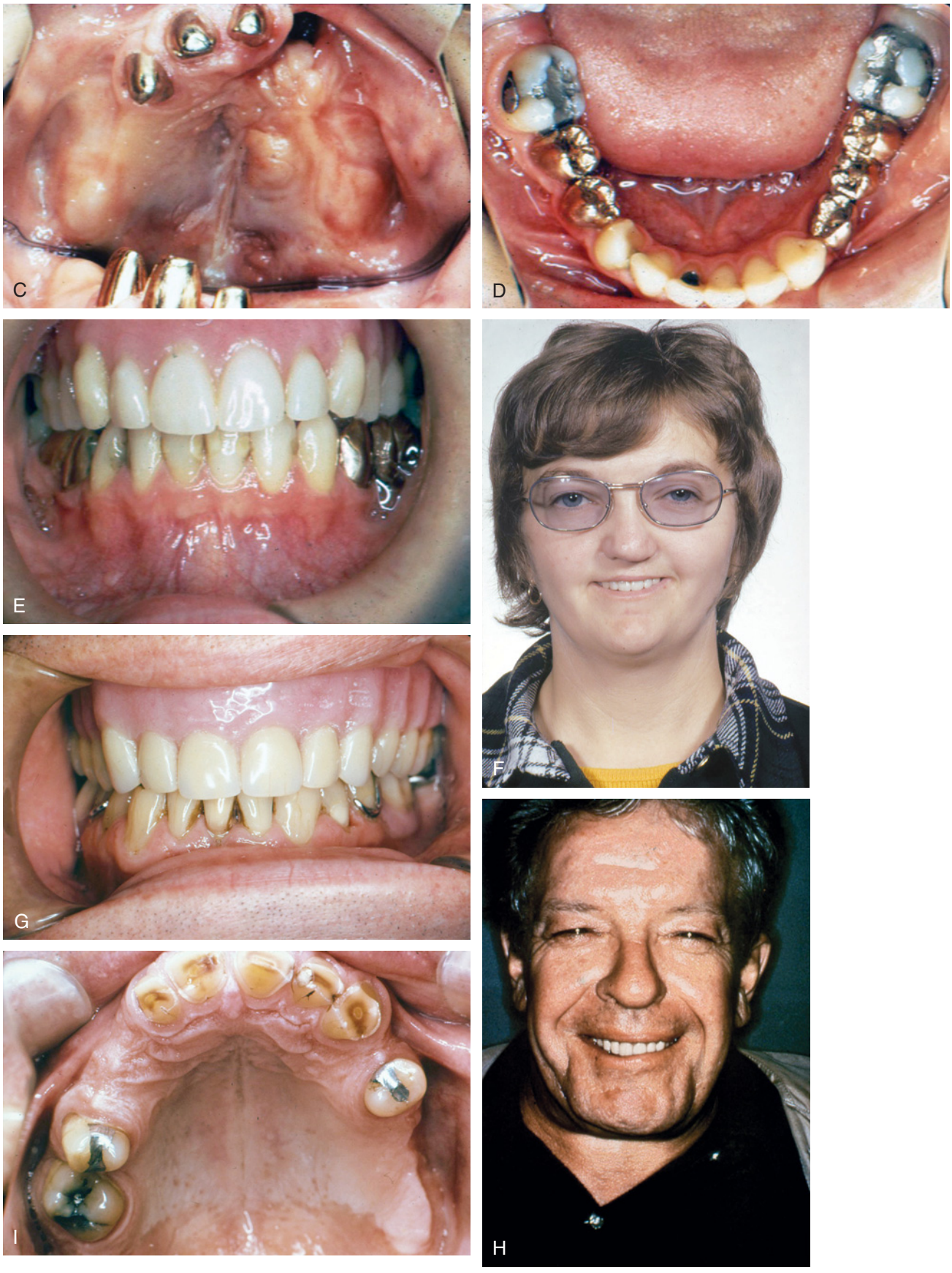


Figure 6-8, cont'd.

ulceration, and compromised masticatory function. The technique is also regarded as a "gentle" transition to the completely edentulous state. Moreover, it appears that the clinical maintenance of bone levels surrounding the abutments is more favorable than if teeth abutments were not present. For example, in 1993 Van Waas et al randomly assigned 74 subjects to treatment with immediate complete dentures, versus immediate complete overdenture prostheses supported on two mandibular canines. They evaluated the 2-year loss of bone in the canine area using cephalometric radiographs. The authors reported a reduction of 0.9 mm in the overdenture group and 1.8 mm in the denture group; in the molar area the loss of bone was 0.7 mm and 1.9 mm, respectively, with all measurements being statistically significant.

ADVANTAGES AND DISADVANTAGES OF THE OVERDENTURE TECHNIQUE

Both clinical experience and a number of research reports suggest numerous advantages for the overdenture method. They are listed in Box 6-4.

There are also disadvantages to the technique since it is prudent to regard it as a provisional treatment approach. The time-dependent transition to complete denture treatment is largely related to the patient's oral hygiene commitment and the nature of the selected abutments. It also must be emphasized that the covered teeth abutments' environment is not conducive to maintaining a plaque-free milieu and poses a serious risk of adverse sequelae. Furthermore, the often encountered age-related inability to apply a scrupulous hygiene protocol and the presence of refractory periodontal disease can be serious deterrents to successful teeth retention outcomes. Thus many clinicians frequently cite significant occurrence of caries and periodontal disease around abutments (Fig. 6-9). Caries can develop rapidly, with different degrees of susceptibility recorded, particularly among older persons. However, some studies also have emphasized the feasibility of controlling carious lesions through nutritional counseling, a sustained program of oral hygiene, and regular fluoride applications.

The prevention of gingival and periodontal disease is a very compelling concern. It remains the patient's responsibility, and scrupulous hygiene accompanied by regular—at least biannual—professional monitoring is mandatory to ensure continued abutment-supporting tissues' health. This entails a rigid and frequent recall appointment protocol with its implied additional expense, and it is one that is increased in the context of endodontic and frequent restorative requirements. Furthermore, available interarch space is sometimes judged inadequate on technical convenience grounds, and extensive abutment or design modifications will be required to expedite treatment. Potential weakness in the acrylic resin denture base also will need to be identified, and extra laboratory steps such as a cast metal superstructure fabrication can lead to additional expenses.

The increased costs associated with the technique are, however, often justified since overdentures may be regarded as a superior health service when compared with the standard complete denture. But this assertion depends on one essential caveat—patient ability to maintain a plaque-free environment.

Box 6-4 Cited Advantages for the Overdenture Technique

- Better maintenance of residual ridge bulk or original form than if an "unsupported" denture is worn. This results from a presumed improvement in occlusal stress distribution and the functional periodontal ligament fibers maintaining alveolar bone.
- Denture stability and even retention (particularly in the mandible) may be enhanced.
- Patients' subjective perceptions regarding a retained "natural feeling" tend to be positive ones. This may translate into better occlusal awareness, biting force, and consequent neuromuscular control than if the abutments in the overdenture were absent.
- The technique is a viable and simple alternative to complete denture therapy, and it is frequently self-reported as providing immense psychological support for patients.
- Its application lends itself to clinical versatility and depends on the dentist's judgment and skill and, above all, on the patient's motivation to maintain an impeccable oral environment

INDICATIONS AND TREATMENT PLANNING

The versatility of the overdenture service is demonstrated in the clinical examples selected for this chapter. They underscore the logic of including the method as an integral part of every dentist's treatment-planning repertoire that can be basically applied to two patient groups—Group 1 and Group 2 patients—described in the subsequent sections.

GROUP 1

Group 1 patients may present with a few remaining teeth that may be healthy and coronally intact, or with reversible periodontal disease, or malpositioned or even morphologically compromised. These teeth lend themselves to modifications for use as abutments. Treatment here is conceptually and technically straightforward with minimal preprosthodontic intervention needed. Analysis of articulated diagnostic casts, full-mouth radiographs, and overall patient

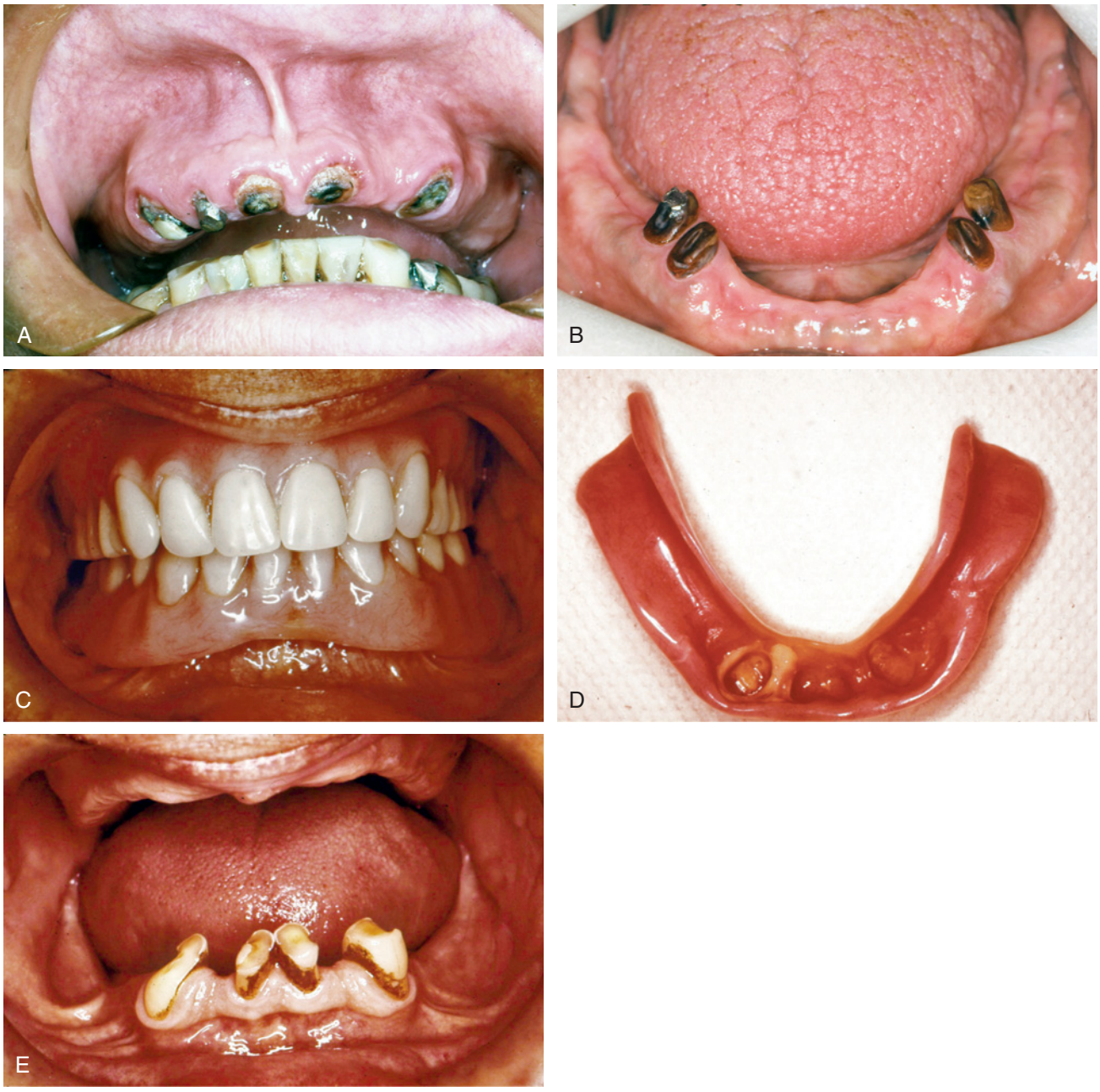


Figure 6-9 **A** and **B,** Caries presents a major challenge in the effort to prolong the useful healthy life of overdentured abutment teeth. The prepared root surfaces were left totally "bare" in part B, although no periodontal disease progress was noted. **C** to **E,** In contrast, this patient's home maintenance program, which included fluoride gel use, has yielded good treatment outcomes.

concerns will enable the dentist to determine potential abutment teeth's restorative and endodontic requirements (if any) in the context of the proposed overdenture's design. Particular consideration should be given to those patients in whom the overdenture will oppose a natural or restored natural dentition. The presence of overdentured abutments in an otherwise edentulous arch will reduce the considerable risk of soft tissue morbidity and bone resorption associated with significant occlusal stresses. The example of the hammer and anvil effect is most obviously simulated in single complete denture therapy (see Chapter 13).

GROUP 2

Group 2 patients have a diagnosis of mutilated or severely compromised dentitions of missing teeth and tooth structure, gross occlusal plane discrepancies, apical lesions, and gross recurrent caries. These patients appear to be heading

in an edentulous direction, and their treatment is defined by the complexity, expense, and time implications of the required interventions. Selected extractions will need to be performed, keeping in mind that retention of teeth with good alveolar support will preserve bone at the selected sites. Conversely, retention of periodontally compromised teeth can risk further depletion of bone levels if such teeth are retained—thus the need for their early extraction. Such an initiative serves to improve the periodontal status of the adjacent retained teeth

SELECTION OF ABUTMENT TEETH

Specific critical factors that influence the selection of abutment teeth to support an overdenture include periodontal status, mobility, location within the arch, and endodontic and prosthodontic considerations. Costs remain an ever present and often overriding consideration. The final treatment plan is defined by the number and required interventions on the retained teeth, as well as the following:

- Periodontal and mobility status: An abutment root or tooth must be chosen that is surrounded by healthy periodontal tissues. The tissues may already be healthy or rendered so by appropriate periodontal therapy. Compromised teeth with a good treatment prognosis are generally regarded as suitable candidates even when horizontal bone loss is present. Conversely, significant vertical bone loss, particularly if accompanied by class II or III mobility, often precludes a tooth's selection. Slight tooth mobility with horizontal bone loss is not a contraindication because a decrease in the crown-root ratio that is required in abutment preparation may actually ameliorate tooth mobility. A circumferential band of attached gingiva, albeit a narrow one, is regarded as improving the long-term prognosis of the abutment.
- Abutment location: Since the anterior mandibular alveolar ridge appears to be most vulnerable to time-dependent RRR, canines or premolars are regarded as the best overdenture abutments to reduce adverse forces at these sites. This conviction applies to the maxilla as well, although incisors also are frequently used. Maxillary abutments are particularly desirable if the mandibular arch is intact or is a naturally restored one. Clinical experience supports the recommendation of including at least one tooth per quadrant. If this recommendation is exceeded, retained teeth should preferably not be adjacent ones, or there should be several millimeters of space between the reduced tooth forms to minimize the risks of compromise in soft tissue health. It is also important to keep in mind (1) the number and locations of retained abutments in either arch and (2) the status of opposing ones, when planning to restore or preserve the balance of forces between opposing arches. Considerations for selecting maxillary overdenture abutments are summed up in Table 6-1.
- Endodontic status: Anterior single-rooted teeth are easier and less expensive to manage endodontically. Whenever pulpal recession to the extent of calcification within the pulp chamber has occurred, endodontic treatment usually can be avoided. Teeth with previous endodontic procedures should be considered for abutments. Their clinical crowns can be modified for

TABLE 6-1 CONSIDERATIONS IN SELECTION OF MAXILLARY TEETH AS OVERDENTURE ABUTMENTS

Maxillary Teeth	Advantages	Complicate Utilization
Central incisors	Ideal location, provide protection of the premaxilla	Proximity and alveolar prominence may complicate utilization
Canines	Longest root of the anterior teeth	Diverging facial tissue undercuts Overcontoured flanges Excessive lip support Potentially uncomfortable placement/removal of prosthesis Complicates placement of prosthetic teeth Internal relief to accommodate canines may weaken, create a food trap, compromise the peripheral seal
Lateral incisors	Widely separated, facilitating plaque control Tissue undercuts do not pose a problem Path of placement/removal is not compromised Ability to create a flange/ peripheral seal	Diminished root surface area

Data from Nelson DR, von Gonten AS: Biomechanical and esthetic considerations for maxillary anterior overdenture abutment selection, *J Prosthet Dent* 72(2):133-136, 1994.

technical convenience and treated with sealants, and restorations that prevent leakage into the endodontic access. As a cost-containment method, the use of cast copings largely has been eclipsed by composite resins and alloy restorations, with or without adjunctive interradicular retention. All abutment teeth require regular, preferably daily, fluoride application.

METHODS AND TECHNIQUES FOR ENHANCING THE OVERDENTURE'S RETENTIVE ROLE

Various methods and devices have been proposed for preparing abutment teeth to receive an overdenture. It is our impression that the essential feature in this technique is not the type of attachment used per se but the following basic principles:

- The overall objective is maximum reduction of the coronal portion of the tooth. This is readily achieved by routine endodontic therapy that also permits optimal accommodation of the overlying prosthetic teeth replacements and supporting acrylic resin denture base. A more favorable crown-root ratio also is established, and in patients with advanced pulpal recession and extensive tooth wear, coronal reduction may be carried out without the need for endodontic treatment (see Fig. 6-7, G). There are two general approaches to the recruitment of teeth abutments for overdenture support. One approach is to leave the prepared abutment teeth "bare" or "unprotected" and plan to monitor hard tissue integrity via plaque control and daily fluoride applications that can be placed in the abutment recess within the denture base. The second approach stipulates that prepared teeth abutments need "protection" with cast copings and is discussed in subsequent points.
- In most situations, a "bare" tooth root preparation can provide adequate long-term service for both immediate and replacement overdentures and is the selection of choice. Frequently, a devitalized and broken-down tooth also can be restored with an alloy or a composite and then reshaped and polished with fine sandpaper disks. This approach also permits an evaluation of the status of selected abutment teeth and whenever a patient's (usually an elderly one's) general health precludes several dental appointments. It is also the least expensive option, and a coping's presumed protective qualities can probably be exceeded with fluoride gel application, maintenance of an excellent level of oral hygiene, the use of chlorhexidine mouthwashes, and appropriate adjunctive restorative therapy. Current research also underscores the reliable clinical performance of alloys and composite resins as restorations for these abutments. As discussed in a 1999 study by Keltjens et al, the decision not to place extensive restorations is a philosophy of cost containment and understanding that vertical support from the abutments and lateral stability from the retained alveolar height can assist prosthodontic success.
- The need for a gold coping or a crown-and-sleeve coping retainer depends on several factors. Occasionally, a gold coping is necessary and can be prepared with or without an interradicular dowel or retentive pins, depending on the amount of tooth structure remaining coronal to the gingival attachment. Often the coping preparation can extend into the endodontic preparation to gain increased surface area. The gold coping (Fig. 6-10) does involve an additional expense, but some patients are uncomfortable with the sight of discolored and "unprotected" roots in their mouth. The patient's susceptibility to caries also must be considered because provision of a coping does not guarantee reduced caries activity. Tooth preparation is similar to that for a complete gold crown, with or without additional pin retention, and it includes a combination of shoulder and chamfered gingival margins as dictated by the amount of residual tooth structure. It must be emphasized that the main objective in preparing and restoring overdenture abutments is to prolong the useful life span of the retained abutments and the preservation of alveolar bone; it is not necessarily to introduce a technique for more retentive dentures. Consequently, a simple, short, convex abutment preparation (with or without a casting) is widely regarded as the optimal root surface preparation. As a cost-containment method, the use of cast copings has been largely eclipsed by composite and alloy restorations, with or without adjunctive interradicular retention. As mentioned earlier, all abutment teeth require daily fluoride application.
- A cast restoration technique also is popular because it permits the additional option of selecting a specific adjunctive retentive device from a large choice of commercially available components. This is an extension of the precision-retained abutment concept used in removable partial dentures and modified for use with overdenture abutments. It is a technically ingenious idea and offers a diversity of techniques, for example, intracoronal and extracoronal attachments, chairside attachments, or indirect attachments with cast copings. Several of these attachments are available in resilient and nonresilient designs. Commercially available patrix attachments cemented within the canal increase the risk of root fracture and should be used sparingly in roots of small dimension.

Emphasis on the use of such readily available commercial attachments risks shifting the overdenture design from stability and retardation of RRR concerns to major and perhaps unjustified emphasis on prosthesis retention. Apart

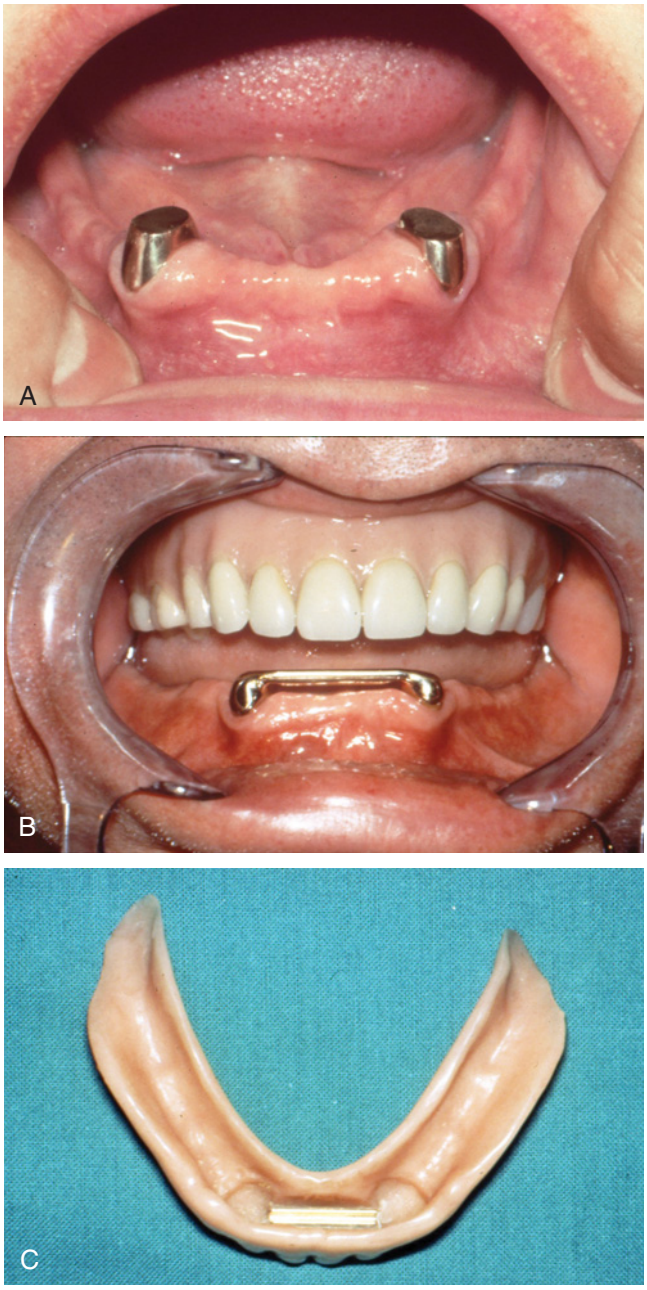


Figure 6-10 **A** to **C,** Different coping designs, with or without additional commercial attachments, are readily available.

from the increased expense, the risks include additional technical demands and difficulties, particularly when repairs are required. Oral hygiene maintenance requirements also may be more demanding, and interarch space for esthetic and functional tooth positions may be compromised. It must therefore be emphasized that this approach may significantly increase the costs associated with the professional service but without improving the merits of the overdenture experience other than in a short-term retentive context. Nonetheless, attachment systems do expand the scope of the overdenture technique in situations in which retention concerns dominate design considerations.

Gold copings and telescopic crowns are one more method of improving overdenture retention. These may be conical crowns with a friction adaptation at the marginal area of the abutment or milled crowns with larger surface area for frictional retention. Frictional retention is more commonly used with multiple abutments creating exclusively tooth-supported overdentures. In overdenture situations where the prosthesis also rests on resilient edentulous ridges, the copings and telescopic crowns usually are designed with a coronal relief area of 0.3 to 0.5 mm, allowing tissue-ward movement and lateral movements. The remainder of the edentulous ridge is covered by acrylic resin bases. The telescopic crowns resemble porcelain crowns, and they are incorporated in the overdenture. In 2001, Wenz et al described these methods with both (1) complete tooth-supported dentures and (2) tooth-tissue–supported dentures. Tooth-tissue–supported dentures had an average of three or fewer abutments. The total of both groups in the Wenz study was 125 subjects with 460 abutments. A total of only 16 subjects lost 38 abutments, and the probability of keeping all abutments was similar in both groups, with 84% (95% confidence interval [CI], 67 to 94) at 5 years and 66% (95% CI, 38 to 84) at 10 years. These abutments should be in very good health when considered for this restoration technique.

LOSS OF ABUTMENT TEETH

Emphasis has been placed on the fact that overdentured abutment teeth are vulnerable to relatively short-term outcomes. In fact, several studies have reported loss of abutment teeth during varying observational follow-up periods. After 5 to 6 years, about 10% of abutment teeth supporting overdentures were lost. The most frequent causes were periodontal disease (about 70%), caries (about 25%), and endodontic complications (about 5%). Many of the long-term clinical studies of overdenture populations have been fraught with logistical problems of poor clinical follow-up and poor patient compliance in home care. Therefore their projection of abutment loss is a suspect point estimate but one that can be explained through little fault of the investigators or clinicians. This patient population is usually older, with comorbid conditions, social problems of finances and transportation, and an overall lack of perceived dental need. Many authors reported that although yearly or biannual examinations were planned, after a few years, more than 25% of populations ceased evaluations or were sporadic in attendance. The level of compliance with home care also was sporadic and at times nonexistent because this was a patient population that likely had long-standing habits leading to a terminal dentition that culminated in the overdenture treatment plan. The success of overdenture treatment demands effective prevention of caries

and periodontal disease. Regular follow-up visits are essential, and oral health maintenance measures are periodically reviewed and revised as necessary.

Ideally the patient must be well motivated to maintain the hygienic phase of periodontal care. It has been amply demonstrated that inadequate oral hygiene is a major contributor to abutment loss. Given the fact that this population may lack dexterity and motivation for adequate hygiene, the dentist might prescribe the many mechanical toothbrushes that are available. Lack of patient compliance and predicted lack of motivation should not exclude a patient from overdenture therapy. In 1998 Griess, Reilmann, and Chanavaz described mentally challenged subjects who maintained 81% of three-teeth telescopic overdentures at 8 years. Unfortunately, actual "loss of dentures" was more a problem than loss of abutments. One-tooth mandibular overdentures were not as well tolerated, and patients often discarded these dentures.

Long-term monitoring of patients with overdentures reveals the occasional need for removal of one or more abutment teeth. This must be expected, and the cause is usually a periodontal abscess. Removal of the affected tooth, with appropriate revision of the contacting space in the overdenture, can be done readily and inexpensively, without loss of the prosthesis. Caries accounts for the remainder of maintenance issues and abutment loss. Fluoride gel is prescribed for daily application to the inside of the overdenture to bring the fluoride into intimate contact with the natural tooth structure. It is understood that the effectiveness of fluoride on root and dentinal surfaces has not been as well defined as fluoride remineralization and incorporation in enamel. Studies of root surface caries in patients exposed to lifelong fluoridated water supply reveal a decrease in caries activity. Its use has been prescribed for patients with overdentures and seems to decrease caries activity. As in enamel, the greater the fluoride concentration, the greater the efficiency of the fluoride.

In 1997 an in vitro evaluation was performed by Ettinger et al to simulate overdenture abutment root surface caries, and the depth of remineralization bands were evaluated with polarized light microscopy. Fluoride preparations were 5000-ppm acidulated phosphate fluoride (pH 5.6), 5000-ppm neutral sodium fluoride, and 1000-ppm neutral sodium fluoride, with a distilled water control. Over 18 days the extracted teeth with exposed root surfaces were repeatedly placed in fluoride for 4 minutes, then in a demineralizing solution for 6 hours, and then in a remineralizing solution for 17 hours. The lesions in the 5000-ppm preparation had statistically shallower lesions. All groups except the control group exhibited remineralization bands. Reduction of demineralization was found to have a dose response in favor of the greater 5000 ppm. These findings are consistent with in vivo fluoridated dentifrice studies on root surface caries.

Given these findings, one should consider the preparations with greater fluoride concentrations. There are also dentifrices with 5000-ppm fluoride that can be prescribed. The role of preparation pH also is being questioned in root surface caries models. The thought that the tissues may be severely irritated by the daily use of fluorides with low pH is an unlikely scenario because patients undergoing irradiation have been using daily stannous fluoride preparations (pH 4.0) in tray applicators for 10 minutes daily for many years without noticeable tissue irritation or patient complaints. In addition, stannous fluoride (SnF2) preparations have been shown to inhibit plaque formation and periodontal microorganisms in multiple periodontal studies. If patients complain about tissue irritations, neutral preparations can be considered. The clinician should continue to evaluate the commercial fluoride preparations and the fluoride literature as it relates to root surface caries and overdenture abutments.

SUMMARY: TREATMENT OUTCOME STUDIES

The desire to prolong the useful life of at least a few of our patients' teeth led to a dramatic surge of interest in the overdenture concept. Several reports endorsing the technique have been published and many anecdotal claims made, but until recently there has been a lack of well-documented, long-term clinical follow-up of these patients. Current research appears to endorse the claim that overdentures are an effective alternative to conventional complete denture therapy, and their use in routine practice continues to be endorsed. However, the very nature of overdenture design and its relationship to plaque must always be kept in mind if this treatment modality is to fulfill its potential. Furthermore, the impressive and virtually morbidity-free outcomes reported in implant-supported overdenture studies have now virtually eclipsed the traditional role of teeth-supported overdentures.

THE POTENTIALLY EDENTULOUS PATIENT TO BE TREATED WITH IMMEDIATE DENTURES

George Zarb, Rhonda F. Jacob

An immediate denture is one made for immediate placement following teeth removal. Immediate dentures may be single ones made for either arch, or else for both arches. In the latter case, they are made together to ensure optimal control over esthetics and occlusal relationships, and they may be made as complete or partial ones, or even as overdentures. Immediate complete dentures in particular are challenging to make since a try-in appointment is not possible before their completion. This "missing step" may preclude optimal control over both esthetic and occlusal relationship outcomes. Consequently there is a risk that

patients may not be completely satisfied or comfortable with the resulting appearance and fit at the time an immediate denture is inserted. The dentist should explain, and the patient should fully understand, the limitations of the procedure before beginning treatment.

There are two popular clinical protocols associated with the making of immediate dentures. The first relies on a refitting/relining of the immediate denture following the time-dependent completion of soft tissue healing and stabilization of supporting bone morphology. This approach is a logical extension of a patient's satisfaction with the esthetic and overall technical results that were initially achieved at the time of the denture's insertion. It is also a very practical and financially prudent way to address patients' needs and is referred to in this chapter as a conventional immediate denture (CID).

The second method regards the immediate denture as an interim or transitional one (IID) that is designed to enhance function, esthetics, and prosthesis stabilization, but for only a limited period of time. It is then replaced by the definitive prosthesis when the overall healing response is complete. From a practical point of view, this method is used most often when many anterior and posterior teeth are retained until the day of extraction and placement of the immediate denture. Advances in dental materials now permit very rapid and convenient fabrication of interim immediate dentures. This is a particularly useful approach when dealing with extenuating circumstances such as emergencies related to health or time restriction concerns. In these situations, the denture teeth may be made with tooth-colored autopolymerizing resins and also may include patients' preexisting fixed or removable partial dentures. Immediate dentures also can be made from articulated preextraction casts mounted in maximum intercuspation position (MIP) when it closely approximates the patient's centric relation position. The casts are then modified and denture teeth are articulated on the mounted casts. Convenience, cost, and expediency are the major indications for a number of technical variations on a theme of immediate replacement of missing teeth.

ADVANTAGES AND DISADVANTAGES OF IMMEDIATE DENTURE TREATMENT

Several advantages are cited for the immediate denture technique. They are listed on the basis of being both self-evident and logical. They also are supported by long-standing convictions shared by numerous experienced dentists and clinical educators.

- The avoidance of even a short-term edentulous period means that the patient's appearance is unchanged.
- As a result, circumoral support, muscle tone, vertical dimension of occlusion, jaw relationships, and face height are maintained. Moreover, the tongue will maintain its position and not spread laterally and posteriorly over the alveolar ridges as a result of teeth loss.
- Less postoperative pain is likely to be encountered since the extraction sites are protected from tongue and food contact, although proper mastication does not occur until soft tissue discomfort subsides.
- If preexisting conditions are acceptable, it is easier to duplicate the natural tooth shape and position, plus arch form and width. The horizontal and vertical positions of the anterior teeth also can be replicated.
- Patients gradually adapt to dentures while healing is progressing because they will advance the consistency of their diet over time as soft tissue discomfort subsides. Speech and mastication are rarely compromised and suitable nutrition is readily maintained.
- The availability of interim soft lining materials allows for considerable versatility in the correction and refinement of the denture's fitting surface, both at the insertion stage and at subsequent appointments.
- Psychological and social well-being are preserved since patients do not have to go without teeth and the attendant interruption of a normal lifestyle of smiling, talking, eating, and socializing.

In fact, a 1995 Dutch study by Jonkman et al observed that 1 year after immediate denture placement, a majority (76% to 79%) of the study patients reported that they could eat properly and had easily adapted to wearing the denture. There also was no difference at a 1-year follow-up found in denture satisfaction, comfort, chewing ability, esthetics, and overall satisfaction between patients in the immediate denture group and two groups of control subjects—one group with immediate overdentures and another group with tooth-attachment–retained overdentures.

There are understandably also some disadvantages to the technique. They include these observations:

- Immediate dentures may require a more challenging execution of routine clinical steps because the presence of teeth can make registration of impressions and maxillomandibular positions more difficult.
- The anterior ridge undercut (often severe in the maxilla) caused by the presence of the remaining teeth may interfere with impression procedures. This could affect accurate registration of important posteriorly located undercuts.
- The presence of different numbers of remaining teeth in various locations (anteriorly, posteriorly, or both) frequently leads to incorrect recording of the centric relation position, or the proper determination of the vertical dimension of occlusion. An occlusal adjustment, or even selective pretreatment extractions, may be needed to make accurate records at the proper vertical dimension of occlusion.

- The inability to accomplish a denture tooth try-in, in advance of extractions precludes knowing what the denture will actually look like on the day of insertion. Careful planning and explanation to the patient, plus operator experience and attention to technique details, best address this technique's inherent problem.
- Because this is a more difficult and demanding procedure, more chair time, additional appointments, and therefore increased costs are unavoidable. Patients' dissatisfaction with tooth position or gross denture tooth modification postinsertion to correct vertical dimension or centric relation occlusion may require the remake of both dentures. The patient must be aware that making new dentures may be required, thereby increasing time and costs.
- Functional activities (e.g., speech and mastication) are likely to be temporarily compromised. However, this is a very short-term inconvenience.

Comparative indications for the two methods are summarized in Table 6-2.

CONTRAINDICATIONS TO IMMEDIATE DENTURE TREATMENT

Some patients are simply not good candidates for immediate dentures. They include those who are in poor general health or who are poor surgical risks, such as those with systemic conditions that affect healing or blood clotting, cardiac or endocrine gland disturbances, and psychological disorders, as well as patients who have received irradiation of the head and neck regions. Other patients who are regarded as uncooperative because they cannot understand and appreciate the scope, demands, and limitations of immediate denture treatment also are not good candidates for the service.

Quite infrequently, patients will not object to going without teeth during the healing period. This is especially true if these patients have extensive tooth loss or severe caries or periodontal disease. For these patients, extractions followed by a suitable healing period and eventual conventional complete denture treatment are simpler and less expensive.

TREATMENT PLANNING THE CHOICE OF THE IMMEDIATE DENTURE CLINICAL TECHNIQUE OR PROTOCOL

Scrupulous treatment planning and patient education, plus meticulous clinical performance aided by the careful use of soft tissue liners, can virtually ensure a predictably favorable treatment outcome for either of the two described protocols. Careful clinical monitoring and time-dependent modifications will of course be necessary, but either type of technique protocol can lead to a good clinical result.

In some patients, the presence of numerous posterior teeth and the need for surgically addressing other hard and soft tissue–related procedures can complicate treatment. For example, the sequelae of advanced periodontal disease, including aberrant occlusal relationships, might require a "staged" surgical approach to the final objective of a definitive prosthesis. In such situations the preliminary extraction of posterior teeth and performing other required preprosthetic surgical or medical procedures would be necessary to prepare the mouth for a CID approach.

Some patients will not tolerate being without their posterior teeth, even if this would be for a relatively short time period. They would then benefit from an occlusal adjustment that may be extensive, plus a select number of extractions that would permit the IID choice with scope for excellent predictable results. In either situation, the pretreatment proviso that must be agreed to by both patient and dentist is that if the esthetic and occlusal outcomes are not satisfactory, a new definitive prosthesis would have to be made. In this manner, a patient can feel reassured about a satisfactory outcome, while the dentist acknowledges the inherent risks and shortcomings of this service.

Experience also suggests that many patients tend to opt for the convenience of the interim denture (ID) approach. Furthermore, if the dentist performs the technique meticulously and the patient is cooperative, the resulting ID can be very successful indeed. A second denture procedure would then allow for even greater optimization of the first result, or else patient and dentist satisfaction may result in a decision to treat the IID in a similar manner as a CID and merely reline or refit it accordingly.

EXPLANATION TO THE PATIENT

The patient should always be provided with a careful explanation of the limitations of the immediate denture service. Box 6-5 contains a useful synthesis of the sort of information that patients need to have so as to best understand the implications of the treatment. Dentists should also include an informed consent with wording specific to the nature of the immediate denture (Box 6-6). At this stage of diagnosis and treatment planning, patients should be provided with written information (to take home) concerning dentures, immediate dentures, or both, so that they have time to ask questions at a subsequent visit when treatment procedures begin.

ORAL EXAMINATION

The shade and mold of the existing teeth should be determined. A gingival shade should be taken with denture-base shade tabs. Patients should be asked if they like their current shade and tooth position and what changes they would

TABLE 6-2 COMPARISONS OF CIDS AND IIDS

Conventional Immediate Denture (CID)	Interim Immediate Denture (IID)
Intended as definitive or long-term prosthesis	Transitional or short-term prosthesis
After healing is complete, it is relined	After healing, a second denture is made; the IID is kept as a spare denture and may be relined for use as a spare
At the patient's initial presentation, usually only anterior teeth (plus possibly premolars) are remaining	At initial presentation, usually both anterior and posterior teeth are remaining
Usually has good retention and stability at placement, which is possible to maintain during healing	Usually has only fair retention and stability at insertion, which must be improved by provisional relines (tissue conditioning) during healing
The overall cost of CID treatment is less than IID treatment because it is the cost of the CID plus a reline	The overall cost of IID treatment is greater than CID treatment because it includes the cost of the interim denture and a second denture
Treatment process takes longer than the IID because there is a delay of 3-4 weeks for the posterior teeth extraction areas to heal partially before making the final impression	Treatment process takes less time than the CID because denture fabrication procedures can begin right away
Generally indicated when only anterior teeth are present or few posterior teeth remain *that do not support an existing removable partial denture*	Generally indicated when there are multiple anterior and posterior teeth remaining or full arch extractions and/or these teeth support a removable partial denture that the patient desires to retain until insertion
Generally indicated when patient can function without posterior teeth for approximately 3 months (3-4 weeks posterior area healing time plus 2 months to fabricate and place the CID)	Generally indicated when the patient cannot or will not go without posterior teeth or an existing removable partial denture because of esthetic or functional concerns
At placement of the CID, usually only anterior teeth are extracted (possibly also one premolar on each side that had been retained to preserve the vertical dimension of occlusion)	At placement of the IID, usually both anterior and posterior teeth are extracted
Indicated when two extraction visits are feasible	Indicated when only one surgical visit is preferable (e.g., to meet "one hospital surgical visit" insurance benefits or when the patient's medical condition warrants only one surgical and/or hospital visit)
Esthetics of the CID are acceptable	The second denture procedure after the IID allows an alteration of esthetics and any other factors if indicated
At the end of the treatment, the patient has one denture	At the end of the treatment, the patient has a spare denture to use in case of extenuating circumstances
If all posterior teeth are initially removed, the vertical dimension of occlusion is not preserved; opposing premolars can be maintained for this purpose	Because posterior teeth need not be removed before fabrication of the IID, the vertical dimension of occlusion may be preserved
Contraindicated for a patient who has a complex treatment plan (e.g., periodontal therapy, crowns, fixed partial dentures and removable partial dentures in the opposing arch) or for changes in the vertical dimension of occlusion	Indicated when the patient will become edentulous in one arch and become partially edentulous in the opposing arch for the first time or complex procedures are needed (such as crowns, fixed partial dentures, and removable partial dentures) or changes in the vertical dimension of or changes in the vertical dimension of occlusion; an upper IID against a transitional lower partial denture can be made; then any periodontal procedures, crowns, and fixed partial dentures can be done during the initial healing stage
Not useful for converting existing prostheses such as removable partial dentures	Can be useful in converting existing prostheses to an IID

make, if any. This discussion should include deciding whether to preserve diastemata, rotations, and overlapping of teeth for a more natural transition and a more natural-looking denture. This initial esthetic dialogue will streamline the final tooth selection process at a later visit. It also is best to include photographs as part of the permanent record, including full-size face and profile, lips closed and smiling, and an intraoral view of the teeth in maximum occlusion.

Time should be spent evaluating the lip support, philtrum shape, position of high lip line, low lip line, occlusal plane and amount of tooth exposure in function while the

Box 6-5 Explanation to the Patient Concerning Immediate Dentures

1. They do not fit as well as complete dentures. They may need temporary linings with tissue conditioners and may require the use of denture adhesives.
2. They will cause discomfort. The pain of the extractions, in addition to the sore spots caused by the immediate denture, will make the first week or two after insertion difficult.
3. It will be difficult to eat and speak initially, almost like learning to eat and speak all over again.
4. The esthetics may be unpredictable. Without an anterior try-in, the appearance of the immediate denture may be different from what you or the dentist expected.
5. Many other denture factors are unpredictable, such as the gagging tendency, increased salivation, and facial contour.
6. It may be difficult or impossible to insert the immediate denture on the first day. Every effort will be made to do so. If it is not possible, it will be inserted or remade as quickly as possible.
7. Immediate dentures must be worn for the first 24 hours without being removed by the patient. If they are removed, they may not be able to be reinserted for 3 to 4 days. The dentist will remove them at the 24-hour visit.
8. Because supporting tissue changes are unpredictable, immediate dentures may loosen up during the first 1 to 2 years. The patient is responsible for all fees involved in refitting or relining the dentures.

Box 6-6 Example of Informed Consent for Immediate Dentures

An immediate denture is a denture that is inserted immediately on extraction of your remaining teeth. The fit, appearance, or comfort of such dentures is very difficult to predict. There is no way that teeth can be fitted in advance to show you what the denture will look like, how well you will be able to bite and chew, and how they will fit.

Immediate dentures often require tissue conditioning or temporary liners during the healing phase as the natural process of gum and bone shrinking takes place. After several months, the immediate denture will need a definitive reline or you may require a new denture. The costs of these liners, relines, or the new denture are not included in the fee for the immediate denture. The fee for each of these services has been discussed with you.

Every effort will be made to duplicate or improve on the position of your natural teeth, but if the immediate denture is not quite what you expected, you may have to have a second denture made, even if a reline was what was originally planned.

patient is both silent and talking. Notation of the following factors will help in later visits:

- The patient's existing midline and need for modification of its position (existing teeth may have drifted, especially if a nearby tooth has been lost for some time)
- The patient's existing vertical dimension of occlusion and amount of interocclusal distance (freeway space) and the need for conforming to or changing it, according to whether the patient's existing maximum occlusal position coincides with the planned centric relation position for the immediate dentures and how difficult it is to manipulate or achieve that position for recording
- The present amount of horizontal and vertical overlap of anterior teeth
- Whether a horizontal cant or lack of harmony of the occlusal plane with facial form, or a hypererupted alveolus requires correction with surgery or correction with prosthetic tooth position
- An estimate of the Angle classification of occlusion for the patient
- Display of posterior teeth in the buccal corridor

EXAMINATION OF ANY EXISTING PROSTHESIS IF IT IS TO BE INCLUDED IN AN IID

In some instances it may be possible to retain an existing prosthesis while replacing teeth that had already been lost or may be lost in the preparatory phases. Such teeth can easily be added to the existing prosthesis in a laboratory procedure to allow the patient to continue to use this prosthesis if it is currently performing adequately. When an existing prosthesis is to be used, it is critical that this prosthesis be carefully evaluated. Any existing prostheses should be examined for shade, mold, tooth position, lip support, and smile line. The shade of the denture base also should be noted.

TOOTH/TEETH MODIFICATIONS

Many immediate dentures will require modification of opposing natural teeth to correct the occlusal plane or to eliminate prematurities in centric relation. Occlusal plane adjustment is necessary because indications for tooth extraction (e.g., extensive caries, periodontal disease, and extrusion or drifting) are often associated with occlusal discrepancies (Fig. 6-11) and can affect the correct registration of centric relation. They also can interfere with the proper



Figure 6-11 Planning CIDs for the maxillary arch (**A** and **B**) and both arches (**C** and **D**) would require having the mandibular anterior teeth modified so as to correct the uneven plane of occlusion, as well as changing the VDO to avoid the resulting anterior mandibular slide shown in **B** and **D.**

determination of the occlusal vertical dimension. Any tooth or teeth modifications should be made before making final impressions.

On occasion, an occlusal analysis and the location of the plane of occlusion are best made by performing a diagnostic articulation of the preliminary casts. In many instances this may require the fabrication of an occlusion rim because there may be too few remaining teeth to accomplish the diagnostic articulation without this valuable orientation device. This permits optimal planning of any necessary changes. The required dialogue with the patient on denture esthetics is initiated at the oral examination visit and the relevant information recorded and marked on the articulated diagnostic casts. These preliminary casts also serve as a preextraction record (Fig. 6-12).

PROGNOSIS

All of the foregoing features allow the dentist to determine a prognosis for the immediate denture. The professional fee should be quoted only after this thorough examination. At this point, there will be a good indication of the best type of immediate denture protocol for the patient; the anticipated



Figure 6-12 Preextraction records on any patient may be determined even when a compromised residual partial dentition is present. This patient was scheduled for a maxillary immediate denture, and it was possible to acquire very useful information such as an evaluation of occlusal relations, smile line, midline, and posterior limit for prosthetic teeth placement, planes of occlusion, extruded teeth, and more via a simple clinical evaluation. However, this also can be conveniently done via mounted diagnostic casts, which will then serve as a permanent record.

difficulties (e.g., inability to achieve a reliable centric relation position); esthetic demands on the part of the patient; a compromised residual ridge for denture support; systemic diseases and medications that may affect denture success; sensitive tissues or sharp, bony prominences that may necessitate more sore spot adjustment, and other concerns. Once the patient understands and accepts the diagnosis, treatment plan, and prognosis, treatment can begin.

REFERRALS/ADJUNCTIVE CARE

If other dentists are to be involved in the patient's treatment, any necessary consultation referral is requested at this time. For example, a surgical consultation should occur early in the treatment to establish good communication between the patient, practitioner, and the surgeon. Common preprosthetic surgical procedures are considered and a written referral with a copy of the radiographs also should be sent to the surgeon in advance. Requests for specific surgical interventions(s) and where to not do surgery (e.g., when bone trimming is not needed or when saving teeth for overdenture abutments is chosen) plus additional future surgical considerations (e.g., dental implants) also are identified.

This surgical consultation visit will further reassure the patient as to the events that will occur on the surgical date(s). If the patient desires any type of sedation anesthesia, the details of this can be worked out in advance. The surgeon and the practitioner should communicate after the consultation so that they can arrange a mutually convenient surgical date and so that the practitioner can receive input and suggestions from the surgeon's examination of the patient.

Should an endodontic consultation for any planned overdenture abutments also be necessary, this could be started at any time but preferably initiated early in the treatment sequence. The same applies if periodontal treatment is indicated for any remaining teeth in the opposing arch or any identified overdenture abutments. It is usually preferable to perform any needed periodontal therapy after the placement of the immediate denture. Clinical experience indicates that the removal of periodontally compromised adjacent teeth frequently facilitates the periodontal treatment that may be required for the remaining teeth.

ORAL PROPHYLAXIS

The patient should preferably have a general scaling of the teeth to minimize calculus deposits and the adverse impact of inflammatory processes associated with the residual dentition. This will reduce the postoperative edema and chance of infection.

OTHER TREATMENT NEEDS

Often, patients with single immediate dentures also require restorations such as crowns or removable partial dentures in the opposing arch. These restorations are usually performed prior to, but as an integral part of, the overall treatment plan.

For the patient with a single CID, the proposed restorations can be completed during the 3 to 4 weeks of healing after the first surgical visit and also coincident with the immediate denture procedures. For the patient with a single IID, any required restorative and removable partial denture procedures for the opposing arch are done after placement of the IID. The only exception to this is if a transitional removable partial denture is planned for the opposing arch; this is usually fabricated coincident with the immediate denture procedures.

Bibliography

Considerations for Implant Prosthodontic Treatment

Attard NJ, Zarb G: Long-term treatment outcomes in edentulous patients with implant-fixed prostheses: the Toronto study, *Int J Prosthodont* 17(4):417-424, 2004.

Attard NJ, Zarb G: Long-term treatment outcomes in edentulous patients with implant overdentures: the Toronto study, *Int J Prosthodont* 17(4):425-433, 2004.

Attard NJ, Zarb GA, Laporte A: Long-term treatment costs associated with implant-supported mandibular prostheses in edentulous patients, *Int J Prosthodont* 18(2):117-123, 2005.

Brånemark PI, et al: *Osseointegrated implants in the treatment of the edentulous jaw—experience from a ten-year period*, Stockholm, 1977, Almquist and Wiksell.

Brunski JB, Moccia AF Jr, Pollack SR, et al: The influence of functional use of endosseous dental implants on the tissue-implant interface. II. Clinical aspects, *J Dent Res* 58:1953-1969, 1979.

Bryant SR, Zarb GA: Outcomes of implant prosthodontic treatment in older adults, *J Can Dent Assoc* 68(2): 97-102, 2002.

Carmichael RP, Apse P, Zarb GA, et al: Biological, microbiological and clinical aspects of the peri-implant mucosa. In Albrektsson T, Zarb GA, editors: *The Brånemark osseointegrated implant*, Chicago, 1989, Quintessence.

Eckert S, Parein A, Myshin HL, et al: Validation of dental implant systems through review of literature supplied by system manufacturers, *J Prosthet Dent* 77:271-279, 1997.

Jacob RF: The traditional therapeutic paradigm: complete denture therapy, *J Prosthet Dent* 79(1):6-13, 1998.

Kiener P, Oetterli M, Mericske E, et al: Effectiveness of maxillary overdentures supported by implants: maintenance and prosthetic complications, *Int J Prosthodont* 14(2):133-140, 2001.

Rentsch-Kollar A, Huber S, Mericske-Stern R: Mandibular implant overdentures followed for over 10 years: patient compliance and prosthetic maintenance, *Int J Prosthodont* 23(2):91-98, 2010.

Visser A, Raghoebar GM, Meijer HJA: Implant-retained maxillary overdentures on milled bar superstructures: a 10-year follow-up of surgical prosthetic care and aftercare, *Int J Prosthodont* 22(2):181-192, 2009.

Walton JN, Glick N, MacEntee M: A randomized clinical trial comparing patient satisfaction and prosthetic outcomes with mandibular dentures retained by one or two implants, *Int J Prosthodont* 22(4):331-339, 2009.

Zarb GA: The edentulous milieu. Toronto conference on osseointegration in clinical dentistry, *J Prosthet Dent* 49:825-831, 1983.

Zarb GA, Albrektsson T: The University of Toronto symposium proceedings from toward optimized treatment outcomes for dental implants, *Int J Prosthodont* 11:5, 1998.

Zarb GA, Schmitt A: The edentulous predicament I: a prospective study on the effectiveness of implant supported fixed prostheses, *J Am Dent Assoc* 127: 59-65, 1996.

Zarb GA, Schmitt A: The edentulous predicament II: longitudinal effectiveness of implant supported overdentures, *J Am Dent Assoc* 127:66-72, 1996.

The Potentially Edentulous Patient to Be Treated with Overdentures

Budt-Jörgensen E: Prognosis of overdenture abutments in elderly patients with controlled oral hygiene: a 5 year study, *J Oral Rehabil* 22:3-8, 1995.

Ettinger RL, Jakobsen JR: A comparison of patient satisfaction and dentist evaluation of overdenture therapy, *Comm Dent Oral Epidem* 25:223-227, 1997.

Ettinger RL, Jakobsen J: Caries: a problem in an overdenture population, *Community Dent Oral Epidemiol* 18:42-45, 1990.

Frentzen M, Schüler N, Nolden R: Correlation between caries prevalence (DMFS) and periodontal condition (CPITN) in more than 2000 patients, *Int Dent J* 140: 313-318, 1990.

Geertman ME, Slagter AP, Van Waas MAJ, et al: Comminution of food with mandibular implant-retained overdentures, *J Dent Res* 73:1858-1864, 1994.

Griess M, Reilmann B, Chanavaz M: Telescopic retained overdentures in mentally handicapped and schizophrenic patients—a retrospective study, *Eur J Prosthodont Restor Dent* 6:91-95, 1998.

Griess M, Reilmann B, Chanavaz M: The multi-modal prosthetic treatment of mentally handicapped patients—necessity and challenge, *Eur J Prosthodont Restor Dent* 6:115-120, 1998.

Keltjens HM, Creugers TJ, Mulder J, et al: Survival and retreatment need of abutment teeth in patients with overdentures: a retrospective study, *Community Dent Oral Epidemiol* 22:453-455, 1994.

Keltjens HM, Creugers TJ, van't Hof MA, et al: A 4-year clinical study on amalgam, resin composite and resin-modified glass ionomer cement restoration in overdenture abutments, *J Dent* 27:551-555, 1999.

Keltjens HM, Schaeken MJM, Van der Hoeven JS, et al: Caries control in overdenture patients: 18-month evaluation on fluoride and chlorhexidine therapies, *Caries Res* 24:371-375, 1990.

Keltjens HM, Schaeken MJM, Van der Hoeven JS, et al: Effects of chlorhexidine gel on periodontal health of abutment teeth in patients with overdentures, *Clin Oral Implants Res* 2:71-74, 1991.

Shaw MJ: Attachment retained overdentures: a report on their maintenance requirements, *J Oral Rehabil* 11: 373-379, 1984.

Toolson LB, Taylor TD: A 10-year study of a longitudinal recall of overdenture patients, *J Prosthet Dent* 62: 179-181, 1989.

Van Waas MAJ, Jonkman REG, Kalk W, et al: Differences two years after tooth extraction in mandibular bone reduction in patients treated with immediate overdentures or with immediate complete dentures, *J Dent Res* 72:1001-1004, 1993.

Van Waas MAJ, Kalk W, van Zetten BL, et al: Treatment results with immediate overdentures: an evaluation of 4.5 years, *J Prosthet Dent* 76:153-157, 1996.

Wenz HJ, Hertrampf K, Lehmann KM: Clinical longevity of removable partial dentures retained by telescopic crowns: outcome of the double crown with clearance fit, *Int J Prosthodont* 14:207-213, 2001.

Immediate Dentures for Potentially Edentulous Patients

Carlsson GE, Bergman B, Hedegard B: Changes in contour of the maxillary alveolar process under immediate dentures: a longitudinal clinical and x-ray cephalometric study covering 5 years, *Acta Odontol Scand* 25:45-75, 1967.

Farmer JB: Surgical template fabrication for immediate dentures, *J Prosthet Dent* 49:579-580, 1983.

Goldstein GR: An alternative immediate complete denture impression technique, *J Prosthet Dent* 67:892-893, 1992.

Jonkman RE, Van Waas M, Kalk W: Satisfaction with complete immediate dentures and complete immediate overdentures: a 1-year survey, *J Oral Rehabil* 22: 791-796, 1995.

Pence B Sr, Lee MW, Baum L: Transitional dentures: a better immediate prosthesis leads to successful restoration, *General Dentistry* 40:319-323, 1992.

Raczka TC, Esposito SJ: The "jiffy" denture: a simple solution to a sometimes difficult problem, *Compend Contin Educ Dent* 16:914, 1995.

Rayson JH, Wesley RC: An intermediate denture technique, *J Prosthet Dent* 23:456-463, 1970.

Tallgren A, Lang BR, Walker GF, et al: Roentgen cephalometric analysis of ridge resorption and changes in jaw and occlusal relationships in immediate complete denture wearers, *J Oral Rehabil* 7:92, 1980.

Terry BC, Hillenbrand DG: Minor preprosthetic surgical procedures [review], *Dent Clin North Am* 38:193-216, 1994.

Zalkind M, Hochman N: Converting a fixed partial denture to an interim complete denture: esthetic and functional considerations, *Quintessence Int* 28:121-125, 1997.

This page intentionally left blank

The Materials Used

PART III

CHAPTER 7

Materials Used in the Management of Edentulous Patients

Yoav Finer, Randa Diwan

The selection of materials for dental restorations is based on a reconciliation of their biocompatibility, physical and biomechanical properties, and the acceptability of their esthetic qualities (Box 7-1).

The expansion in the spectrum of treatment options for edentulous patients with either conventional or implant-supported prostheses has been accompanied by the evolution of dental materials and clinical techniques that help dentists fulfill their treatment goals.

Ideally, clinical effectiveness of prosthodontic biomaterials should be based on a hierarchy of evidences, including long-term, large-scale clinical trials, as well as strict adherence to internationally recognized specifications and standards that gauge the quality and properties of those materials. This is important to ensure maximum safety, durability, and effectiveness, which in turn decrease the risk of clinical failures that may result from insufficient knowledge because of a lack of studies of new materials before their full-scale marketing.

Major dental manufacturers provide the dental profession with materials of presumed adequate quality. However, it is the dentist's responsibility to weigh the quality of evidence regarding manufacturers' claims from an informed, intelligent perspective to ensure optimum treatment outcomes for the patients.

It is also crucial to understand that fulfilling the critical requirements is challenging because none of the materials used in dentistry or medicine are totally inert. Biodegradation of materials in the oral environment may occur and are frequently related to chemical and/or mechanical factors prevailing in the oral cavity. This may, in turn, lead to local and systemic adverse biologic responses such as alteration of intraoral flora, toxicity, allergy, and inflammation.

Biocompatibility is now considered a fundamental requirement for any dental restoration. It depends on the condition of the host, properties of the material, and the context in which the material is being used, namely its interaction with its environment. The requirements for appropriate biologic responses are increasing as materials are required to perform more adequately for longer times. This is well demonstrated in the field of dental implants with its great variety of manufacturers and designs.

It is therefore expected that dentists acquire sufficient knowledge of the properties, behavior, and limitations of dental materials used in the rehabilitation of the edentulous patient. One way to achieve this goal is to integrate new approaches of evidence-based and problem-based learning with traditional approaches of materials, science, and their utilization in clinical settings to ensure their proper use and facilitate a proper process of optimal selection and utilization.

The aim of this chapter is to present a synthesis of key information regarding the biomaterials prescribed in the management of the edentulous patient starting from the first examination and diagnosis appointment up to insertion of the prostheses. This includes a review of impression materials used for making preliminary and final impressions; denture base materials and teeth; denture lining materials

Box 7-1 General Requirements for Biomaterials Used to Make Complete Dentures

1. The material must be biocompatible (i.e., with minimal harmful effects on the oral tissues):
   - Nontoxic, nonirritating
   - Nonallergenic, noncarcinogenic
   - Chemically minimally degradable or its degradation processes are biocompatible
2. The material must fulfill clinical objectives by possessing appropriate optimal physical properties:
   - Adequate mechanical properties such as hardness, elasticity, and strength
   - Adequate wear resistance
   - Adequate thermal coefficient of expansion and conductivity properties
   - Acceptable esthetic properties
   - Ease of cleansing
   - Relative ease of fabrication and manipulation
   - Readily available and economical to use
   - Allows for easy and inexpensive maintenance such as repairs and additions

and tissue conditioners; denture cleansers; metal alloys used for the fabrication of denture bases; and denture adhesives, which are adjunctively used to enhance denture base retention. Knowledge of the properties and clinical applications of each material should help the dentist analyze both their benefits and limitations, making rational decisions on their selection and use in clinical practice.

IMPRESSION MATERIALS

The fabrication of accurate preliminary and final casts for edentulous patients necessitates impressions that are capable of capturing and replicating all anatomical peripheral and denture-supporting structures. This is inarguably a key factor that ensures optimal retention, support, and stability of the complete dentures. A wide variety of impression materials is currently available and includes elastic impression materials such as hydrocolloids, nonaqueous synthetic elastomeric polymers, and nonelastic materials, such as impression plaster, impression compound, and zinc oxide eugenol pastes.

The large selection of available materials enables dentists to select a suitable one that is based on a sound understanding of its properties and limitations. The choice is influenced by numerous factors, such as the proper selection of trays, whether it is stock or custom-made, the condition of residual ridges, the presence of displaceable tissues in the denture-bearing areas, oral conditions such as reduced salivary flow that can affect handling of the material, and the dentist's ability to handle the material.

Box 7-2 Optimal Qualities for Prosthodontic Impression Materials

- They should have low enough viscosity to adapt to the oral tissues, yet be viscous enough to be contained in the impression tray.
- The material should have adequate wettability of the oral tissues to allow for accurate adaptation and capturing of the oral structures and tissues.
- The material must have a pleasant taste and odor.
- In the mouth, the material should set into a rubbery or rigid solid in a reasonable amount of time.
- Upon removal from the mouth, the set impression should show adequate elastic recovery with no permanent deformation.
- The material must have adequate strength to avoid tears or breakage upon removal from the mouth.
- The impression should be dimensionally stable after setting and until pouring of the cast.
- The impression can remain dimensionally stable to be repoured after removal from the cast.
- The material must be compatible with the cast material.
- The material must be biocompatible, nontoxic, and without irritant constituents.
- The material must be of a color and opacity that allows for proper evaluation of the impression by the dentist.
- The material could be readily disinfected without significant loss of accuracy or loss of mechanical properties.
- The material must have an adequate shelf life for storage.
- The materials, associated processing time, and equipment should be cost-effective.

The availability of elastomeric materials with various viscosities, has greatly simplified the choice of materials to fulfill the various clinical requirements for each individual patient. Custom trays, made specifically for a patient, are normally used with elastomeric impression materials, providing optimal fit to the anatomical features of the patient and a uniform thickness of the material, thus helping in the overall accuracy of the procedure. In general, materials used to produce accurate replicas of intraoral tissues, should fulfill the properties outlined in Box 7-2.

Impression materials are classified either by their setting mechanism, their elasticity, or their clinical application, and it must be emphasized that none of the currently available impression materials fulfill all of the cited requirements. However, most available materials can be selected and used in an optimal fashion to carry out most specific clinical tasks.

NONELASTIC IMPRESSION MATERIALS

Nonelastic materials were initially used for taking final impressions for edentulous patients. Most nonelastic materials have been replaced for this purpose by elastic materials, overcoming the former materials' inability to be withdrawn from undercut areas without fracture.

Being inelastic, the materials exhibit an insignificant amount of elastic deformation when subjected to bending or tensile stresses. They tend to fracture when the applied stresses exceed their tensile, shear, or compressive strength values. They include impression plaster, zinc oxide eugenol paste, and dental impression compound. Their current use as final impression materials has become very limited, with compound mainly being used for border molding of custom trays for the final impression.

Impression Plaster

Impression plaster was used as a "mucostatic" impression material for making final impressions for edentulous patients because it does not compress and displace tissues during seating of the tray. The technique is applicable to patients with displaceable soft tissues that should be recorded in a passive state.

The main component of impression plaster is calcium sulphate hemihydrates, which react with water to form calcium sulphate dihydrate. The powder is sprinkled into the water and allowed to sit for 30 seconds before it is mixed to a homogeneous consistency.

The mechanical limitations of impression plaster preclude its regular use as a traditional impression material but encourage its use as an occlusal registration material.

Zinc Oxide Eugenol (ZOE) Impression Paste

ZOE is supplied in either a powder and liquid form or as two pastes. It has a negligible setting shrinkage of <0.1%, with no significant changes after that. This makes the material dimensionally stable, and the impressions can be stored without distortion for a considerable time. It produces accurate impressions with good surface details because of its low viscosity before setting (Fig. 7-1). Because the material is nonelastic, it may fracture in the presence of undercuts and

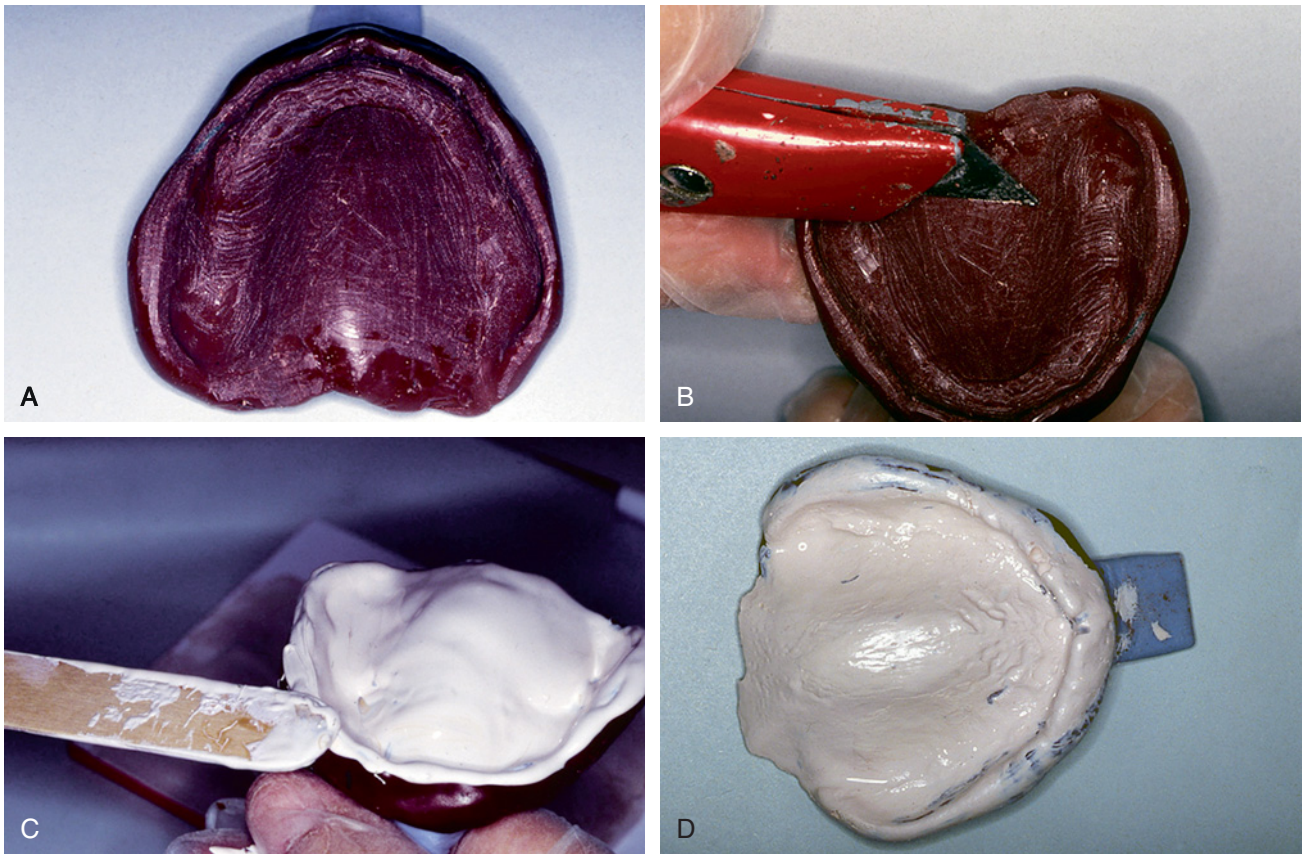


Figure 7-1 A combined compound and zinc oxide eugenol wash impression. **A,** Impression compound is used to make an impression of the denture-bearing areas. **B,** Sufficient material is removed to allow space for the ZOE paste to record all the anatomic details with greater accuracy. **C,** ZOE paste is applied to the relieved compound. The material flows easily to produce good surface details **(D).**

Box 7-3 Zinc Oxide Eugenol (ZOE) Impression Paste

Applications

- Mainly used for final impressions of edentulous ridges with minor or no undercuts
- As a wash impression with other impression materials, such as impression compound (see Fig. 7-1)
- As an occlusal registration material
- As a temporary liner material for dentures
- As a surgical dressing

the set material does not adhere to set plaster or stone. The impression should be immersed in warm water to ease its removal from the cast. ZOE impressions can be disinfected by immersion in a 2% alkaline glutaraldehyde solution then rinsed and poured. It also is considered a very stable and accurate occlusal registration material. Applications of ZOE are provided in Box 7-3.

Zinc oxide, in the presence of moisture, reacts with eugenol to form zinc eugenolate. The setting reaction is accelerated by the presence of water, high humidity, or heat. Some of these factors can be controlled by the dentist to decrease or increase the setting time. The materials are classified as hard or soft pastes according to their consistencies, hardness, and setting times (10 and 15 minutes, respectively). Initial setting time for both types is 3 to 5 minutes. Noneugenol pastes, containing carboxylic acids in place of eugenol, also are available. This avoids the stinging and burning sensation of eugenol experienced by some patients.

Dental Impression Compound (Types I and II)

Impression compound, also called modeling plastic, is a thermoplastic material that is supplied in the form of cakes (red) or sticks (green, grey, or red), with the colors representing different fusing temperatures (Box 7-4).

The setting mechanism of compound is a reversible physical process. The thermoplastic nature of the material requires it to be preheated and to be used warm (~45° C) and then cooled to the intraoral temperature (37° C), at which it is fairly rigid.

The material is softened by heat over a flame or in a temperature-controlled water bath to the required softening temperature. When direct flame is used, such as when using compound sticks, the material should be moved over the flame in such a manner that it will not be allowed to boil or ignite so that the constituents are volatilized. Similarly, when the material is placed in a water bath, prolonged immersion or overheating can result in low molecular weight ingredients leaching out from the compound, resulting in increased brittleness and/or grainy mass.

Box 7-4 Compound Types: Composition and Manipulation

Type I (Lower Fusing Material)

Cakes: As an impression material for completely edentulous patients, the material is softened by heat, inserted into the tray, and placed against the tissues before it cools to a rigid mass (see Fig. 7-2).

Sticks: As a border molding material for the custom tray, the material is used before making the final impression (see Fig. 7-3).

Type II (Higher Fusing Material)

Type II compound is used as a tray adaptation material, which requires more viscous properties. It is used for making a primary impression of the soft tissues and then used as a tray to support a thin layer of a second impression material, such as ZOE paste, hydrocolloids, or nonaqueous elastomers (see Fig. 7-1).

Composition and Manipulation

Dental compound is a mixture of waxes and thermoplastic resins (principal ingredients that form a matrix) plus fillers that increase viscosity above mouth temperatures and provide rigidity at room temperature.

It also includes shellac, stearic acid, and gutta percha, which contribute to plasticity and workability.

Softening of the compound in a warm water bath should be carried out at a proper temperature to slowly convert it to a totally plastic state. The material should be uniformly soft as it is placed in the tray, and it remains in a plastic state while the impression is being made. Once the tray is seated in the mouth, it should be held passively in position, until the impression cools below the fusion temperature of the compound. The tray is removed only when the impression reaches oral temperature. Cold water can be sprayed on the tray while it is in the mouth until the material is thoroughly hardened before its removal from the mouth.

Important Considerations for Proper Use of Impression Compound

- The material has a very low thermal conductivity; therefore, an adequate time is needed to attain thorough heating and cooling. Stress-induced distortion of the set impression occurs if the material was not completely cooled before removal from the mouth because the inner portions of the impression will still be soft when the impression is removed.
- The incorporation of water as a result of wet kneading results in excessive flow of the material at mouth temperature, producing distortion as the impression is removed from the mouth.
- The tray used for the impression must be strong and rigid enough to support the material and to avoid distortion of the impression.

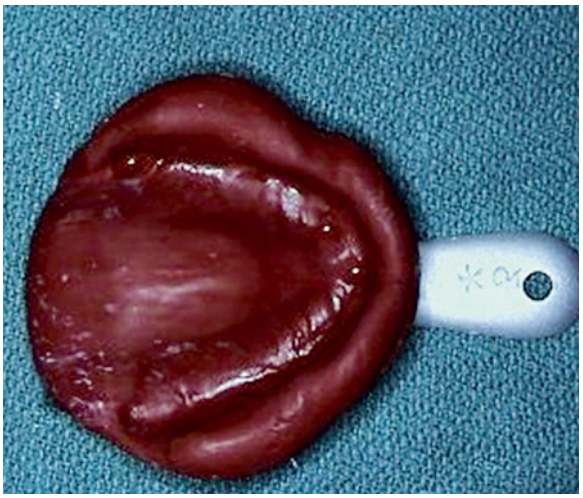


Figure 7-2 Compound preliminary impression using a stock metal tray.

- The relatively high viscosity of compound limits its ability to record fine details (Figs. 7-1 to 7-3).
- The cast should be poured as soon as possible, at least within the first hour, to minimize any distortion due to relaxation of the impression compound, which occurs in a comparatively short time.
- Impression compound can be safely disinfected by immersion in sodium hypochlorite, iodophors, or phenolic glutaraldehydes. The impression is immersed for the required time, rinsed, and poured as soon as possible.

ELASTIC IMPRESSION MATERIALS

Elastic impression materials are rubbery polymers that are chemically cross-linked. They can be stretched or compressed slightly and still rebound without significant permanent deformation, such as when the tray is removed from the mouth. These materials have the advantage of accurately reproducing both soft and hard tissues, even in the presence of undercuts. Their versatility has enabled them to be the most commonly used materials for taking preliminary and final impressions for edentulous patients.

Hydrocolloids

Agar (Reversible Hydrocolloid). Reversible hydrocolloids are considered one of the most accurate impression materials for recording fine details because of their low viscosity and great degree of recovery after deformation around undercuts.

The setting of a reversible hydrocolloid, termed gelation, is a solidification process that involves phase changes from sol to gel states. The physical change from sol to gel, and vice versa is induced by a change in temperature.

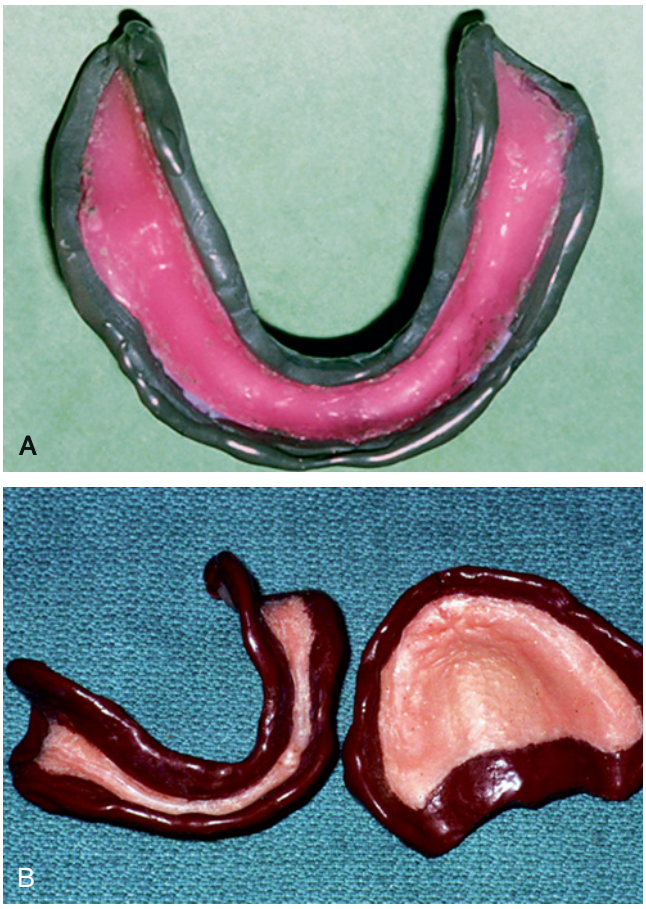


Figure 7-3 **A** and **B,** Compound must be applied in sections around the borders of the custom tray. A wax spacer is kept in place during this procedure to maintain adequate space for the final impression material.

Box 7-5 Composition of Agar

Agar is supplied as a gel and contains the following ingredients:

- Agar: gelling agent
- Borax: improves strength
- Potassium sulphate: gypsum hardener, provides a good surface for the gypsum casts
- Alkyl benzoates: preservatives
- Water: reaction medium, the principal ingredient in the set material (>80%)
- Coloring agents
- Flavoring agents

Heating converts the gel into a sol at a liquefaction temperature of 70° C to 100° C, and upon cooling, the sol transforms into a gel at a gelation temperature of ~43° C.

Composition and Manipulation of Agar (Box 7-5)**.** Agar hydrocolloids are available in tray and syringe consistencies. Tubes are used to fill water-cooled trays and cartridges are used with the syringes.

Box 7-6 Composition and Setting Reaction of Alginate

Alginate is provided as a powder, which contains the following ingredients:

- Potassium or sodium alginate: dissolves in water and reacts with calcium ions
- Calcium sulphate dihydrate: a reactor, reacts with potassium alginate to form a dihydrate insoluble alginate gel
- Zinc oxide: filler particles, affects properties and setting time
- Potassium titanium fluoride: accelerator, counteracts the inhibiting effect of the hydrocolloid on the setting of stone; ensures good quality surface of the cast
- Diatomaceous earth: filler particles, controls the consistency of the mix and the flexibility of the set alginate
- Trisodium phosphate: retarder, controls the setting time to produce either regular or fast-set alginates
- Coloring agents
- Flavoring agents

For making agar impressions, the gel is liquefied by placement in boiling water. The material can be stored in this sol state until it is placed in the water-cooled tray. Tempering of agar is necessary before placing the tray in the patient's mouth to avoid any thermal injuries to the tissues. The impression tray is maintained in position, allowing the fluid mix to intimately capture all anatomical details. The material is then cooled in the mouth to below mouth temperature to ensure full gelation of the agar.

Agar requires a special conditioning unit with three chambers to simultaneously liquefy the gel, store it at 65° C, and then temper the material. Tempering of the tray material increases the viscosity so that the material does not flow out of the tray such as when making a mandibular impression.

Syringe material, on the other hand, does not require tempering because it must remain in the fluid state to adapt to the tissues that are being recorded. As the material is extruded from the small tip of the syringe, its temperature is lowered enough to be easily tolerated by the patient. Agar has a relatively long working time in comparison with other elastic materials at 7 to 15 minutes and sets in ~5 minutes.

Agar can be disinfected by immersion in sodium hypochlorite, iodophors, and glutaraldehyde, rinsed, and then poured in stone. Its major, albeit limited, use is in making partially edentulous impressions, especially in fixed prosthodontics.

Alginate (Irreversible) Hydrocolloid Material (Box 7-6)**.** Alginates are the most widely used impression materials in dentistry. They were developed as a substitute for agar when the latter material's supply became scarce during World War II. The versatility of alginate lies in its ease of manipulation, without the need for expensive equipments, its relatively low cost, and comfort to patients. Alginate is the material of choice for making preliminary impressions for edentulous patients (Fig. 7-4). However, because of its high viscosity and its ability to displace tissues, it is not recommended for use as a final impression material for complete denture construction.



Figure 7-4 Alginate impressions in stock trays. Nonperforated trays must be coated with an alginate adhesive. The bulk of the material is due to its high viscosity and displaced tissues. Pencil outline marks the anatomical location of the denture-bearing areas. The mandibular impression may be underextended lingually because of a lack of support by the tray and/or utility wax.

Dustless alginates are produced by the incorporation of glycerin into the alginate powder. This prevents the constant inhalation of alginate dust, which occurs during the dispensing procedure as the powder cans are opened. To control infection and microbial contamination, disinfectant materials, such as chlorhexidine acetate or quaternary ammonium, are added to the alginate powder.

The sol-gel reaction of alginate is that of soluble potassium alginate with calcium sulphate to form an insoluble calcium alginate gel. The chief ingredient of alginate impression materials is one of the soluble alginates: sodium, potassium, or triethanolamine alginate. When the powder is mixed with water, it forms a sol very rapidly. The result is a cross-linked polymer network. A retarder such as trisodium phosphate is added to allow sufficient working time.

Technical Considerations in the Manipulation of Alginates

- Use the correct powder/liquid ratios, and proper mixing techniques as provided by the manufacturer. Modifications of these can result in changes in the properties of the gel, tear strength, and elasticity. Alginates are provided in a fast set (1.5 to 3 minutes), and regular set (3 to 4.5 minutes) materials. Altering the water temperature to control setting time may be safely done within a degree or two of a standard temperature (~20° C). When mixing the material, it must be squeezed between the spatula blade and the side of the rubber bowl, thus

minimizing the inclusion of air bubbles and the production of in a porous mix.

- Powder should be added to the water in the mixing bowl to ensure complete wetting of the powder.
- The mixing bowl should be clean and without traces of gypsum. Calcium sulphate dehydrate is a common ingredient for both alginate and gypsum and can alter setting time and properties of alginate.
- Mixing time should be between 45 seconds and 1 minute, depending on the brand.
- Alginates can be used with either perforated or nonperforated trays. An adhesive is required if the tray is nonperforated. The tray size is an important factor in the production of accurate impressions. To avoid tears in the impression, a minimum of 3 mm of impression material should be present between the tray and oral tissues.
- The compressive strength of alginate nearly doubles in the first 4 minutes after gelation, and its elasticity improves over time. This minimizes distortion during removal of the impression, especially around undercut areas. It is thus recommended to leave the impression in place for at least 3 minutes after gelation before attempting to remove it from the mouth.
- Alginates such as agar hydrocolloids are strain-rate dependent. The tear strength of alginate increases with the rate at which a stress is applied; thus it is desirable to rapidly remove the impression from the mouth. Avoid twisting or torquing the impression.
- Alginates are dimensionally unstable. The impression can undergo syneresis and imbibition when exposed to air and water. Once removed from the mouth, the impression should be rinsed with cold water to remove traces of blood or mucin and then be disinfected. The protocol that is recommended by the Centers for Disease Control is to use household bleach (1 to 10 dilution), iodophors, or synthetic phenols. The impression is sprayed liberally with the disinfectant, wrapped immediately in a disinfectant-soaked paper towel, and placed in a plastic bag for 10 minutes. The wrapped impression is then removed from the bag, unwrapped, rinsed, and shaken to remove excess water and then is poured immediately. Alternatively, the impression could be immersed in a disinfectant but not for more than 10 minutes.
- Alginate is easily poured in gypsum (plaster and stone), and the casts are easily removed from the impressions. Once poured, stone casts should remain in contact with alginate between 30 to 60 minutes before separation from the impressions to ensure complete setting of the stone. On the other hand, desiccation of the hydrocolloid can occur if the impression is left for a long time, causing abrasion of the cast and poor quality of its surface.
- Alginates have many advantages as elastic impression materials including ease of manipulation, low cost, their hydrophilic nature, and ease of pouring. However, when compared with agar and elastomers, they exhibit less elastic recovery, which contributes to increased distortion and reduced reproduction of fine details.
- The hydrocolloids agar and alginate are effectively used as duplicating materials. Agar is more popular than alginate because it is reversible and can be reused in the dental laboratory.
- Both materials are biocompatible in the oral environment, especially when using dustless alginate powders. Agar has a potential for causing thermal injury to the patient if improperly handled.

TABLE 7-1 COMMON ERRORS ENCOUNTERED WHEN MAKING ALGINATE IMPRESSIONS

Problem	Reason
Inadequate working or setting time	High water temperature; incomplete spatulation; low water/powder ratio; improper storage of the alginate powder
Distortion	Movement of the tray during gelation; premature removal of the tray; no snap quick removal of the tray; delay in pouring the cast
Tearing	Impression removed before it sets; slow rate of removal of the impression from the mouth; thin mix used; presence of deep undercuts; inadequate material in the tray
Loss of detail	Premature tray removal from the mouth
Consistency	Incorrect water/powder ratio; inadequate mixing; hot water used for mixing
Dimensional changes	Delay in pouring the impression
Porosity	Air entrapped in the mix during spatulation
Poor stone surface	Delay in separating the cast from the impression

Common errors encountered when making alginate impressions are listed in Table 7-1.

ELASTOMERIC IMPRESSION MATERIALS

Polysulfides were the first synthetic elastomeric material to be introduced in 1950. Condensation silicones followed in 1955, polyethers in 1965, and finally addition silicones in 1975. Silicones and polyethers form the majority of elastomeric impression materials used worldwide today.

Recommended Technique for Final Elastomeric Impressions

All elastomeric impression materials are indicated for making accurate final impressions for edentulous patients when used in custom trays. The trays may be border molded with a wax spacer in place. Once the proper seal around the borders has been verified, the wax spacer is removed, the appropriate tray adhesive is applied and allowed to dry, and the dentist can start taking the final impressions. Border molding can be carried out using modeling compound sticks, or using a medium-to-high viscosity elastomeric material, such as polyether, which is applied with a syringe around the borders of the tray. The custom tray must have its borders 2 to 3 mm short of the full sulcus extension to allow functional molding of the tray borders.

Points of Importance When Handling Elastomers

- Elastomers are supplied as two-component paste systems or as a paste and a liquid.
- The different colored pastes are dispensed either through a spiral mixing tip or in equal lengths on a mixing pad.
- Setting occurs through a combination of chain-lengthening polymerization and chemical cross-linking by either a condensation or addition reaction.
- Each type of the elastomeric materials is further divided into four viscosity classes: light body, medium or regular body, heavy body, and putty (extra heavy).
- In addition, there are three types of systems available to mix the catalyst and base: hand mixing, static automixing, and dynamic mechanical mixing.
- To record the soft tissues for edentulous patients under minimum compression, a free-flowing, minimum viscosity material is used, such as polysulfides or addition silicones. If moderate compression is required, medium-viscosity polysulfides, addition silicones, or polyethers can be used. The availability of different impression systems, such as the simultaneous or dual-viscosity technique, monophase (shear thinning), and putty-wash techniques, are quite effective for making final impressions for the fabrication of fixed prostheses. However, for complete dentures, usually one consistency of the elastomeric material within the custom tray suffices for making an accurate impression.
- All types of elastomers undergo shrinkage upon polymerization, and those with reaction by-products, such as the condensation type silicones, undergo additional contraction. Polysulfides and condensation silicones have the highest dimensional changes during setting, followed by addition silicones and polyethers.

Box 7-7 Polysulfide Rubber

The Base

Polysulfide polymer is the principal ingredient.
Fillers such as titanium dioxide and zinc are added.
Sulphate, copper carbonate, or silica is added for strength.
The filler content varies according to the consistency of the paste.
Dibutyl phthalate, a plasticizer, confers viscosity to the base.

The Accelerator/Reactor

Lead dioxide, hydrated copper oxide, or organic peroxide is used as a reactor.
Sulfur, a promoter, accelerates the reaction.
Oleic or stearic acid, a retarder, controls setting reaction.
Working time: 5-7 minutes, considered the longest among elastomers
Setting time: 8-12 minutes
Pouring the cast: The impression must be poured within 30 minutes to 1 hour.

Polysulfide Rubber

Polysulfide rubber is a two-paste system that is available in low, medium, and high consistencies and is made up of a base and accelerator/reactor as noted in Box 7-7.

When the pastes are mixed together, a polymerization reaction occurs, resulting in chain lengthening and cross-linking with an increase in molecular weight. Setting is indicated once the color of the paste has changed to a dark brown or gray-brown rubber. The color is a result of the presence of lead oxide.

The condensation reaction of polysulfide rubber is only slightly exothermic and is accompanied by water as a by-product. The reaction also is accelerated by the increase in temperature and the presence of moisture. It is thus important that the impression be poured within an hour to minimize dimensional changes.

Polysulfide rubber produces excellent detail reproduction (Fig. 7-5). The material has long working time, good flexibility, and high tear strength. However, being hydrophobic in nature, it is important to dry the tissues before making the impression. The material is messy, stains cloths, and has an offensive odor.

Condensation Silicone (Box 7-8)

The material is supplied as a two-paste system, or a base paste and a low-viscosity liquid catalyst. It is available in low and very high consistencies.

The basic component in these elastomers is a polydimethylsiloxane. The elastomer is formed through cross-linking between terminal hydroxyl groups of the silicone polymer

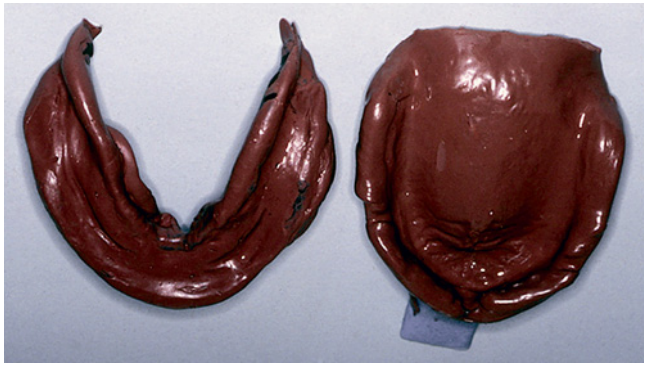


Figure 7-5 Polysulfide impressions show excellent detail reproduction. However, the impressions need to be poured immediately to avoid distortion as a result of the loss of by-products and the continuous curing shrinkage that occurs.

Box 7-8 Condensation Silicones

The Base Paste

High molecular weight polymer, such as polydimethylsiloxane
Fillers, such as silica or calcium carbonate

The Liquid Accelerator

A metal organic ester, such as tin octoate
Orthoalkyl silicate
Oil-based diluents
As a paste, the accelerator would have thickening agents added to increase viscosity
Working time: 3 minutes
Setting time: 6-8 minutes
Pouring the cast: The impression must be poured as soon as possible within the first 30 minutes

and an alkyl silicate in the presence of stannous or tin octoate. This leads to the formation of a 3-dimensional polymer network. Ethyl alcohol is a by-product of this condensation reaction. Its subsequent evaporation accounts for much of the contraction that occurs upon setting of the material. The extra heavy or putty consistency of the material, which has higher filler content, was developed to counteract the large polymerization shrinkage that occurs in the material, which is noticeable especially when using stock trays.

Addition Silicones (Box 7-9)

Addition silicones are commonly referred to as polyvinyl siloxanes (PVS). They are supplied as low, medium, high, and very high consistencies. These materials are based on silicone prepolymers that carry vinyl and hydrogen side groups, which can polymerize by addition polymerization.

Box 7-9 Addition Silicones

The Base

Polymethylhydrosiloxane (low molecular weight polymer), fillers

The Accelerator

Divinyl polymethyl siloxane
Other siloxane prepolymers, fillers
Platinum salt, as a catalyst
Retarder, controls the working and setting times
Working time: 2-4.5 minutes
Setting time: 3-7 minutes
Pouring the cast: The cast can be poured up to 1 week after making the impression.

The reaction is activated by a platinum salt catalyst, such as chloroplatinic acid, without the release of by-products. However, in the presence of impurities or moisture, a secondary reaction may occur between the residual hydrides and moisture, leading to the evolution of hydrogen gas. This can cause minute gaseous voids in the gypsum casts and reduce effectiveness of cross-linking in the polymer structure. Manufacturers recommended waiting for an hour before pouring the impression to ensure that the setting reaction has been completed. However, more recent formulations of the addition silicone material have been modified to prevent the release of hydrogen, so casts can be poured immediately after impression.

The automatic mixing systems for addition silicones has simplified their manipulation, reduced voids in the impressions, reduced the amount of material wasted, and reduced the sensitivity of their mixing technique.

Silicones are the most highly elastic of the currently available materials, with virtually negligible distortion upon removal from undercuts. They have exceptional accuracy in reproducing anatomic details and their dimensional stability allows pouring long after impression taking (Fig. 7-6). Their properties render them as excellent occlusal record registration materials.

One of the main disadvantages of silicones is their inherent hydrophobic nature. The wettability of an impression material is regarded as one of the most important properties for the clinical success of the material. Recent advances have focused on developing silicones that are more hydrophilic in nature. This allows the materials to make more intimate contact with the oral tissues, to capture better surface details with fewer defects, and to simplify the pouring of bubble-free stone casts. However, the impression material must have an adequate free surface energy to be easily separated from the set cast material.

A nonionic surfactant wetting agent is added to the silicone paste rendering the surface of the impression more hydrophilic. The resulting material is called a hydrophilized addition silicone.

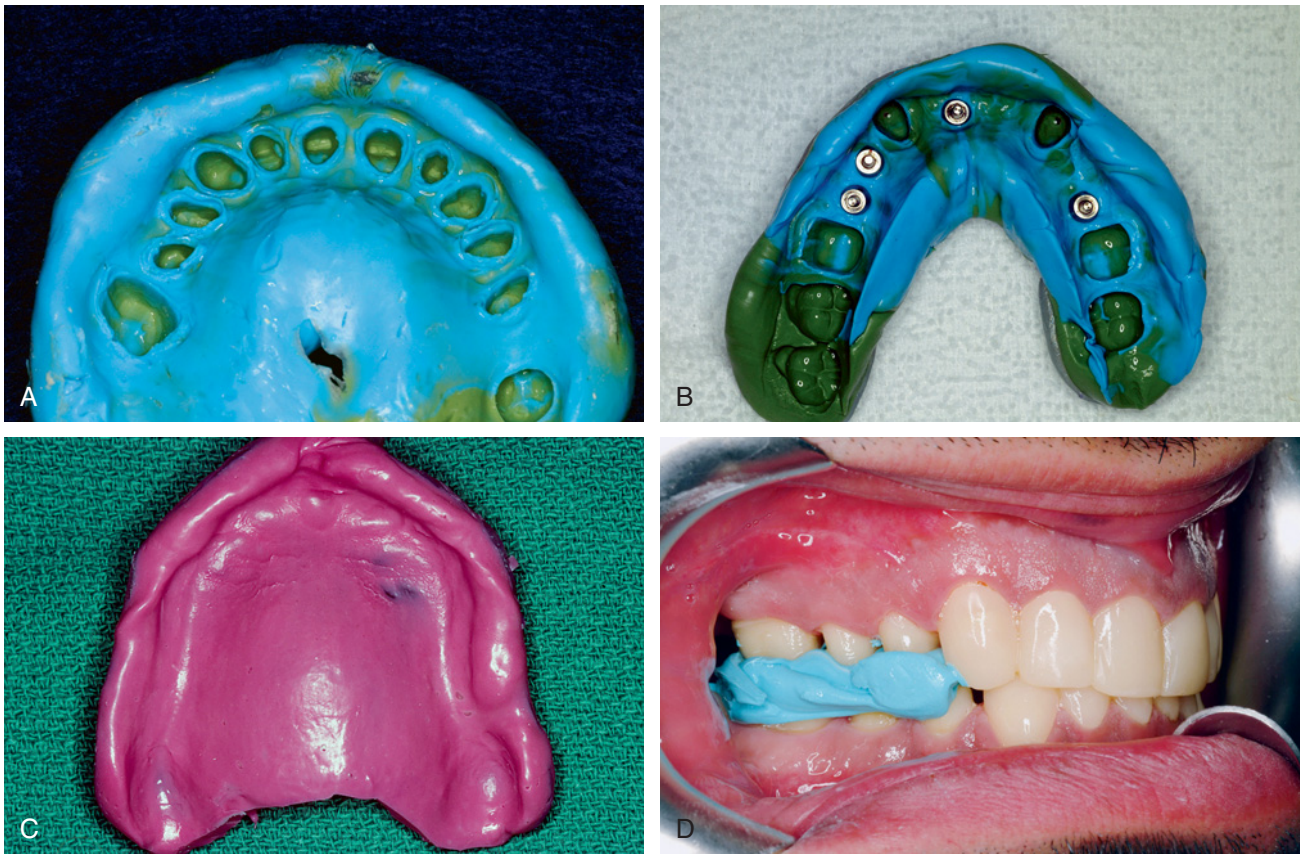


Figure 7-6 **A,** Polyvinyl siloxane (PVS) impressions of fixed partial prostheses. **B,** Implant-supported prosthesis. **C,** Complete denture. Because of the hydrophobic nature of PVS, complete dryness of the tissues is required for impression taking. The variability in the application of these materials is achieved by using the appropriate viscosity or combination of viscosities for the task: lower viscosity is used for capturing details; higher viscosities are used to support the wash materials. PVS has exceptional accuracy in reproducing anatomic details and its excellent dimensional stability allows for pouring a long time after impression taking. These properties render it an excellent material for occlusal registration **(D).**

Polyether Impression Materials

Polyether is another elastomer and is supplied as a two-paste system in low, medium, and high consistencies (Box 7-10).

The base paste contains low molecular weight polyether with an ethyleneimine terminal group. The catalyst paste contains an aromatic sulfonic acid ester in addition to a thickening agent and fillers. Upon mixing the two pastes, ionic polymerization occurs by ring opening of the ethyleneimine group and chain extension. The reaction converts the paste to a rubber.

Polyether has a high degree of wettability of the oral tissues. The inherent hydrophilic nature of the material relates to its chemical structure. The material's affinity to water allows it to flow onto hydrated intraoral surfaces, and it is cast with gypsum products more easily than addition silicones.

Stiffness of the original polyether made the material quite difficult to remove from undercuts. This problem has

Box 7-10 Polyether Elastomer

The Base
Polyether polymer
Colloidal filler, such as silica
Plasticizer, such as glycol ether or phthalate

The Accelerator
Alkyl aromatic sulfonate, an initiator
Filler
Plasticizer
Working time: 2.5 minutes
Setting time: 4.5 minutes
Pouring the cast: The impression can be poured up to 1 week of storage.

been overcome to a large extent in the newer formulations of polyether by reducing the silica contents. The combination of relative stiffness and good wettability make for an excellent material for applications that require good duplication of fine details and rigid support for pick-up copings (Fig. 7-7).

Disinfection of Elastomeric Impression Materials

All elastomers can be disinfected by immersion in several disinfectants without loss of surface quality and accuracy before casts are poured. The duration and mode of applying the disinfectant depends on the potential of the material to absorb water and the time elapsed since the impression was made. Condensation silicones, addition silicones, and polysulfides can be disinfected as indicated by the manufacturer. Polyether, being hydrophilic in nature, may undergo dimensional changes if immersed for longer than 10 minutes. The impression must be sprayed by a 2% glutaraldehyde until saturated, wrapped in a disinfectant-soaked paper towel, and placed in a sealed plastic bag for 10 minutes before it is rinsed, dried, and poured.

A synthesis of comparative considerations that can guide a dentist's selection of an elastomeric impression material is presented in Table 7-2.

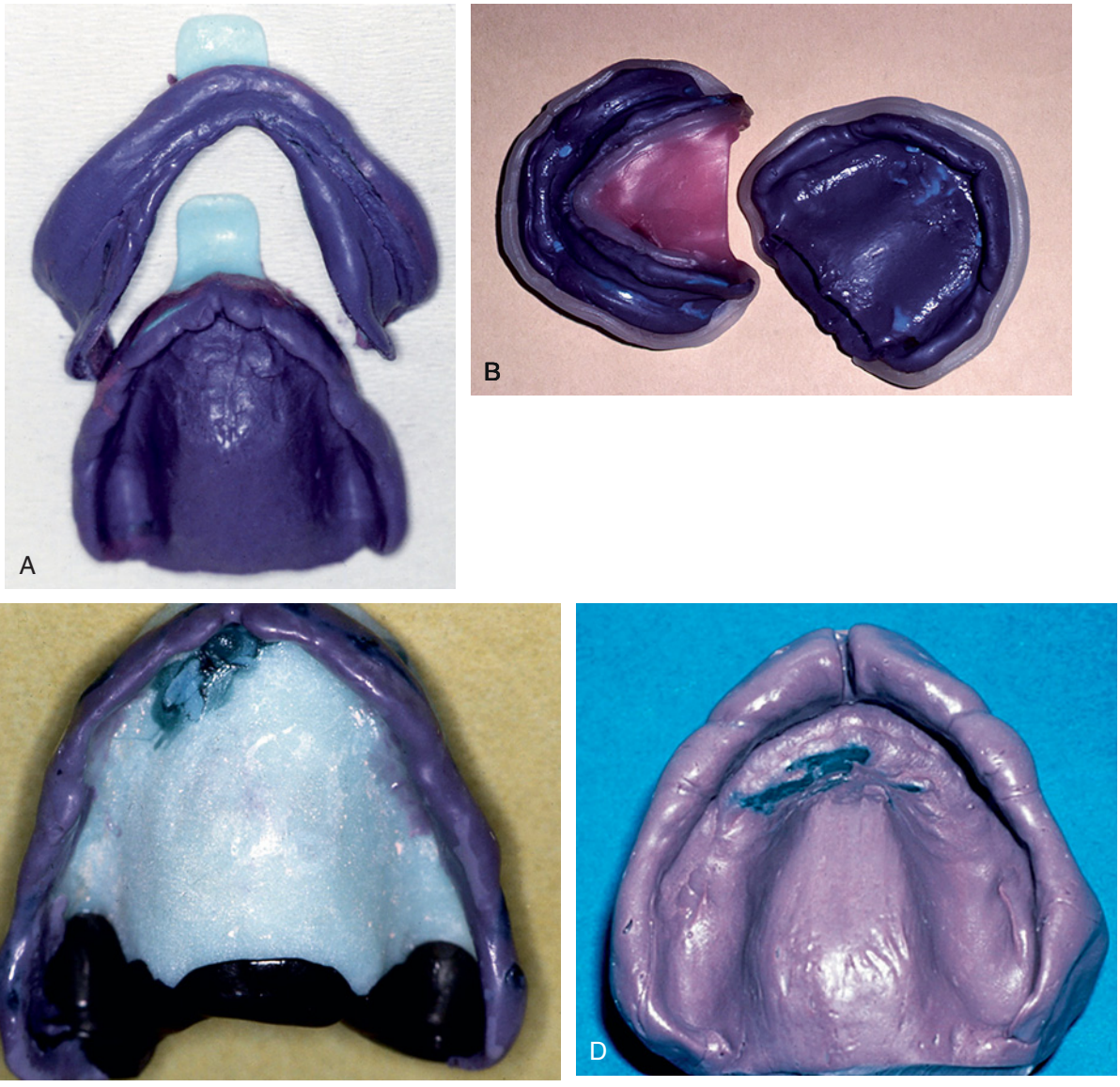


Figure 7-7 **A,** Polyether final impressions made using custom trays for an edentulous patient. **B,** Polyether impressions, boxed before pouring the casts in dental stone. **C,** Polyether material was used to border mold the custom tray with a wax spacer in place. Note that the posterior palatal seal area was recorded functionally using green stick compound. **D,** The final impression is made with the same material after removing the spacer, and applying an adhesive.

Continued





Figure 7-7, cont'd **E,** Polyether final impression for implant-supported overdenture. **F,** Polyether pick-up impression. The material is dimensionally stable, so that casts could be poured not immediately after impression taking. However, the relative stiffness of the material limits its use for the production of multiple casts, but it is an excellent material for applications that require rigid support for pick-up copings.

TABLE 7-2 COMPARISON OF THE PROPERTIES, ADVANTAGES, AND DISADVANTAGES OF ELASTOMERIC IMPRESSION MATERIALS

Elastomers	Properties	Disadvantages	Advantages
Polysulfide rubber (Mercaptan)	Elastic recovery is moderate* Flexibility high, more flexible than all other elastomers† Highest tear strength among elastomers Flow rates moderate to high	Unpleasant odor Stains cloths Needs a custom tray to avoid distortion May flow down patient's throat because of its low viscosity Must be poured within 1 hr; low dimensional stability	Long working time Good flow before setting Good surface reproduction High flexibility, easy removal from undercuts Cheaper than silicones and polyether
Condensation silicones	Elastic recovery is high Flow rates low, lower than polysulfides Stiffer than polysulfides Tear strength is low to moderate High polymerization shrinkage can be offset by using a two-step putty-wash technique	Must be poured within 1 hr because it may distort as a result of shrinkage Hydrophobic in nature, requires a dry field, and is difficult to pour in stone	Well accepted by the patients High elasticity The putty-wash method eliminates the need for a custom tray
Addition silicones	Elastic recovery is excellent Flow rates very low Low dimensional changes Have greater rigidity, so are removed with difficulty from undercuts Tear strength, low to moderate; comparable to condensation silicones but still less than polysulfides	More rigid than condensation silicones May release hydrogen, causing imperfections in the stone cast; delay pour for 1 hr Hydrophobic in nature Latex gloves can inhibit polymerization Expensive	Highly accurate High elasticity Pleasant taste, odor, colors May be poured 1 week after making the impression Multiple pours possible Can be used with both stock and custom trays
Polyether	Elastic recovery moderate Minimum shrinkage, 0.3% in 24 hr; gives high accuracy, but inferior to some addition silicones Flow rates are very low Stiffness is high, difficult to remove from the mouth and to separate from cast Low tear strength values	Short working and setting times, improved in recent formulations Material is stiff after setting, least flexible of all elastomers Bitter taste objectionable to patients May distort if stored in humidity or water Can be damaged by disinfectants if left for long periods Expensive	Easy to handle and to mix More accurate than polysulfides and condensation silicones Good surface reproduction Easily poured in stone; if kept dry, can stay for 1 week without dimensional changes

*Elastic recovery, after removal of the impression from the mouth.
†Flexibility during removal from the mouth.

SUMMARY OF IMPRESSION MATERIAL

Innovations in impression techniques and the development of new formulations for current impression materials continue to be a research focus. As impression philosophies have changed and developed, concurrent development and application of newer materials also took place. Simplicity of the newly introduced impression mixing techniques together with accuracy and ease of manipulation and the availability of a wide variety of viscosities for the elastic materials have helped widen the scope for more effective clinical applications

POLYMERIC DENTURE BASE MATERIALS

Numerous materials have been used for the fabrication of denture bases with polymers such as poly(methyl methacrylate) (PMMA) resins being the most common ones. Their popularity is due to their favorable working characteristics, acceptable physical and esthetic properties, ease of fabrication, and cost-effectiveness (Box 7-11). Yet, as with all other known denture base materials, PMMA resin has its inherent limitations and does not fulfill all the requirements of a hypothetically ideal denture base material.

The polymerization process of PMMA involves the conversion of low molecular weight compounds (monomers) to high molecular weight polymers. Denture base polymerized resins are formed by a process of addition polymerization mediated by free radicals. The reaction passes through three stages: activation and initiation, propagation, and finally termination. An initiator like benzoyl peroxide yields free radicals, which sets off the chain reaction. Activation of the initiator can be achieved through the application of heat (heat-activated or cured PMMA), chemicals such as tertiary amines (chemically activated PMMA), or by any other source of energy such as visible light–activated (VLC) dimethacrylate, or via electromagnetic radiation such as in the case of microwave-activated resins.

Copolymers are formed when monomers of two or more compatible types are joined. The vast majority of today's dentures are made of heat-activated PMMA and rubber-reinforced PMMA. The latter is a high impact resin in which the PMMA forms graft copolymers with polystyrene-butadiene rubber. The rubber inclusions have been found to greatly improve impact strength of the polymerized denture base.

Polymers with chemical bonds between their different polymeric chains are regarded as cross-linked. Cross-linking affects the physical properties of the polymer. In the case of PMMA-based material, it increases its rigidity and its craze resistance and creep. Craze is defined as the tendency of resins to form minute surface cracks, while creep is defined as the deformation of the denture base under load because of its viscoelastic properties. Cross-linking also reduces the resin's solubility in organic solvents. The chemical compositions of frequently used denture base resins are listed in Box 7-12.

Box 7-11 Requirements of an Ideal Denture Base Material

- Biocompatible: nontoxic, nonirritant (see Fig. 7-9)
- Adequate physical and mechanical properties:
  - High flexural, transverse and impact strength
  - High modulus of elasticity for better rigidity
  - Long fatigue life
  - High abrasion, creep and craze resistance
  - Good thermal conductivity
  - Low density
  - Low solubility and sorption of oral fluids
  - Softening temperature higher than that of oral fluids and food
  - Dimensionally stable and accurate
  - Superior esthetics and color stability
  - Radiopacity
  - Good bond with denture teeth and liners
  - Ease of fabrication with minimum expenses
  - Easily repaired if fractured
  - Readily cleansable

Box 7-12 Chemical Composition of Denture Base Resins

Heat-activated PMMA:
Powder-liquid system
- Powder: Prepolymerized spheres of PMMA
- Initiator: Benzoyl peroxide (~0.5%)
- Pigments and dyed synthetic fibers
- Liquid: Methyl methacrylate monomer
- Inhibitor: Hydroquinone (traces)
- Cross-linking agent: Ethylene glycol dimethacrylate (~10%)
- Activator: NN-dimethyl-p-toluidine*

Microwave-activated PMMA:
Powder-liquid system
- Similar to heat-activated PMMA, with slight modifications to accommodate the microwave activation procedure

Light-activated Resins:
Single component, premixed composite sheets and ropes
- Matrix: Urethane dimethacrylate
- Filler: Methacrylate resin beads, microfine silica
- Photo initiator: Camphoroquine/amine combination

*Only in chemically activated resins.

TECHNICAL CONSIDERATIONS AND PROPERTIES OF DENTURE BASE RESINS

Heat-Activated PMMA

Following the try-in procedure of the waxed-up trial denture, the resins are commonly processed in a brass flask using a compression-molding technique ("dough technique"). The polymer and monomer are mixed in the proper ratio of 3:1 by volume or 2.5:1 by weight. The mixed material goes through four stages: a wet sandlike mixture, then a tacky fibrous stage as the polymer dissolves in the monomer, followed by a smooth doughlike stage that is suitable for packing into a mold. Finally the mix becomes rubbery and stiff. Dough formation is assisted by internal plasticizers chemically attached to the polymer beads that locally softens them and facilitates monomer diffusion.

Following wax elimination, the dough is packed in the gypsum mold, and the flasks are placed under pressure in a time-and-temperature–controlled water bath to initiate polymerization of the resin.

The Polymerization Cycle. The polymerization cycle refers to the heating process used to control the polymerization of the resin bases.

The polymerization reaction is exothermic in nature and should be carefully controlled to avoid a marked increase in temperature, which may exceed the boiling point of unreacted monomer (100.8° C), leading to denture porosity.

Currently, a number of polymerization/curing cycles have yielded clinically acceptable denture bases:

- One technique involves placing the flask in a constant–temperature water bath at 74° C (165° F) for 8 hours or longer without a terminal boil at 100° C.
- Another technique processes the base at 74° C for 8 hours or more followed by a terminal boil at 100° C for 1 hour.
- A shorter cycle involves processing the resin at 74° C for approximately 2 hours then boiling at 100° C for 1 hour or more.

It must be noted that an optimum degree of polymerization that includes adequate times and temperatures of processing is one of the most important determinants for the production of resin bases with adequate physical properties and strength.

Denture Base Porosity. Presence of minute surface or subsurface voids in a denture that has been processed is relatively uncommon nowadays, considering the high technical standards that are followed in dental laboratories. However, if significantly present it would inevitably compromise physical properties, strength, and esthetics. A porous denture would increase liability for staining and calculus deposits, and would promote adhesion of fungal and bacterial biofilms (dental plaque), which could adversely affect the health of the denture-supporting tissues.

Porosity development is the result of a complex multifactorial phenomenon that includes the following:

- Gaseous porosity occurs as a result of rapid heating of the flask, leading to monomer evaporation; this appears as fine uniform subsurface spherical pores, localized more often in the thicker portions of the denture.
- Inadequate pressure during flask closure or insufficient amount of dough present upon packing of the mold can lead to denture porosity. The voids are large, irregular in shape, and abundant. The resulting denture appears lighter and more opaque in color.
- Inadequate mixing of powder/liquid components also may result in denture porosity. The areas that contain more monomer tend to shrink more than the adjacent areas. This localized polymerization shrinkage leads to the production of large voids that are uniformly spread throughout the base.

Rapid-Cure Type Resins

These resins are polymerized by rapidly heating the packed dough in boiling water for 20 minutes. The materials are hybrid PMMA, in which activation of the polymerization reaction is carried out through both chemical and heat activators, allowing rapid polymerization without porosity. After placing the denture in boiling water, the water is boiled at 100° C for 20 minutes.

Following the polymerization procedure, the denture flasks are cooled slowly to room temperature allowing adequate release of internal stresses and thus minimizing distortion of the bases. Deflasking then follows and should be done carefully to avoid fracture or flexing of the dentures.

The popularity and relative simplicity of the compression molding technique is usually overshadowed by the high processing stresses that are induced in the resins during polymerization. These stresses result from various factors:

- Polymerization shrinkage occurs as polymer chains are formed. This accounts for a volumetric shrinkage of about 7%.
- Thermal shrinkage then follows as the resin cools.
- Differences in thermal contraction of the resin and gypsum mold collectively yield residual stresses in the resin.

When proper fabrication steps are being followed, the above dimensional changes have been found to be clinically insignificant in the fit of heat-activated methacrylate resin denture bases and, in most instances, do not cause discomfort to the patient.

Occlusal errors that are commonly encountered following processing are effectively corrected and the



Figure 7-8 Processing errors in the heat-cured methacrylate resin bases may lead to an increase in the vertical dimension of the dentures, which is demonstrated by a rise in the incisal pin off the incisal guide table.

predetermined vertical dimension of occlusion restored through routine laboratory remount and selective grinding procedures (Fig. 7-8).

The Bond Between Heat-Cured Denture Bases and Resin Denture Teeth

One of the main advantages of heat-cured resin bases is their excellent bond with resinous denture teeth. This results from the increased rate of diffusion of the monomers into the polymerized teeth at the high temperatures of processing, leading to the formation of welts between the teeth and the bases. This simplifies the various procedures of grinding and set up of teeth even in cases of limited interarch spaces, without the fear of loss of bond or fracture of the teeth, as in the case of porcelain teeth. Porcelain teeth are mechanically attached to the bases. Treatment of the ridge lap area of porcelain teeth with organosilane compounds has been used to overcome this problem with considerable success.

Biocompatibility of Methacrylate-Based Resins

The wide spread use of PMMA resin-based dentures constantly raises concerns regarding the biodegradation of these resins in the oral environment. There are a number of factors that may lead to biodegradation; among them are the enzymes present in saliva, chewing, and occlusal forces. Furthermore, thermal and chemical dietary changes that occur in the oral cavity may contribute to the degradation of the resin. There is emerging evidence in the literature on *in vitro* degradation of restorative resins, including the elution of unbound leachable materials, such as MMA monomer and its derivatives (methacrylic acid), phthalate esters in soft liners, and additives like benzoyl peroxide,

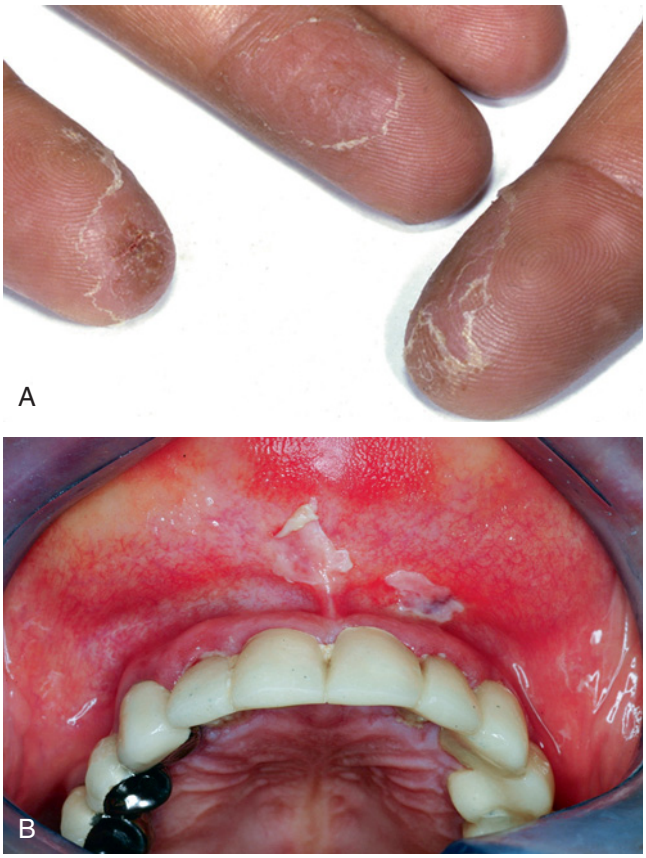


Figure 7-9 Adverse reactions to methyl methacrylate. **A,** Direct contact with the methacrylate resin during packing of the resin dough by the laboratory technician resulted in dermal irritation. **B,** Direct contact of the oral mucosa resulted in severe irritation and inflammation.

upon storage in water and artificial saliva. Possible adverse biologic effects of these compounds range from chemical irritations, ulcerations, burning mouth syndrome, and denture stomatitis to more toxic effects, such as genotoxicity, cytotoxicity, and changes in the cytokine/growth factor expression in host cells.

Residual Monomer Content

- Methyl methacrylate has been associated with immune hypersensitivity reactions in the gingiva and mucosa. Processing dentures at temperatures that are too low or for shorter times increases the residual monomer content in the processed denture base. The small size and hydrophilic nature of this monomer allows for its fast diffusion into the oral cavity and the body. This could lead to tissue irritation, hypersensitivity, or allergic reactions in some patients (Fig. 7-9).
- One major advantage of conventionally heat-cured resin bases is that they have significantly lower, residual monomer contents than chemically cured resins.

Terminal boiling of the flasks at 100° C for at least 1 hour decreases the monomer content to a clinically acceptable level, approximately 0.2% to 0.5%, which is significantly lower than the free monomer in the chemically cured resins.

- The plasticizing effect of excess monomer has been shown to adversely affect the mechanical properties and dimensional stability of dentures. Fortunately, hypersensitivity to residual monomer is relatively rare, and most patients are well able to tolerate the amount of residual monomer that often remains. Unbound monomer and other additives are mostly eluted within the first 24 hours after processing, followed by a slow and moderate release over a long period of time. Storage of the dentures in water is a major factor in releasing residual monomer from the bases.
- Patients with a history of allergy or sensitivity to the monomer in the denture bases benefit from alternative base materials like vinyl acrylics or light-activated materials for the fabrication of the dentures (see Fig. 7-9).
- The existing literature is inconsistent and largely speculative on the effects of any benzoyl peroxide initiators that remain in the polymerized bases. A post-polymerization curing cycle has been suggested to remove any remaining peroxides. Peroxide-sensitive patients also may benefit from alternate resins, such as urethane dimethacrylate or polyurethane-based materials.

Table 7-3 provides a summary of physical and biological considerations for heat-activated resins and their clinical implications.

Radiopacity of Denture Bases

Attempts to improve radiopacity of the denture bases have been carried out to facilitate the detection of fragments of resin bases that may be ingested accidentally or, more seriously, inhaled by the patient. These attempts included the use of metal inserts, radiopaque salts and fillers, and organometallic compounds. Many of those attempts have been accompanied by adverse effects on esthetics, increased water sorption and flexural strength of the denture base resins, and cytotoxic effects.

A new radiopaque terpolymer that recently has been synthesized contains (2,3,5 tri-o-benzoyl)-ethyl methacrylate, methyl methacrylate, and 2-hydroxyethyl methacrylate and is being tested for use as a radiopaque denture base material. Ongoing research is currently focusing on the production of esthetically pleasing radiopaque resins that have reasonable properties for prosthetic applications and still have no adverse cytotoxic or mutagenic responses. The resulting radiopaque resins, once verified and thoroughly tested, would be a great advance in the new generations of dental polymer resins.

Injection Molding Technique

Heat-activated PMMA is less frequently processed using an injection molding technique. The resin mix is injected into a closed sprued flask under continuous pressure. The classic use of compression molded methacrylate resins has been well accepted for the past 70 years. The technique has been frequently refined because of its shortcomings. It is considered too laborious, is relatively prone to errors, and carries a risk of contact dermatitis to dental technicians. In recent years, the injection molding technique has been shown to improve the level of fit and adaptation of the processed resins to the underlying stone casts, and later to the tissues, minimizing the need for further postinsertion occlusal adjustments.

Earlier versions of this technique were perceived to be less consistent than compression molding. However, recent studies have indicated that complete dentures processed by newer injection molding techniques and materials exhibited less polymerization shrinkage and greater accuracy and dimensional stability than those processed by standard compression molding techniques.

Other plastics used for denture fabrication also can be injection molded. These include polycarbonates, nylon, and polyvinyl acrylics. As pointed out, these plastics could be considered in patients with confirmed allergy to the methacrylate monomer. However, high capital costs and sensitivity of the technique limit its wide-based applications. In addition, the technique does not lend itself for denture reline procedures.

Chemically Activated Resins (Box 7-13)

These resins are often referred to as cold-curing, self-curing or autopolymerizing resins. As pointed out earlier, in this group the methyl methacrylate monomer contains a tertiary amine initiator, which activates the polymerization process without the need for any heat or source of energy. Chemically activated resins are much less frequently used for denture fabrication as compared with the heat-activated resins. Processing of the resins could be carried out by compression molding in a flask where initial hardening of the resin occurs within 30 minutes of flask closure, or it can be poured in a fluid consistency that is termed the "pour-type resin technique." Comparison of the properties of heat-cured and chemically cured resins is provided in Box 7-13.

Pour or Fluid Resin Technique

The principal difference in the chemical composition of these resins and the compression molded chemically activated resins is the smaller size of the powder particles necessary to ensure fluidity of the mix.

The pour technique involves pouring the fluid mix into a sprued mold made of a reversible hydrocolloid material (agar agar). The flask is placed under pressure at room

TABLE 7-3 PHYSICAL AND BIOLOGICAL CONSIDERATIONS FOR HEAT-ACTIVATED RESINS AND THEIR CLINICAL IMPLICATIONS

Physical and Biological Considerations of Conventional Heat-Cured Denture Bases	Clinical Implications
Denture bases undergo water absorption by diffusion resulting in linear expansion, which favorably offsets polymerization shrinkage. Denture bases also dry out in dry hot conditions.	• Patients are advised to store dentures in tepid water when out of the mouth. • Placing dentures in hot water (>35° C) results in the release of internal residual stresses, leading to significant distortion.
Methacrylate resin (PMMA) dentures have a low thermal conductivity.	• This is portrayed as a substantial decrease of thermal stimulation of the patient's oral tissues under the denture base. • This could be a source of inconvenience, particularly to first-time denture wearers.
Denture base resins are subjected to a variety of stresses during function: • Midline fractures of dentures during function are considered a flexural fatigue failure due to cyclical deformation of the base during function. This is usually more evident in ill-fitting or poorly designed dentures. • Impact fracture may result from patients accidentally dropping the dentures.	• Periodical recalls of the patient by the dentist are required to address problems that may arise from long-term denture wearing, such as bone resorption that may affect the fit of the dentures. • Patients are advised on the proper handling of their dentures, such as cleaning them over a sink full of water, to avoid fracture if dropped. • Use of rubber-reinforced methacrylate bases in cases of repeated fractures has been advocated. Metal bases also can be used for maximum strength.
Biocompatibility of denture base methacrylate resin to the surrounding oral environment is considered an attribute to the material. However, water sorption, cracks, surface imperfections, and microporosity of the bases are usually associated with the ability of certain organisms to colonize the fitting and other surfaces of the denture, mostly in the absence of adequate oral hygiene. The predominant oral fungus isolated from dentures is *C. albicans* (75%). Other implicated species include *C. glabrata* (30%), *C. dubliniensis*, *C. parapsilosis*, *C. krusei*, and *C. tropicalis*. These fungi and other bacterial species collectively form biofilms. Adhesion of biofilms on the denture surfaces, as well as the mucosa, causes adverse pathophysiologic effects such as denture-induced stomatitis.	• Frequent cleansing or soaking the dentures in chemical cleansers is usually sufficient to minimize, but not totally resolve, this problem. • The temporary treatment of the resin surface with Nystatin and the use of chlorhexidine gluconate have been recommended to effectively reduce the colonization of *C. albicans*. • Minimizing adhesion of *C. albicans* to denture bases has been attempted by incorporating negative charges in the resin surface. Copolymerization with methacrylic acid, creates a surface-modified PMMA (mPMMA) that alters the ionic interaction between the resin bases and candidal hyphae, potentially decreasing adhesion of the microorganisms to the bases. • Coating the resin surfaces with a self-bonding protective polymer, such as poly(dimethylsiloxane), also has been implemented to discourage microbial attachment and growth on the denture surfaces.
PMMA resin bases demonstrate low abrasion resistance. The bases and teeth may undergo wear if cleaning of the dentures is carried out with a stiff brush or using abrasive agents.	• Patients are advised to clean their dentures with soap and water using a soft brush. Avoid the use of abrasives or scouring agents.
PMMA resin is soluble in organic solvents. Upon exposure to alcohol or acetone, the polymer network swells as the resin dissolves, leading to irreversible damage to the resin surface.	• Patients who frequently drink alcoholic beverages can benefit from cross-linked polymeric base.

PMMA, Poly(methyl methacrylate).

temperature, or at a slightly higher temperature, (45° C). Polymerization is completed in about 30 to 45 minutes. The technique is obviously simpler and cleaner in regard to flasking and deflasking, as compared with the conventional, compression-molding technique. The use of a hydro-flask increases atmospheric pressure around the mold, minimizing air inclusions in the mix and thus yielding a denser resin base. The main drawback of this technique is the increased tendency of the denture teeth to shift position during pouring of the fluid MMA mix into the mold.

Box 7-13 Properties of Chemically Activated Resins

In comparison to heat-activated resins, chemically activated resins exhibit the following:

- They contain higher residual monomer contents of 3% to 5% as compared with heat-activated resins.
- Incomplete polymerization leads to inferior mechanical properties of the resins and dramatically compromises their biocompatibility.
- They exhibit higher solubility in oral fluids and water sorption.
- They demonstrate inferior color stability due to oxidation of the amine accelerator.
- High creep rates occur in these resins under increased stresses.
- The materials display less polymerization shrinkage. Reduction in the residual stresses during polymerization leads to greater dimensional stability of the resins.

Box 7-14 Properties of Microwave-cured Denture Resins

- The technique is more time efficient and cleaner than the conventional technique.
- Microwave-activated resins have comparable physical and mechanical properties to conventionally heat-activated resins, with reportedly lower incidences of denture tooth movements.
- Claims of greater dimensional stability and improved denture base adaptation to the underlying tissues have been attributed to adequate temperature control in the resin; equal distribution of temperature throughout the resin and gypsum mold, respectively; and increased homogeneity of the dough.
- Limitations, however, are relatively due to its cost effectiveness for a wide production base, particularly because of high equipment expenses and fragility of the plastic flasks that are more prone to fracture than the conventional metal flasks.

Microwave-Activated Resins (Box 7-14)

Microwaves are nonionizing electromagnetic radio waves in the gigahertz frequency range that have been advocated to activate the polymerization process of methacrylate base resin. The procedure was greatly simplified in 1983 with the introduction of a special glass fiber–reinforced plastic flask, suitable for use in a microwave oven. The resin is mixed in the proper powder/liquid ratios and the composition of the liquid monomer is usually modified to control the boiling of monomer, in a very short curing cycle of about 3 minutes at 500 to 600 W/cycle. In this technique, heat is rapidly generated within the monomer as a result of numerous rapid intermolecular collisions. As the degree of polymerization increases, monomer content decreases proportionally, and as energy is further absorbed, the remaining monomer is converted into a polymer. Careful control of the time and wattage of the oven is essential to yield porous-free resins and still ensure a complete polymerization cycle that enhances the intrinsic characteristics of the resin.

Box 7-15 Properties of Light-activated Resins

- Light-activated resins are indicated for PMMA-sensitive patients because they contain no methyl methacrylate monomer.
- They exhibit smaller polymerization shrinkage, reportedly half that of conventional resins, because of the presence of high molecular weight oligomers. Intimate adaptation of the bases to the underlying tissues is a great asset of the material.
- The physical and mechanical properties of the resins compare well to conventional heat-activated resins, particularly in regard to transverse and impact strengths and hardness.
- Elastic modulus and flexural strength are lower than conventional resins, which could increase deformation of the dentures during function.
- Inferior bond strength of VLC resins to resin denture teeth has been reported frequently but has greatly improved with the use of bonding agents.
- Biocompatibility of VLC denture base resins raises concern, with reports of possible hypersensitivity reactions and cytotoxic effects in epithelial cells in culture. Further research is strongly required to assess the long-term biological effects of these materials on oral tissues and systemic effects.

Light-Activated (VLC) Resins (Box 7-15)

These resins are copolymers of urethane dimethacrylate and a methacrylate resin along with microfine silica fillers. The material has been promoted as an alternative to heat-activated and microwave-activated resins for the fabrication of various prosthodontic appliances. The polymerization process is activated by placing the premixed, moldable resin on the master cast on a rotating table in a light chamber and exposing it to high intensity visible light of 400 to 500 nm for an appropriate time period of about 10 minutes. In this technique, following an initial cure of the resin base, the teeth are repositioned on the base using a light-cured template; contouring is carried out, followed by a final cure in the light chamber. The resin is coated with a nonreactive barrier compound to prevent oxygen inhibition of the polymerization process.

Box 7-16 Limitations of Reinforced Denture Base Resins

- Tissue irritation can occur from protruding glass fibers
- Poor esthetics is associated with dark carbon fibers (black) or straw colored Kevlar fibers
- Require increased production time
- Difficulties in handling, orientation, placement or bonding of the fibers within the resin
- Metal inserts have been associated with failures due to stress concentration around the embedded inserts

Modified Resin Base Materials (Box 7-16)

To overcome shortcomings in the physical and mechanical properties of conventional heat-activated methacrylate resins, modifications have been introduced into the structure of the polymers. The aim was to reduce water sorption and improve mechanical properties such as flexural, tensile, and impact strengths, as well as fatigue resistance of the resins.

- Water sorption, an inherent weakness in the structure of methacrylate-based resins, leads to dimensional changes in the denture bases. It is influenced by the type of resin, its thickness, and amount of cross-linking of the polymer. Heat-activated resins reach their water saturation levels longer than their chemically activated counterparts because of their lower water diffusion coefficients.
- The mechanism is simple; water molecules penetrate into the spaces between the hydrophilic polymer chains, pushing them apart and decreasing the secondary bonding forces (Van der Waals forces) between the chains, thus acting as plasticizers. This in turn adversely affects the physical and mechanical properties of the resin.
- Reducing water sorption of methacrylate resins has been attempted by the incorporation of fluoro-substituted and styrene-type monomers in the polymer structures.
- The results were quite promising because an increase in the number of fluorine atoms was directly proportional to the reduction in the water sorption of the resins.
- Chemical modification to produce graft copolymer resins through the incorporation of a rubber phase has been attempted. The resulting resin consists of a matrix of PMMA in which is dispersed an interpenetrating network (IPN) of rubber and PMMA. The resins absorb more energy at higher strain rates before fracture occurs, resulting in a significant increase in impact strength. However, this modification has been shown to be accompanied by a reduction in the stiffness or rigidity of the resins.
- Rubber reinforcement of PMMA is a successful alternative to conventional resins. However, the high cost of the material may limit its routine use for widespread denture fabrication.
- Mechanical reinforcement of methacrylates also has been attempted through the inclusion of fibers such as glass, carbon, aramid (Kevlar) fibers, nylon, and ultra-high modulus polyethylene (UHMWPE) polymers, as well as metal inserts (wires, plates, fillers). The incorporation of (triethoxyvinylsilane) treated fillers and oligomers in the polymer structure improved the mechanical properties of fiber-reinforced resin bases. The resulting resins have demonstrated an increase in impact and flexural strength and a significant improvement in fatigue resistance, effectively minimizing denture fractures.

A summary of the classification of denture base materials is provided in Table 7-4.

MATERIALS USED IN THE FABRICATION OF PROSTHETIC DENTURE TEETH

Prosthetic or denture teeth are produced in a variety of molds and shades and are available as vacuum-fired porcelain, methacrylate resins, modified methacrylate resins, vinyl resins and composite resins.

In general, teeth used in the fabrication of dentures should demonstrate optimum physical and mechanical properties to withstand the rigorous demands of masticatory functions such as chewing, biting, shearing or crushing of food, and simultaneously exhibit superior esthetics, particularly in the anterior region of the mouth.

High wear resistance of denture teeth is of utmost importance, as it contributes substantially to their longevity, and constitutes an important requirement for their acceptance and selection. Wear of denture teeth is the result of a complex interaction of mechanical factors and others, such as pH levels, erosion and corrosion processes, parafunctional habits, and nutritional habits. It thus varies a lot among individuals.

Excessive wear of denture teeth results in the wear of occluding surfaces, loss of vertical dimension of occlusion, alteration in the functional pathways of masticatory movements, and ultimately fatigue of the muscles of mastication.

A summary of the properties required for prosthetic denture teeth is provided in Box 7-17.

METHACRYLATE-BASED (PMMA) RESIN TEETH

Methacrylate-based resin (poly[methyl methacrylate] [PMMA]) denture teeth are manufactured either by the compression molding dough technique or by injection

TABLE 7-4 CLASSIFICATION OF DENTURE BASE MATERIALS

Denture Base Resin Method of Activation	Processing Technique	Advantages	Disadvantages
Conventional heat-activated resin	Compression molded/dough technique Flask and gypsum mold Water bath short or long cycles	Good biocompatibility Low density Good esthetics, color stability, and surface finish Low solubility in oral fluids Strong adhesion to resin teeth Acceptable dimensional stability Cost-effective fabrication process Ease of repair	Low thermal conductivity Low impact and flexural strength Short fatigue life Low abrasion resistance Radiolucent
Heat-activated rubber-reinforced PMMA	Compression molded/dough technique Water bath short or long cycles	High impact strength	Reduced stiffness/rigidity More expensive than conventional PMMA
Heat-activated fiber-reinforced PMMA	Compression molded/dough technique Water bath short or long cycles	High impact and flexural strengths Good fatigue resistance High stiffness	Unesthetic color of carbon and Kevlar fibers Inferior surface finish Increased production time Difficulty in handling and placement of fibers
Chemically activated PMMA	Compression molded/dough or pour/fluid resin Use agar-agar mold Chemically activated	Dimensionally accurate Pour resins easy to deflask Processing is less time consuming	High residual monomer content High creep rates Reduced stiffness Lower impact/fatigue strength Color instability High solubility Tooth bond failures in pour resins
Microwave-activated PMMA	Compression molded Fiber-reinforced plastic flask Microwave energy in an oven at 500-600 W Curing time as short as 3 min	Short processing time Processing technique easy/clean Dimensional accuracy Comparable physical/mechanical properties to conventionally processed resins	High capital cost Flasks easily fracture/limited serviceability Porosity if time/temperature of oven not controlled
Light-activated resins	No flask required High intensity visible light (wavelength 400-500 nm) in special light chamber Curing time 10 minutes	Simple processing technique Short processing time No methacrylate monomer Low polymerization shrinkage Improved fit Impact strength and hardness comparable to conventionally processed dentures	High capital cost Inferior bond to resin denture teeth Decreased elastic modulus Slightly lower flexural strength

PMMA, Poly(methyl methacrylate).

molding. Several manufacturers have developed resins purported to provide improved wear resistance. Among those are the multiplex polymer matrix (MPM) resin teeth, resin teeth containing an IPN of polymers, and double cross-linked (DCL) resins.

IPN teeth have become quite popular as denture teeth. The resin exhibits good esthetics, low creep and flow rates, high wear resistance, and minimum dissolution in solvents. In addition, the teeth bond effectively to the resin bases (Fig. 7-10, *A* and *B*).

Attempts to increase wear resistance of resin teeth have been the focus of many researchers. Incorporation of inorganic fillers, such as amorphous silica filler in the polymer matrix has improved the wear resistance significantly but

Box 7-17 Requirements of Prosthetic Denture Teeth

- Durable bond with the denture base material
- Resistance to oral fluids/solvents
- High heat-distortion temperatures, no permanent deformation under forces of mastication
- High impact strength to withstand forces during mastication
- High abrasion resistance with little or no wear to maintain the predetermined vertical dimension of occlusion and withstand parafunctional movements
- Esthetically pleasing, inconspicuous, with adequate translucency, color stability, good surface texture, and ease of characterization to produce a natural appearance
- Easily adjusted and refined by grinding and easily polished

was accompanied by an increase in the adhesion of microbial biofilms onto the teeth. Thermodynamic factors such as low surface energy and the hydrophobic behavior of the filled resins may have contributed to this phenomenon. Unfilled and IPN teeth, in comparison, do not promote microorganism adhesions.

A significant advantage of methacrylate resin teeth is that they bond chemically to methacrylate resin bases. Conventional methacrylate resin teeth usually achieve a better bond to the resin bases, more than highly cross-linked teeth. The reason is that high amounts of cross-linking restrict the availability of unlinked polymer chains to bond with the denture base to form a polymer network. Most resin teeth are thus highly cross-linked in the coronal portion to improve strength and provide resistance to crazing but with little or slight cross-linking in the gingival or body portion to improve bonding to the denture base.

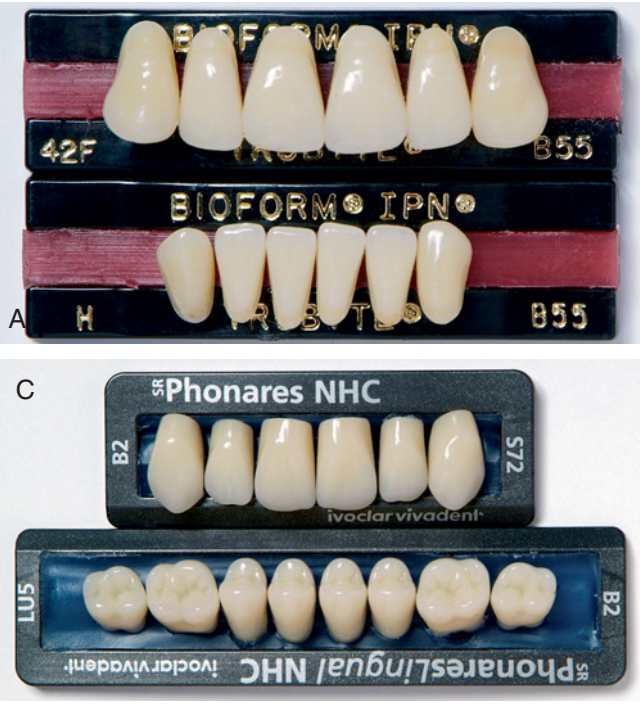








Figure 7-10 Denture prosthetic teeth. **A** and **B,** Resin denture teeth provide good esthetics and wear resistance and bond chemically to the resin bases. **C,** Composite resin denture teeth result in reduced wear to opposing enamel and gold surfaces than porcelain teeth. They could be the material of choice for single dentures opposing natural dentitions. Porcelain denture teeth are mechanically attached to the resin bases by pins **(D)** or diatoric holes **(E).** This bonding mechanism is a major disadvantage that limits the use of the teeth in complete denture fabrication.

Detachment of methacrylate resin teeth from their denture bases is not uncommon. It could be attributed to a variety of factors, including:

- Impurities, such as wax, on the ridge-lap areas of the teeth
- Contamination of the ridge-lap areas with tinfoil substitutes
- Inadequate chemical and/or mechanical preparation of the tooth surfaces
- Processing variables, such as resin-dough time and polymerization cycle
- Presence of porosities at the base-tooth interface, adversely affecting their bond strength

Water sorption of the resins and differences in their coefficient of thermal expansions also has been linked to failure in the bond between teeth and their bases. The deboned areas at the base-tooth interface tend to grow progressively in size under the effect of cyclic stresses in the oral cavity. It is prudent for dentists and dental technicians to select compatible denture base resins and denture resin teeth combinations to minimize bond failures.

Technical Considerations

- In the compression-molding technique for processing dentures, following wax elimination, the mold and denture teeth are flushed with boiling water and/or steam cleaned (Fig. 7-11). The teeth are then thoroughly cleaned with a mild detergent solution. The glossy ridge-lap areas should be surface treated by sandblasting and/or wetting with monomer before resin introduction. This will enhance the bond strength of the teeth to the bases by creating additional micromechanical retention and optimizing the surface energy.



Figure 7-11 To ensure an adequate bond between the resin denture teeth and the bases, the ridge lap areas of the teeth must be free of any impurities such as wax or tinfoil-substitute before packing the mold following wax elimination.

- Chemical bonding facilitates grinding of the teeth to accommodate the available interocclusal spaces and allows reshaping of the teeth to fit small spaces for esthetic purposes without fear of destroying the bond to the base.
- The use of adhesive promoters such as (4-methacryloxyethyl trimellitic anhydride, [META]) has been advocated to facilitate bonding of highly cross-linked methacrylate teeth to resin bases. Adhesive resin cements containing this compound also have been used to facilitate bonding of resin bases to base metal alloys. This procedure also could facilitate the addition of a methacrylate posterior palatal seal to metal bases and the relining of these bases.
- Bonding of resin teeth to chemically activated denture bases is achieved by either mechanical or chemical means. The necks of the teeth are softened by adding a mixture of methylene chloride and chemically activated methyl methacrylate monomer for 5 minutes. This treatment softens the resin to facilitate chemical bonding during polymerization. The same technique is recommended when replacing broken methacrylate teeth onto a denture base using autopolymerized repair resins.

Esthetics of Methacrylate Resin Teeth

The esthetic qualities of resin teeth have improved significantly over the years, and they are clinically acceptable. The teeth are prepared in layers of different colors with lighter shades towards the incisal or occlusal portions, thus increasing their translucency. Both methacrylate and porcelain teeth also could be characterized using surface stains to enhance their natural appearance. Custom tinting of the resin bases to yield a more realistic representation of soft tissue color and the present-day selection of esthetic denture teeth have transcended the traditional artificially veined resin appearance and provide the patients with natural esthetics.

Additional Advantages and Disadvantages of Methacrylate Resin Teeth

- A specifically great advantage of resin teeth is the ease of their occlusal reshaping or grinding to achieve the desired articulation needed for various occlusal schemes.
- Resin teeth have high resiliency and are tougher than porcelain teeth, making them less liable to fracture or chip on impact.
- Unfortunately, they exhibit inferior abrasion resistance, which could lead to alteration in the vertical dimension of occlusion, particularly in long-time denture wearers.
- Resin teeth have low heat-distortion temperatures, a property that has improved considerably by

cross-linking the polymers. Care must be taken to avoid flaming the teeth during the setup of the waxed denture.
- Resin teeth are insoluble in oral fluids. Non–cross-linked teeth, however, may soften with organic solvents, and undergo discoloration by organic dyes.
- The teeth are not as dimensionally stable in water as porcelain teeth.
- Newer generations of resin teeth are more wear resistant and stain much less than earlier teeth.

COMPOSITE RESIN DENTURE TEETH

Composite resins were introduced in the 1980s, as suitable materials for fabrication of denture teeth (Fig. 7-10, *C*). Modifications in the organic and inorganic components of composite resins aimed at improving their wear resistance and other mechanical properties. This included the addition of microfine and nanofiller particles, such as silica.

Nanofilled composite resin teeth have clinically acceptable mechanical and physical properties such as high wear resistance, good strength, and surface finish. However, they still fall short of competing with porcelain teeth or natural enamel in terms of wear resistance. The fillers act as binding agents in the matrix of the resin, creating internal cavities that allow large scale plastic deformation under impact forces. This in turn significantly increases the fracture toughness of the teeth and helps absorb the stresses of mastication. Because of their high elastic modulus, nanofilled teeth show light, well-distributed pressure transmission to the underlying soft tissues, causing significantly less wear to opposing enamel surfaces than methacrylate resin or porcelain teeth.

Considering the above characteristics, these resin teeth could be considered a material of choice when designing a single complete denture opposing a natural dentition. Continued improvements in the polymer structure of composite resin denture teeth will facilitate their widespread use in the future.

PORCELAIN TEETH

Porcelain denture teeth are commercially manufactured and supplied as individual or complete sets of teeth of excellent quality. They are available in a wide range of shades and molds. The teeth exhibit superior esthetic qualities, excellent color stability, and high abrasion resistance as compared with resin teeth. However, for the past two decades they have been replaced to a great extent by the newer generation methacrylate resins.

The ceramic composition of porcelain denture teeth is a triaxial composition. The raw materials for porcelain teeth are mainly feldspar, quartz (15%), and kaolin (4%), which is added to improve moldability of the ceramic material. The teeth are made in split metal molds, fired under vacuum in high temperature ovens, glazed by the glass produced from the feldspar, and slowly cooled to prevent crazing.

The teeth show excellent esthetics, closely resembling the optical and physical qualities of natural teeth. The colors are internally blended and projected outwards through layers of translucent enamel, similarly to the effect of natural teeth. Impeccable optical characteristics include an increase in the color intensity of the teeth, from incisal to gingival, and progressively from central incisor to lateral to canines. The translucency of the teeth enables them to pick up, reflect, and refract the light from all surroundings and under all lighting conditions, creating an almost natural effect.

A major drawback of porcelain teeth is their method of attachment to the resin bases; the teeth are mechanically attached to the bases by pins or diatoric holes (Figs. 7-10, *D* and *E*). This precludes their ability to be ground, or reshaped, to fit limited interarch spaces. Detachment of porcelain teeth from the resin bases is a major drawback for these teeth. To overcome this major limitation, the bond with methacrylate resin bases has been enhanced by a combination of micromechanical retention and chemical bonding. This is carried out by treating the ridge lap area of the tooth with an etchant such as hydrofluoric acid gel, followed by a silane coupling agent.

Chemical bonding of methacrylate resin or porcelain teeth to a denture base has another major clinical advantage over mechanical attachment alone—it prevents capillary spaces around the teeth, which are difficult to clean and in which microorganisms may grow.

Additional Advantages and Disadvantages of Porcelain Teeth

- Porcelain teeth cause significant wear of opposing enamel and metallic occlusal surfaces. This prohibits their use in single complete dentures opposing natural teeth or those with gold occlusal surfaces.
- The teeth are quite brittle and easily crack or chip on impact.
- The teeth are difficult to grind for occlusal adjustments because they lose their surface glaze, and polishing is quite difficult. They are not indicated in limited interarch spaces because of the very limited ability to reshape their cervical areas.
- Porcelain teeth produce noisy clicking sounds upon contact with each other.
- Their higher density increases their weight.
- Mismatches in the coefficient of thermal expansion of porcelain and resins produce stresses in the resin base, which may lead to distortion of the bases.
- They exhibit high heat distortion temperatures.
- They allow the dentures to be rebased without a need to replace the teeth.
- They are insoluble in oral fluids and in most organic solvents.

TABLE 7-5 A COMPARISON OF THE PROPERTIES OF METHACRYLATE RESIN AND PORCELAIN TEETH

Property	Methacrylate Resin Teeth	Porcelain Teeth
Bond with resin base	Chemical bond	Mechanical via pins or diatoric holes
Mechanical properties	Less brittle than porcelain; high resilience and toughness	Very brittle/chipping occurs on impact
Solubility in oral fluids and dimensional changes	Insoluble—some dimensional changes	Insoluble—inert in oral fluids No dimensional changes
Maintenance of vertical dimension (VDO)	Low abrasion resistance Wear is significant Wear can result in reduced VDO	Excellent abrasion resistance Hard—wear is insignificant VDO tends to be maintained
Effect on opposing occlusion	Can oppose natural teeth or metallic occlusal surfaces	Abrades opposing tooth enamel/metallic surfaces
Tooth contouring/occlusal adjustment/repolishing	Relatively easy	Difficult, may result in loss of surface glaze
Grinding of ridge/lap areas	Easy to grind without compromising tooth-resin bond	Difficult to position or retain in limited interarch spaces
Esthetic properties	Excellent can be characterized as required	Excellent can be characterized
Clicking sounds	None on contact with opposing teeth (natural feel)	Noisy/clicking occurs with opposing porcelain teeth
Resistance to thermal shocks	Good resistance	Less than resins

- They are dimensionally stable and hard in comparison with the softer resins.
- Porcelain teeth have a high wear resistance that is equal to or greater than natural teeth, and 10 to 20 times that of resin teeth.
- They exhibit no permanent deformation under occlusal loading.

SUMMARY OF PROSTHETIC TEETH

In the selection of denture teeth for complete dentures and considering the above properties of the various materials, the dentist should avoid combining posterior resin teeth with anterior porcelain teeth. The significant differences in abrasion resistances in both materials, with resin wearing more rapidly than porcelain, would potentially create destructive occlusal forces in the anterior region of the mouth, leading to anterior ridge resorption and instability of the prostheses.

A comparison of the properties of different prosthetic teeth is provided in Table 7-5.

DENTURE LINING MATERIALS

Edentulous patients must be made aware of the fact that their anatomic structures, physiological conditions, and tissue tolerance are highly variable. In addition, it is imperative for them to understand that residual ridge resorption is inevitable, so a prosthesis needs to be modified to compensate for these changes on a timely, recurring basis. Inherent changes in the bone and soft tissues supporting a denture may lead to ill-fitting dentures and result in significantly abused tissues.

Denture lining materials are used to refit the surfaces of complete dentures, help "condition" traumatized/abused tissues, and even provide a time-dependent, simulated cushionlike effect. They also may aid in the retention of extraoral and intraoral prostheses.

The earliest resilient liners were made from natural rubber. The first synthetic resin used as a liner, a polyvinyl resin, was developed in 1945; in 1958, silicone-based liners were introduced.

Denture lining materials are generally classified into the following types:

1. Short-term soft liners (tissue conditioners)
2. Long-term soft liners

Soft denture liners are polymers with a glass transition temperature* that is below that of mouth temperature.

Clinical success of a resilient liner relies on its ability to recover its shape and adapt to the ridges after initial application of a load in a time-dependent manner. The soft resilient nature of these materials inside the mouth provides them with a whole range of diagnostic, adjunctive, and treatment purposes in the management of edentulous patients.

*The glass transition temperature is the temperature at which a polymer ceases to be glossy and brittle and changes to a rubberlike form.

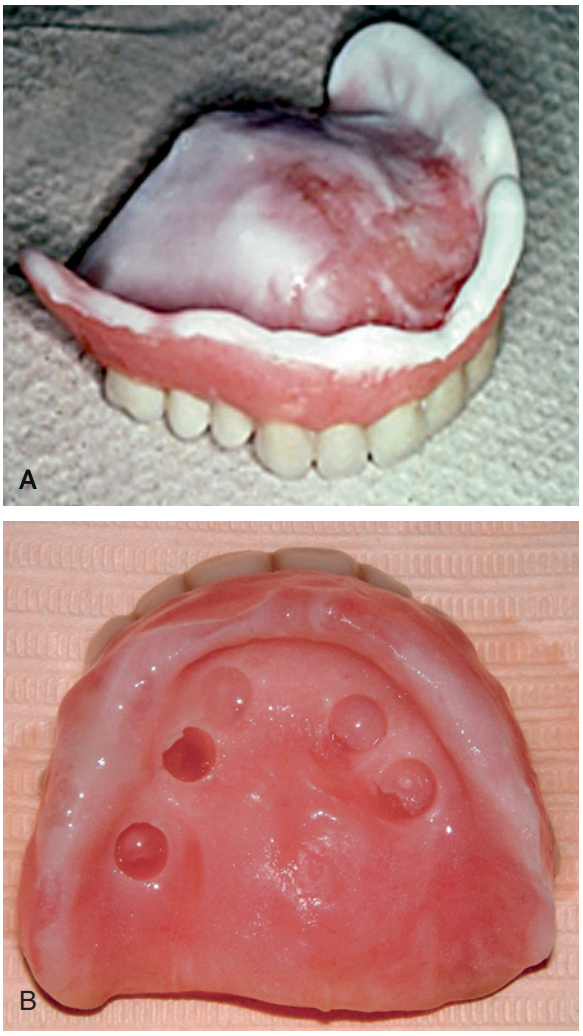


Figure 7-12 A tissue conditioner must be evenly distributed over the whole denture-bearing areas. The material then provides improved adaptation of the denture base to the oral tissues for optimum stress distribution. This is done as a temporary measure before a definitive conventional **(A)** or implant-supported prosthesis **(B)** is fabricated.

SHORT-TERM SOFT LINERS (TISSUE CONDITIONERS)

Short-term soft liners are soft, resilient, plasticized methacrylate resins commonly used as temporary liners; they have been widely used in dentistry to manage a multitude of patient problems and clinical applications (Fig. 7-12). They are mixed at chairside, placed in the denture fitting surface, and then in the patient's mouth. Indication for use and the composition of tissue conditioners are provided in Box 7-18.

The gelation of tissue conditioners is a physical process, which is devoid of any chemical reaction or any monomeric substances that could cause tissue irritation. Upon mixing the powder and liquid, the alcohol/plasticizer mix diffuses into the swellable methacrylate beads. Gelation involves the entanglement of outer polymer chains of juxtaposed swollen beads, resulting in a tacky-set gel with high cohesive properties. This enhances its retention to the fitting surface of the denture. The set gel has viscoelastic and elastic properties that allow it to act as a shock absorber.

Ideally for adequate cushioning, a tissue conditioner should be replaced with a fresh mix every 3 to 4 days. This procedure should continue until full recovery of the tissues has occurred.

Patients must be strongly advised on the temporary nature of these liners and rescheduled for their replacement or removal. Failure to do so results in a multitude of problems, with patients presenting with pain, reabused tissues, oral malodor, debonded liners, and denture bases fouled with adherent microorganisms (Fig. 7-13). The onus is on the dentist to help the patients avoid such a dramatic clinical scenario.

The temporary nature of tissue conditioners stems from the fact that both alcohol followed by the plasticizer leach out and are partially replaced by water. The material shows a weight loss ranging from 4.9% to 9.3% after 24 hours because of a loss of alcohol. The material thus hardens within a considerably short time, which varies from a few

Box 7-18 Indications and Composition of Short-Term Soft Liners/ Tissue Conditioners:

Indications for Use

- Soft liners/tissue conditioners are used to treat and condition irritated denture-supporting tissues. Lining ill-fitting dentures allows the tissues to rest and regain their health before impression making for new dentures.
- They are also used for provisional adjunctive/ diagnostic purposes such as recovery of the vertical dimension of occlusion and correction of occlusion of old prostheses. They allow assessment for the necessity of using a permanent soft liner for patients with chronic pain or soreness associated with denture wearing.
- Temporary relining of immediate dentures/ immediate surgical splints.
- Relining cleft palate speech aids.
- Tissue-conditioning during implant healing period.
- Tissue conditioners can be used as functional impression materials.

Composition of Tissue Conditioning Liners

- They are provided mostly as a powder/liquid system, but preformed sheets of acrylic gels are also available.
- The powder contains a polymer, usually PMMA or copolymers.
- The liquid contains a mixture of ethyl alcohol (solvent) and an aromatic ester (dibutyl phthalate) that acts as a plasticizer that lowers the glass transition temperature of the polymer, rendering it a soft gel.



Figure 7-13 A mandibular denture with a tissue-conditioning material. The material was placed 6 months earlier. The patient presented with severe denture stomatitis, inability to masticate properly, and a feeling that "the denture felt too big in the mouth."

days to a week or two, and gradually loses its proclaimed cushioning effect. In addition, the material becomes increasingly vulnerable to surface deterioration, contamination, and fouling by microorganisms, which in turn can lead to further irritation to the already abused mucosal tissues.

Rheological and Viscoelastic Properties of Tissue Conditioners

The gelation characteristics and viscoelastic properties of tissue conditioners vary depending on differences in their composition and structures. This includes molecular weight, powder particle size, ethyl alcohol content, and the plasticizer used. Some materials are formulated to remain soft and resilient for longer periods. It is important for the dentist to follow the manufacturer's instructions when handling tissue conditioners. Rheological studies have shown that different products must be seated in the mouth at different times from the start of mixing because they may differ both in viscosity and gelation time.

Effectiveness of tissue conditioners is related to their viscoelastic properties, which is a combination of both viscous fluid and elastic solid behavior.

- Viscous behavior allows adaptation of the gel to the inflamed/irritated mucosa underlying the denture, which greatly improves the fit of the denture. Following an initial easy flow, the gel becomes highly viscous, and its flow thereafter is affected by the magnitude of the load applied on the denture as well as its duration. This consequently affects stress distribution in the mucosa.
- Concurrently, under cyclic/intermittent loading such as during chewing, the material demonstrates a time-dependent elastic behavior that allows it to recover initial deformation, absorbing impact forces and cushioning the underlying tissues.

Thus, viscoelastic and elastic properties of tissue conditioners result in an even distribution of load on the underlying mucosa and a cushioning of cyclic forces of mastication. This in turn allows the traumatized mucosa to recover, particularly under an ill-fitting denture.

Short-term soft liners can be used as functional impression materials for denture relines. Requirements for this clinical application would differ slightly from those required for tissue conditioning.

To effectively condition traumatized tissues, a tissue conditioner should demonstrate adequate flow and elastic properties. Maintenance of this viscoelastic behavior is the key to its clinical success. A functional impression material, on the other hand, should display good flow but with minimal elastic recovery. The material should flow readily under functional stresses, ensuring continual adaptation to the underlying soft tissues as they are altered under stresses. However, to ensure accuracy of the impression, the material must:

- Undergo minimum elastic recovery.
- Retain compliancy for many weeks.
- Exhibit adequate dimensional stability in terms of weight change, water sorption, and solubility.
- Bond well with resin bases.

Casts should be poured immediately after removal of the impression from the patient's mouth. Functional impressions are routinely removed from the patient's mouth after a few days, ranging from 5 to 7 days or even shorter periods to obtain optimum results.

As pointed out, materials that are available as short-term soft liners vary considerably in their compositions and properties; some fulfill the requirements of an optimum functional impression material more efficiently than others. The choice of materials, must be based on thorough understanding of their properties in conjunction with their effective clinical applications

Patients must be advised on the care of the temporarily relined denture. Denture cleansers may adversely affect the liner, and the simplest way to clean the denture would be to rinse the denture and use a soft toothbrush or wipe the liner with a wet cotton pad.

SELF-ADMINISTERED HOME RELINES*

- Numerous over-the-counter temporary reline materials are available for patient use and are marketed as "home relines." The materials allow the patient to adjust the fit of their dentures. They are supplied as preformed thermoplastic pads or in a powder/liquid form and

*__Note:__ There is a unanimous consensus among dentists that patients should be strongly discouraged from using these materials as a substitute for seeking proper professional help.

have a similar composition and manipulation as treatment liners.
- The main limitation and danger of these materials is the high potential for their misuse. Improper adherence to manufacturer's instructions on the proper mixing of the components or long-term use of these liners can lead to trauma and irritation to the underlying tissues, which may adversely affect the denture base materials and may cause occlusal errors.

LONG-TERM SOFT LINERS

Long-term soft liners are mostly used as a therapeutic measure for patients who cannot tolerate the stresses induced by their dentures. They are used in the management of edentulous patients who present with problems like chronic pain, soreness, or discomfort caused by prolonged contact between the rigid denture base and the underlying tissues, most commonly because of morphological or physical factors. This may develop in the following clinical situations:

- Patients with sharp, thin ridges
- Patients with highly resorbed ridges
- Patients with sensitivity due to submucosal exposure of the inferior alveolar nerve
- Patients with severe bony undercuts
- Patients with congenital or acquired defects of the palate

In these situations, a viscoelastic soft liner would be a welcome adjunct to compensate for the dramatically depleted mucoperiosteal support and increase denture retention.

Long-term soft liners permit wider dispersion of forces and absorb impact forces that are involved in both functional and parafunctional movements. This consequently allows abused denture-bearing tissues to heal, increasing patient comfort and tolerance to the prostheses.

The most commonly used long-term soft liners are plasticized methacrylates and silicone rubbers, which are either chemically or heat activated. The requirements of an ideal long-term soft liner are presented in Box 7-19.

Other materials available, but not as widely used, include plasticized vinyl polymers and copolymers, hydrophilic polymers, polyphosphazene fluoropolymers, fluoroethylene, and polyvinyl siloxane addition silicones.

Box 7-19 Requirements of an Ideal Long-Term Soft Liner

- Biocompatible
- Low degradation
- Good dimensional stability
- Low water sorption and water solubility
- Good wettability by saliva
- Permanent softness/compliance/viscoelasticity
- Adequate abrasion resistance and tear resistance
- Good bond to the denture base
- Unaffected by aqueous environment and cleansers, easy to clean
- Simple to manipulate
- Color stable and good esthetics
- Inhibits colonization of fungi and other microorganisms

Methacrylate Resin and Heat-Activated Resilient Liners

The composition of heat-activated plasticized methacrylate soft liners follows:

- The liners are supplied as preformed sheets or in a powder/liquid form. The powder consists of a poly(ethyl methacrylate) and benzoyl peroxide as an initiator.
- The liquid consists of methacrylate monomer (such as ethyl, n-butyl, or 2-ethoxyethyl methacrylate) together with a plasticizer, commonly a phthalate ester.

Plasticizers lower the glass transition temperature of the resin, acting as a lubricant between the polymer chains, enabling them to deform more easily and thus imparting flexibility.

During clinical use, the resilient liner is immersed in saliva, and when not in use, the dentures are usually stored in water or cleansing agents. Whereas water is absorbed by the liner, the plasticizer and other soluble components tend to leach out, causing a progressive loss of resiliency of the liner, increasing its hardness values, and diminishing its cushioning effect.

Biodegradation of plasticized methacrylates in the oral environment is their main weakness. The resulting hard rough surface of the liner consequently promotes calculus and food accumulation and undergoes fouling with microorganisms. However, the material exhibits good durable bond strength to the methacrylate base, high tear and abrasion resistance, and can achieve a much better polish than silicone. The liner is processed in the laboratory, usually at the time of processing a new denture.

Chemically Activated Methacrylate Resins

Chemically activated methacrylate resins also are available as soft liners. Their chemical composition is similar to heat-activated resins. Polymerization is initiated by a peroxide-tertiary amine system and usually is completed within several minutes. The materials are applied as chairside relines. However, as with other intraoral-cured liners, they can only be used on a temporary basis because of their tendency to foul and debond from the denture within a few weeks. This major drawback limits their

clinical application. The presence of free monomer also results in inferior mechanical properties and reduced biocompatibility.

Silicone-Based Soft Liners

Silicone rubbers are available as heat-activated or room temperature vulcanized (RTV). The materials have gained considerable success over methacrylate liners mainly because of their superior resilience and ability to retain elasticity for longer periods. They do not depend on leachable plasticizers to maintain their resiliency, a result of their inherent chemical properties.

Heat-Activated Silicone Liners. The material is supplied as a single paste that consists of poly(dimethyl siloxane), a viscous liquid to which silica is added as a filler, and benzoyl peroxide as an initiator. The liner sets by a cross-linking reaction that is catalyzed by heat and the peroxide initiator.

The liner is processed against the methacrylate dough of the new denture. This is recommended over addition of the liner to a previously polymerized base because it results in a better bond with the denture base.

Laboratory procedures for silicone liners, both heat cured and chemically activated are the same. The bases are invested in a flask and mold spaces are prepared. Adequate relief inside the fitting surface of the denture base is provided to permit an acceptable thickness of the chosen liner. Packing, compression molding, and processing are carried out as per manufacturer's instructions. The denture is then deflasked, finished, and polished.

Chemically Activated Silicone Liners (Room Temperature Vulcanized [RTV] Silicones). These liners use a condensation cross-linking process catalyzed by an organotin compound. The condensation reaction is similar to that of condensation silicone impression materials. The materials are supplied as two-component systems, a paste and liquid, and also are laboratory processed to the fitting surface of the denture base. RTV silicones achieve a much lower degree of cross-linking than heat-activated silicones, which in turn compromises many of their attributes as long-term liners and lowers their serviceability.

Silicone rubbers, particularly the heat-activated type, possess numerous properties that enhance their clinical superiority over plasticized methacrylates. The materials can maintain their high resilience and elasticity over time, which enables them to prolong their cushioning effect more than other soft liners. This has led to clinical subjective claims of superior flexibility and shock absorption of the denture bases, which is associated with an improvement in masticatory comfort and function.

The major drawback of silicones is their intrinsic tendency to lose adhesion to the methacrylate resin base. This is more evident around the borders of the denture, a particular problem with RTV silicones, which tend to swell or peel off the denture base. This clinically detrimental behavior is further accentuated by their high water sorption and tendency to undergo volume changes with the loss or gain of water. As the material swells, stresses build up at the base/liner bond interface, and the viscoelastic nature of the liner changes. The material becomes brittle and transfers external load to the bond area. Concurrent debonding of the liner and base promotes staining, increases biofilm adhesion, and decreases the strength of the denture.

Addition of bonding agents and cements has been attempted to overcome this problem. Cements act as chemical intermediates that bond to both the liner and the denture resin. Other attempts include confining the borders of the liner to end within the denture border, rather than extending it to the periphery. However, such a design runs the risk of compromising the shock absorbability of the liner. Attempts made to roughen the methacrylate/liner interface as a means of enhancing the bond strength include the use of lasers, alumina abrasion, and chemical etching.

Despite the vast clinical benefits that have been recognized for plasticized methacrylates and silicones as soft liners, they should not be perceived as a panacea. Both materials exhibit properties that are, by far, short of fulfilling requirements of an ideal permanent liner.

At present, the materials have to be considered as temporary expedients because none of the advocated permanent soft liners has a life expectancy comparable to that of the resin denture base. This fact has limited their efficacy and life expectancy, reportedly to a maximum of 1 year of serviceability. The following facts pertaining to the clinical performance of these materials further underscore their limitations:

- Most challenging in the use of long-term and short-term soft liners is their tendency to support growth of *Candida albicans* and other microorganisms on and within the liners. The porous nature, particularly of silicones, facilitates water absorption and diffusion of nutrient materials. Debris that accumulate in the pores supports this mycotic growth. This is further complicated by the difficulty of cleaning most of these liners using routine mechanical or chemical methods, such as brushing or the use of hypochlorite or peroxide denture cleansers. The latter can cause significant damage to the liners, especially silicones, mostly by decreasing their compliance.
- Patients often report disagreeable tastes and odors related to these materials.
- Excellent oral and denture hygiene and the use of antimicrobial agents can effectively minimize fungal/microbial colonization of liners. Surface coatings of liners with sealants such as fluorinated copolymers to reduce water sorption and integration with antifungal components has yielded satisfactory results, potentially decreasing adhesion of biofilms to the liner surfaces.
- Cleaning of soft liners could be carried out using a soft brush in conjunction with a very mild detergent or

nonabrasive dentifrice. Alternatively, the external surface of the denture could be cleaned as described, but the liner itself could be wiped with cotton under cold water.

- Prescribing a long-term soft liner for the edentulous patient may be accompanied by the potential risk of reducing the strength of the associated denture. As the thickness of the liner increases, the base thickness must be decreased to avoid a change in the vertical dimension of occlusion. In addition, the use of monomers and bonding agents may cause partial dissolution of the base. This may collectively result in fracture of the denture during service.
- Biocompatibility of long-term soft liners raises much concern. Plasticizers incorporated in those materials are reportedly released both *in vitro* and *in vivo*. In animal tests, changes in epithelial cells have been reported, as well as cytotoxic effects in cell cultures. Incorporation of antioxidant molecules in the structure of resilient liners has been recently explored as a way of enhancing their biocompatibility, with promising results. However, as with other dental materials that undergo biodegradation, it is imperative to continue the search for a new generation of denture lining materials that are able to induce favorable reactions in the living tissues.

SUMMARY OF DENTURE LINING MATERIAL

Clinical experience indicates almost universal tissue tolerance of soft liners. Ongoing research should focus on improving the clinical applications of these materials. This includes strength, permanent resiliency, improved adhesion to the denture bases, the ability to inhibit growth of microorganisms, and chemical stability. Silicone rubbers, when properly used, may be the most appropriate of the various types available, but they too are only temporary expedients and must be inspected regularly by the dentist and replaced when unsatisfactory.

Nevertheless, it must be emphasized that the use of these materials does not preclude adherence to the fundamental principles of complete denture construction. When used intelligently, soft liners are an excellent adjunct in removable prosthodontics.

CAST METAL ALLOYS AS DENTURE BASES

Despite the popularity of PMMA as a denture base material, its inherent weaknesses in mechanical properties increases its susceptibility to impact and fatigue failure. Both are considered to be the two main causes of denture fractures. The reinforcement of conventional PMMA resins through the incorporation of rubber inclusions and fibers has significantly enhanced the impact and flexural strengths of the material and its fatigue resistance. However, there are various clinical situations where a dentist may select an alternative material. One such situation is where a single denture opposes a full or partial complement of natural teeth or fixed restorations. An unfavorable/irregular occlusal plane, heavy anterior occlusal contacts, and heavy masticatory forces directed onto a virtually thin resin plate may collectively contribute to denture fracture. In such a situation, the choice of a cast metal base has been recommended as an effective alternative to resin bases. Moreover, metal bases provide an important alternative dental service for edentulous HIV-positive patients or other patients with higher incidences of fungal infections. The nonporous, smooth, highly polished surface of the metal base effectively decreases the growth of *C. albicans* and other microorganisms on the denture surfaces.

TECHNICAL CONSIDERATIONS

A relatively thin metal base is cast to contact the tissue-bearing surface, covering the whole palate and providing superior fit and comfort to the patient. The metal base is designed with a retentive meshwork (Fig. 7-14, *A*), retentive coils (Fig. 7-14, *B*), and/or pins (Fig. 7-14, C) that extend posteriorly, buccally, labially, and lingually in the case of a mandibular denture (see Fig. 7-14, C). The wax pattern is verified by the dentist before the base is cast using conventional lost-wax casting techniques (Fig. 7-14, *D*). Methacrylate resin is used to retain the denture teeth and provide buccal and labial flanges that enhance the esthetic quality of the denture and compensate for the missing soft tissues (Fig.7-14, *E*). The processed methacrylate resin and metal meet at a definite finish line to ensure a strong butt junction. Care must be taken to avoid inadequate shaping of the palatal contours at the finish line or placing the methacrylate resin-metal junction too far laterally or medially, which could result in crowding or inadequate contact with the lateral border of the tongue, risking discomfort or interfering with speech sounds.

The dentist is primarily responsible for selecting an appropriate metal and prosthesis design. The selection and alternative choices must be presented to the patient. The technician is then supplied with sufficient details of the design of the prosthesis.

To ensure clinical success, it is of utmost importance to integrate the dentist's clinical skills, choice of materials, and sound scientific background with the need to provide a high quality design for any dental prosthesis. Design failures can contribute to a prosthesis failure as much as inadequate choices of the selected materials can.

A variety of metals and metal alloys have been used as complete denture bases. Currently, the materials of choice include cast base metal alloys such as cobalt-chromium, nickel-chromium, cobalt-chromium-nickel, and titanium alloys such as CP Ti and Ti-6V-4Al alloys. General

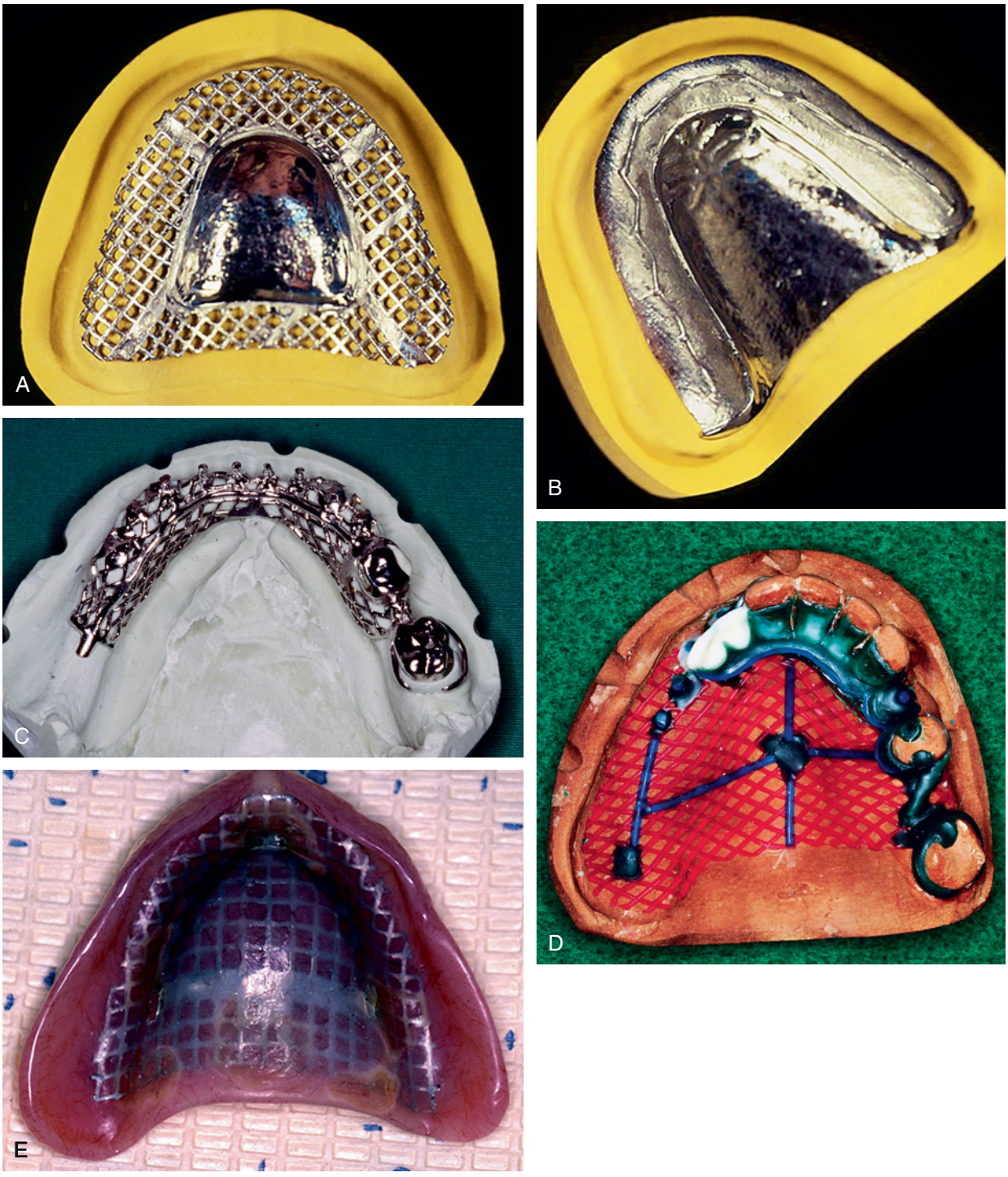


Figure 7-14 **A,** A maxillary cast framework for an edentulous patient. The retentive meshwork is designed to hold the resin all around the borders and provides a posterior palatal seal area for optimum denture retention. The tuberosity area can be entirely covered in metal, or a mesh plus resin as dictated by the interarch space. **B,** A maxillary cast framework showing retentive coils to hold the resin. The rugae area has been reproduced for a natural feel. **C,** A mandibular cast framework with cast posts for added retention of the prosthetic teeth. Many dentists prefer not to cover the residual ridges with metal to allow for relieving and relining. **D,** The wax pattern is verified by the dentist before the base is cast using conventional lost-wax casting techniques. **E,** To decrease the weight of the maxillary denture, the palatal portion of the framework has been designed with a retentive mesh rather than a rigid solid palate. This design does not provide the same strength to the denture as those in parts **A** and **B.** However, it does allow for reline and increased adaptation, if needed.

Box 7-20 General Requirements of a Cast Dental Alloy for Denture Base

- Biocompatibility: No harmful toxic or allergic effects in the patient and operator
- Corrosion resistance: No physical dissolution due to subsurface reactions in oral fluids
- Tarnish resistance: Absence of surface deposits or an interaction layer, as in silver alloys
- Adequate physical and mechanical properties: For example, thermal conductivity, melting temperature, coefficient of thermal expansion, and strength
- Ease of fabrication: Feasible for the average dentist and skilled technician
- Adequate castability: Molten metal must wet the investment very well and flow into the mold without interactions or porosities
- Ease of finishing of the cast metal This is a factor of hardness, ductility(% elongation), and ultimate strength of the used alloy
- Economically affordable

requirements for cast dental alloy used for denture bases are provided in Box 7-20.

COBALT-CHROMIUM ALLOYS

Cobalt-chromium alloys are often referred to as stellite alloys. They consist of about 60% cobalt and 25% to 30% chromium together with minor alloying elements such as manganese and silicone to enhance fluidity for casting. Other components included are aluminum, gallium, copper, iron, and platinum. Molybdenum, tungsten, and carbon also are added as hardening and strengthening elements. The presence of chromium is essential in any cobalt and nickel-based alloy to essentially prevent tarnish and corrosion; this is termed "passivating effect." The resulting alloys display high strength, hardness, high modulus of elasticity (stiffness), low density, and high corrosion resistance and have a substantially lower cost than gold alloys.

COBALT-CHROMIUM NICKEL ALLOYS

These alloys contain 50% cobalt, 25% chromium, and 19% nickel. Molybdenum and carbon contents are much lower than in conventional cobalt-chromium alloys.

NICKEL-CHROMIUM ALLOYS

These alloys contain about 70% nickel and a lower content of chromium (16%). The inclusion of beryllium (0.5%) in minor quantities lowers the melting range and enhances fluidity of the alloy for better castability. Presence of aluminum (2%) leads to the formation of an intermetallic (Ni3-Al) compound that increases the strength and hardness of the alloy.

PROPERTIES OF BASE METAL ALLOYS USED IN REMOVABLE PROSTHESES

Physical Properties

- The melting temperatures of base metal alloys are much higher than dental gold alloys. This influences their casting techniques. They are induction-melted in high-temperature equipment and cast using phosphate-bonded or silicate-bonded investment.
- Their low density enables them to be used for construction of large, bulky maxillary bases and major connectors without causing discomfort to the patient.
- They exhibit relatively high linear casting shrinkage, partly compensated for by the thermal expansion of the investment material. This increases potential for casting defects.

Mechanical Properties

- Chromium-containing alloys are 30% harder than type IV gold alloys, thus requiring special laboratory equipment for finishing and polishing.
- They have adequate yield and tensile strengths. This is essential to ensure minimum permanent deformation during function and ability to withstand occluding forces of mastication.
- Base metal alloys have a high elastic modulus, nearly double that of hardened type IV gold. Rigidity is essential in a denture base design to allow equal distribution of forces on the supporting structures during function. It also allows a reduction in the dimensions of the base, resulting in a relatively thinner base, without compromising its strength.
- The percent elongation of base metal alloys is an indication of their ductility. Increasing the nickel and reducing the cobalt contents can increase ductility. This may be indicated for partial denture clasps.

Chemical Properties

Base metal alloys containing no less than 85% by weight of chromium, cobalt, and nickel are reasonably corrosion-resistant. This occurs by the formation of a thin, contiguous chromium oxide film, rendering the alloy passive in air and in oral fluids. Chromium-type alloys are attacked vigorously by chlorine. Household bleaches should not be used to clean the prostheses. Base metal alloys have retained popularity over noble and high noble metals because of their lower unit metal cost. They are inexpensive and readily available in the dental laboratories.

Biocompatibility

The controversy surrounding the biocompatibility of cobalt-containing and nickel-containing alloys as potential allergens and the biologic risks of metal ions released in the mouth during corrosion (such as with beryllium, a carcinogenic hazard) suggests the merits of another cast base metal, titanium, as an alternative. However, worries concerning systemic effects of casting alloys are based on meager evidence. Dentists should obtain an accurate health history of patients before considering the use of alloys that contain nickel. Nickel sensitivity has been reported in many patients and must be properly managed.

COMMERCIALLY PURE TITANIUM AND ITS ALLOYS

Superiority of commercially pure titanium (CP Ti) as a base metal alloy for the fabrication of complete metal bases stems from the following characteristics:

- Remarkable biocompatibility
- High corrosion resistance
- High dimensional stability
- Relatively low density
- Suitable mechanical properties

The main drawback of titanium as a denture base alloy relates to difficulties in its casting technique because of the following characteristics:

- High melting point (about 1700° C)
- High chemical affinity to gases (oxygen, hydrogen, nitrogen)
- Reactivity with components of most investment materials

This has lead to a variety of problems such as low casting efficiency, casting porosities, and difficulty in finishing, soldering, and welding of the metal.

Casting titanium is a relatively expensive laboratory technique that requires special high cost equipment. Recent advances in casting technology and melting techniques have greatly facilitated the feasibility of casting titanium-based metals and their use in dental laboratories. These include the combination of centrifugal, vacuum pressure and gravity castings; new investment materials; and advanced melting techniques such as electric arc melting and laser welding.

Titanium-based dental technology has yielded clinically acceptable results. One technique described for casting CP Ti complete denture bases used a centrifugal machine to provide a relatively oxygen-free environment, and together with a tungsten arc, was able to reach a temperature of 2000° C. Despite the success in producing relatively accurate denture bases with such techniques, problems such as consistent microporosities and macroporosities in the castings and difficulties in making relatively thin castings remain to be resolved.

TITANIUM ALLOYS

There are several titanium alloys that are used for the commercial production of removable and fixed prostheses; these include Ti-6Al-4V, Ti-30Pd, Ti-20Cu, and Ti-15V. Alloying titanium with other metals is carried out to attain lower melting and casting temperatures in an attempt to address difficulties when casting titanium, while retaining the biocompatibility of pure titanium.

There is currently a significant increase in the number of commercial laboratories that are producing titanium frameworks for removable prostheses, single crowns, and multiunit fixed restorations. There is also a definite growth in the nuclei of trained titanium technicians that is very promising. However, there is still a need for simpler, reliable, and affordable technologies for the routine wide-base production of titanium-based restorations to fully benefit from the unique properties of this base metal in the field of prosthodontics.

A comparison of properties of cast metal alloys versus resinous-based materials for denture bases is provided in Box 7-21.

DENTURE CLEANSERS

Education of patients is crucial to enhance their awareness of both limitations and inherent weaknesses in the physical and mechanical properties of any removable prosthesis.

Improper care of the dentures can have serious detrimental effects on their durability and on the health of the denture-supporting tissues. The majority of patients are unaware of the risks of microbial biofilm (plaque) accumulations around and under the denture-tissue interfaces and the potential for promoting adverse pathological mucosal reactions such as denture stomatitis and angular cheilitis. Most likely reasons could be lack of information provided to the patients by the clinicians or their inability to follow instructions on the care and use of the dentures. This could be a physiologic sequel to the decline in their physical and intellectual capabilities associated with aging and the concomitant depletion in the elderly patient's affective responses to denture wearing.

Denture stomatitis is one of the most common sequelae of wearing complete dentures. It is multifactorial in origin. Contributing factors include salivary flow, denture hygiene, age of the prosthesis, denture base material used, wearing of dentures at night, smoking, nutritional intake, and denture trauma.

The presence of denture deposits and their rate of accumulation are directly related to the presence of

Box 7-21 Advantages, Disadvantages, and Clinical Implications of Base Metal Alloys as Compared with Resinous Complete Denture Bases

ADVANTAGES	DISADVANTAGES
High thermal conductivity	Greater initial and technical costs
Reduced bulk across the palate creates more tongue space and increased comfort to the patient	Difficulty of rebasing and relining metal/currently facilitated with adhesives
Dimensional stability/ increased accuracy of fit of the denture base	Less margin of error permissible in the posterior palate seal area
Superior biocompatibility of titanium bases	Increased weight for a maxillary denture, yet an advantage for a mandibular resorbed ridge
Stronger bases that withstands high masticatory stresses	
Increased weight, enhances stability of a mandibular denture	
Easier to clean and maintain denture hygiene	

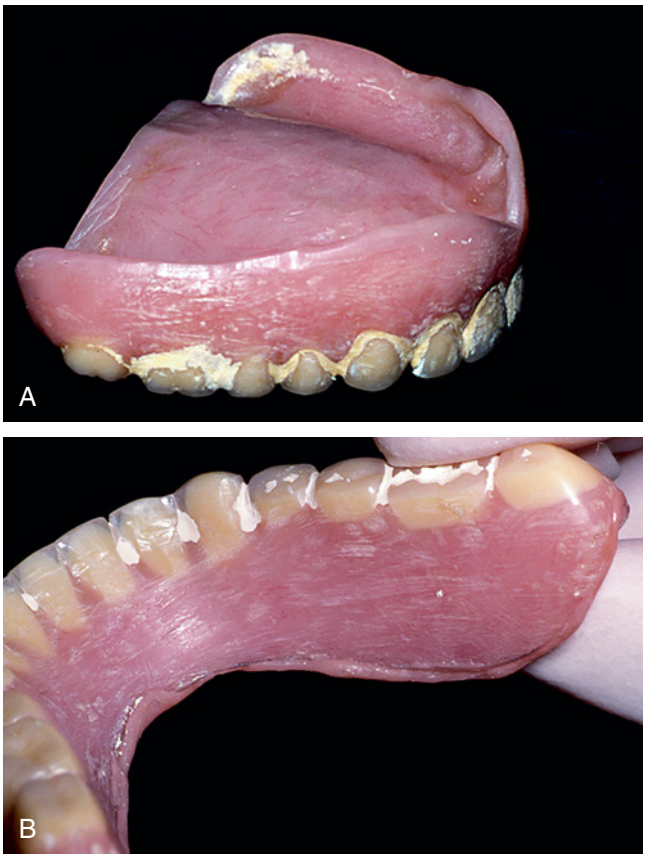


Figure 7-15 **A** and **B,** Calculus deposits on the polished, tissue surface and teeth of the complete dentures. The patient reported wearing the dentures at night. The underlying mucosa showed signs of inflammation.

protein-rich saliva and the microporous nature of polymeric bases, which facilitates microbial adhesions, plaque formation, and ensuing calculus deposition (Fig. 7-15). The organic portion of calculus consists of microproteins that bond the deposits to the denture surface, whereas the inorganic portion mostly contains calcium phosphate and calcium carbonate.

Oral biofilms consist of multiple bacterial strains and *Candida* species, which tend to adhere quite strongly to denture base materials, posing a significant clinical problem. Once formed, cells within the biofilm undergo profound phenotype changes, most notably increased resistance to antifungal agents. A sobering fact is that whereas chemical denture cleansers are capable of reducing biofilm adhesions, they cannot completely eliminate them.

Maintenance of adequate denture hygiene through mechanical or chemical methods or both is essential to minimize, and preferably eliminate, adverse tissue reactions. It must be an integral component of postinsertion patient care. The requirements of an ideal denture cleanser are provided in Box 7-22.

Box 7-22 Requirements of an Ideal Denture Cleanser

- It should be nontoxic, easy to remove, and harmless to the patient.
- It should be harmless to the denture base materials, denture teeth, and soft liners.
- It should also be able to dissolve all the denture deposits such as calculus.
- It should exhibit an antimicrobial effect.
- It should have a long shelf life and be inexpensive.

CLEANSING AND DISINFECTING

Denture cleansing and disinfecting techniques include mechanical brushing, using ultrasonic units, and microwave radiation in conjunction with various chemical cleansers. Dentures should be cleaned at least daily by soaking and brushing. Denture cleansers should only be used outside the mouth. The dentures should be thoroughly rinsed after soaking in cleansers prior to their reinsertion into the mouth.

Commonly available denture cleansing materials include the following:

- Oxygenating cleansers
- Alkaline hypochlorite solutions
- Dilute mineral acids
- Enzyme-containing materials, such as proteases

MECHANICAL TECHNIQUES

Patients are routinely instructed to clean their dentures by light brushing with a soft denture brush or a multifluted soft nylon brush with rounded ends and soap and water. When applied daily, denture brushing will effectively keep the dentures clean without abrading the methacrylate denture bases or teeth. The mechanical cleaning action of the brush is usually sufficient to remove loosely attached soft food debris, but it is ineffective for denture disinfection.

The removal of hard calculus deposits, plaque, and stains also requires more vigorous measures such as the daily use of immersion chemical denture cleansers or brush-on diluted acid cleansers.

The use of hard bristle brushes; forceful brushing; or abrasive dentifrices, such as calcium carbonate or hydrated silica, may cause abrasion of polymeric materials or result in scratches on their surface. The rough, irregular surfaces promote accumulation of deposits, increase staining and fouling with oral microorganisms, and dramatically compromise denture esthetics. Pastes with some gentle abrasives (sodium bicarbonate or PMMA particles) may be used. Similarly, patients should be strongly advised against using abrasive household kitchen or bathroom cleansers, such as scouring powder to clean their dentures.

CHEMICAL DENTURE CLEANSERS

The most commonly used commercial chemical denture cleansers for use with immersion techniques include alkaline peroxides and hypochlorite. Most immersion cleansers are effective in the removal of mucin, stains, and loosely attached food debris. Some can act as sanitizing agents.

Their advantages include full accessibility of the solutions to all areas of the denture, minimum damage from mishandling of the dentures by the patients, minimum abrasion of denture bases and teeth, and the technique is quite simple.

An important requirement in an immersion cleanser is to have no adverse effects on the properties of denture bases and liners. Increased surface roughness, breakdown in surface layers, bleaching, biodegradation, and softening of bases and teeth are among the reported adverse effects of disinfectants and cleansers. Dentists are advised to recommend denture cleansers and brushing techniques that are compatible with the type of base material, and particularly, the soft liner used. It is also crucial to instruct patients on soaking the dentures at the proper water temperature. Immersion of dentures in hot water has been linked to color changes and a decrease in the flexural strength of resin bases.

Oxygenating Cleansers

Alkaline peroxides or percarbonates are provided in powder and tablet forms. The material contains alkaline compounds, detergents, sodium perborate, and flavoring agents. When mixed with water, sodium perborate decomposes, releasing peroxides that in turn decompose, releasing oxygen. Cleansing is a result of the oxidizing ability of the peroxide decomposition and from the effervescent action of the evolved oxygen. This effectively breaks down, dissolves, and floats away organic deposits and kills microorganisms, without adversely affecting the base materials.

Peroxides are not as effective though in removing heavy calculus deposits. Some are not compatible with soft denture liners.

Overnight immersion of dentures in an alkaline peroxide solution is a safe effective method of denture cleaning and sterilization, particularly among geriatric or disabled patients whose limited manual dexterity may deter them from using mechanical brushing techniques.

Hypochlorite Solutions

Diluted household bleaches (sodium hypochlorite) are commonly used as denture cleansers for removing plaque and light stains, and they are capable of killing denture-adherent organisms. One technique involves the immersion of the dentures in a solution of one part of 5% sodium hypochlorite in three parts of water (1:3 water) followed by light brushing.

Alternatively, the denture is immersed in a solution containing 1 teaspoon of hypochlorite (Clorox) and 2 teaspoons of a glassy phosphate (Calgon) in half a glass of water to help control calculus and heavy stains.

Alkaline hypochlorite is not recommended for dentures fabricated from cast base metal alloys. The chlorine ions can result in corrosion and darkening of these metals. Concentrated hypochlorite solutions also should not be used because prolonged use may alter the color of the denture base resins. Bleaches may eventually discolor soft denture liners, particularly silicones. For that reason, placement of dentures in sodium hypochlorite solutions for periods longer than 10 minutes should be avoided. The importance of avoiding soaking dentures in hot or boiling water should be stressed to the patient to avoid distortion of the denture bases.

OTHER TECHNIQUES AND MATERIALS

Ultrasonic Units

Sonification provides vibrations that could be used to clean dentures. When using this technique, the denture is placed into a cleaning unit, which is filled with a soaking chemical

agent supplied by the manufacturer. The cleansing action of the soaking agent is supplemented by the mechanical debriding action of the ultrasonic vibrations. This in turn creates areas of vacuum next to the denture surface and thus dislodges and dispenses debris. Despite its effectiveness, this technique may not completely remove plaque depositions on the denture surface. However, recent studies have established that sonification significantly decreased the fungal burden on removable prostheses; however, its high costs and tendency to damage the denture surfaces limits its use. It is mostly available for use in institutions such as nursing homes and hospitals.

Dilute Acids

Citric acid, isopropyl alcohol, hydrochloric acid, or plain household vinegar is available to remove obstinate deposits. The cleanser is swabbed onto the denture surfaces using a brush. The materials attack the inorganic phosphate portion of denture deposits, thus reducing calculus accumulations. Vinegar also can kill microorganisms but less effectively than bleaching solutions. Brush-on materials must be used cautiously, and the denture must be rinsed thoroughly to avoid contact of the material with the skin and mucosa. Diluted acids also may cause corrosion of some alloys.

Enzyme-Containing Denture Cleansers

Mutanese and protease enzymes have been shown to reduce denture plaque significantly, with a daily 15-minute soak, particularly when combined with mechanical brushing of the dentures.

Silicone Polymers

These cleansers provide a protective coating, which interferes with bacterial adherence to the denture surface until their next application.

Microwave Radiation

Microwaves have been used to disinfect denture bases, mostly in conjunction with mechanical brushing. Microwave irradiation for 3 minutes at 650 W has been used to sterilize complete dentures contaminated with various bacteria. This microwave cycle has been shown to disinfect dentures and resilient liners without exerting deleterious effects on their physical and mechanical properties. Higher microwave temperatures caused a decrease in hardness and dimensional stability of the dentures more than immersion techniques.

The exact mechanism by which the electromagnetic waves kill microorganisms is still not fully understood. Studies have maintained that it is thermal in nature; others related it to the detrimental effect of microwaves on the metabolic activities of microbial cells.

Microwaves have been recommended for prevention of cross-contamination between patients and laboratory personnel. The dentures could be disinfected before they are inserted in the patient's mouth and before they are sent back to the laboratory.

ADVERSE REACTIONS TO DENTURE CLEANSERS

Persulfates are used in denture cleansers as components of the bleaching and cleaning processes. Persulfate has been linked to severe allergic reactions in denture wearers. Symptoms of these allergic reactions include irritation of the tissues, tissue damage, rash, hives, gum tenderness, breathing difficulties, and low blood pressure. As a result, the U.S. Food and Drug Administration (FDA) issued a requirement for the manufacturers of denture cleansers to revise their labeling (e.g., adding instructions that the cleanser should be used only when the dentures are outside the mouth) and consider alternative ingredients.

Other possible reactions as a result of the misuse of denture cleansers include damage to the esophagus, abdominal pain, tissue burns, breathing difficulties, seizures, bleaching of the oral tissues, internal bleeding, and vomiting. Dentists should be aware of these and instruct their patients accordingly.

SUMMARY OF CLEANSERS

Despite the abundant evidence that the use of chemical cleansers and brushing are effective in decreasing plaque adhesion and microbial counts of aerobes and anaerobes, there is still a lack of evidence in the dental literature concerning the comparative effectiveness of the different cleansing materials and methods. Few well-designed randomized controlled clinical trials are available that underscore the superiority of any technique over the other. Future research is needed to focus on comparisons between chemical and mechanical methods and to develop new cleansing materials and techniques capable of effectively reducing adherent microorganisms on denture bases and soft liners, while still having no impact on the topography of the resins as a means to reducing oral *Candida* infections in edentulous patients. A summary of the constituents of disadvantages of denture cleansers is provided in Table 7-6.

DENTURE ADHESIVES

One of the major contributing factors for the success of a complete denture is the perceived retention of the prosthesis by the patient. Retention is defined as the resistance to removal of the prosthesis in an opposite direction than that of its insertion. Factors involved in the retention of complete dentures are interfacial forces, adhesion, cohesion, oral and facial musculature, atmospheric pressure,

TABLE 7-6 CONSTITUENTS OF DISADVANTAGES OF THE VARIOUS TYPES OF DENTURE CLEANSERS

Cleanser	Main Constituent	Disadvantages
Oxygenating cleansers	Alkaline perborate	Do not easily remove heavy calculus deposits Harmful to soft liners
Hypochlorite solutions	Dilute sodium hypochlorite	May bleach denture materials May discolor soft liners May corrode base-metal alloys Has unpleasant odor
Dilute acids	Hydrochloric acid	Corrosion of some alloys
	Citric acid/ isopropyl alcohol	Unpleasant odor
Denture cleansing powder/ paste	Abrasive agents	Abrasion of denture polymeric bases and teeth

undercuts, rotational insertion paths, and parallel walls and gravity (Table 7-7).

ADJUNCTIVE RETENTION BY USING DENTURE ADHESIVES

Commercially available denture adhesives are products that have the capacity to enhance treatment outcome by increasing retention of the prosthesis. It is important for dentists to be familiar with these products so they can be able to identify individuals who may benefit from their application and also to educate the patient about their proper use. The requirements of optimal denture adhesives are outlined in Box 7-23.

Denture adhesive refers to a commercially available, nontoxic, soluble material (powder, cream, or liquid) that is applied to the tissue surface of the denture to enhance denture retention, stability, and performance (see Box 7-23). Denture adhesive improves on the mechanisms already in place when the denture is worn. Adhesives enhance retention by optimizing the interfacial forces by increasing the adhesive and cohesive properties and viscosity of the medium interposing between the denture and its basal seat and minimizing gaps between the denture base and its basal seat. Adhesives are agents that readily adhere to both the tissue surface of the denture and the mucosal surface of the basal seat. The hydrated adhesives are more cohesive than saliva and physical forces intrinsic to the interposed adhesive medium resist dislodgment more successfully than would similar forces within unaltered saliva. In addition to increased viscosity of the interposed salivary medium, the hydrated adhesive swells when in contact with saliva and flows under pressure. This in turn reduces gaps between the denture base and the supporting oral tissues.

Currently, synthetic materials dominate the denture adhesive market. The most popular and successful products consist of mixtures of the salts of short-acting (carboxymethylcellulose or "CMC") and long-acting (polyvinylmethyl-ether maleate or "gantrez") polymers. In the presence of water, CMC hydrates and displays quick-onset ionic adherence to both dentures and mucous epithelium. The original fluid increases its viscosity and CMC increases in volume, thereby eliminating voids between the prosthesis and basal seat. These two actions markedly enhance the interfacial forces acting on the denture. Polyvinylpyrrolidone ("povidone") is another, less commonly used agent that behaves like CMC. Over a more protracted time course than necessary for the onset of hydration of CMC, gantrez salts hydrate and increase adherence and viscosity. The less soluble ("long-acting") gantrez salts also display molecular cross-linking, resulting in a measurable increase in cohesive behavior. This effect is significantly more pronounced and longer lived in calcium-zinc* gantrez formulations than in calcium-sodium gantrez. Unfortunately, all polymers are washed out by saliva; this dissolution is hastened by the presence of hot liquid.

Other components of denture adhesive are required to produce an adhesive with specific physical properties; petrolatum, mineral oil, and polyethylene oxide are included in creams to ease their placement. Silicon dioxide and calcium stearate are used in powders to minimize clumping. There are flavoring agents (menthol, peppermint), dyes, and preservatives.

INDICATIONS AND CONTRAINDICATIONS FOR DENTURE ADHESIVE

While objective comparison of chewing performance fails to show an improvement after use of adhesive, subjects report increased confidence and security in chewing with the use of denture adhesive. These adhesives can be beneficial with new denture wearers throughout the adaptation period. The reported improvement is usually product dependent, so trials with different adhesives until a preferred one is identified are usually required for improved patient satisfaction. Complaints about the material's texture in case of a powder and aftertaste of the materials escaping from underneath the denture base are the most common.

In light of lack of sound scientific evidence, denture adhesives are indicated when well-made complete dentures

*See adverse reactions section for further details of zinc-containing denture adhesives.

TABLE 7-7 CONTRIBUTING FACTORS TO THE RETENTION OF DENTURES

Interfacial force	Interfacial force is the resistance to separation of two parallel surfaces that is imparted by a film of liquid between them. It results from a thin layer of fluid that is present between two parallel planes of rigid material. It is dependent on the ability of the fluid to wet the oral mucosa and denture base. The salivary film between the denture base and the mucosa of the basal seat results in a retentive force by virtue of the tendency of the fluid to maximize its contact with both surfaces. It depends on the existence of a saliva/air interface at the terminus of the liquid/solid contact. Therefore it does not play as important a role in the retention of the mandibular denture as much as for the maxillary one because of the presence of saliva on both sides of the peripheral seal in the mandibular prosthesis. The force is proportional to the surface area of the prosthesis and the viscosity of the saliva. It is inversely proportional to the distance between the denture base and the basal seat. Therefore it is highly dependent on good adaptation of the denture base to the oral tissues.
Adhesion	Adhesion is the physical attraction of unlike molecules, such as saliva and the mucous membrane, through ionic forces between charged salivary glycoproteins and surface epithelium or the denture base resin. In patients with xerostomia, the denture base is adhering to the dry mucous membrane in a significantly less effective manner. Nonalcoholic oral rinses should be used by these patients. The retention is proportionally related to the surface area covered by the prosthesis.
Cohesion	Cohesion is the physical attraction of like molecules for each other, such as within the saliva layer. Saliva is not very cohesive, so the retention forces achieved by cohesion are lower than retention from interfacial forces and adhesion. These forces can be enhanced by the use of denture adhesives that modify the interposed saliva. While thick, high mucin–content saliva is more cohesive than thin watery saliva, it will result in reduced retention because of the increased thickness of the film that results in reduced interfacial retention forces.
Oral and facial musculature	Musculature provides supplementary retentive forces, provided that the prosthetic teeth are positioned in the "neutral zone" between the cheeks and tongue and the polished surfaces of the dentures are properly shaped. Therefore the shape of the buccal and lingual flanges must conform to the musculature to fit against the denture and thereby reinforce the border seal. The base of the tongue also may serve as an additional retentive force for some patients.
Atmospheric pressure	Atmospheric pressure may act to resist dislodging forces applied to dentures if the dentures have an effective seal around their borders. It is also called "suction" (negative pressure), which forms as the result of dislodgment forces in the presence of peripheral seal. In the absence of forces, there is no suction. The retention achieved caused by atmospheric pressure is directly related to the area that is covered by the denture.
Undercuts, rotational insertion paths, and parallel walls	Modest undercuts combined with the relative resiliency of the mucosa and submucosa can enhance retention of the prosthesis. Deep undercuts are less beneficial than modest ones because of the limited resiliency of the supported tissues, which results in limited contact area with the denture base. Undercuts are defined as such if they exist in relation to a linear path of insertion. In some cases, the denture can be seated first in the undercut (relative to the linear path of insertion) and then rotated and brought into close proximity with the basal seat. The so-called "undercut" provides resistance to vertical displacement of the prosthesis. Prominent alveolar ridges with parallel buccal and lingual walls increase retention by increasing the surface area between denture and mucosa and thereby maximizing interfacial and atmospheric forces.
Gravity	In an upright position of the patient, gravity may act as a retentive force for the mandibular denture but as displacing force for the maxillary one. In most cases, the gravitational force is very minimal in comparison with other forces applied on the dentures. Cast metal base may theoretically increase the retention of the mandibular prosthesis because of its increased mass, but its benefits should be highly weighted against its limitations.

Box 7-23 Requirements of an Ideal Denture Adhesive

- It should be biocompatible and nontoxic.
- It should be easy to remove, clean, and replace.
- It should cause no damage to the denture base materials and soft liners.
- It should exhibit antimicrobial properties.
- It should have a long shelf life and be inexpensive.

do not satisfy a patient's perceived retention and stability expectations, since this is the major factor for successful treatment outcome irrespective of the underlying reasons. While these patients should be considered for implant-supported prostheses, this treatment modality is not always feasible for multiple reasons (e.g., health, financial, local factors). Patient populations who can benefit from this strategy include patients with salivary dysfunction or neurological disorders and those who have undergone resective surgical or traumatic modifications of the oral cavity. Another group who can benefit from denture adhesive is made up of patients who have xerostomia due to medication side effects, a history of head and neck irradiation, systemic disease, or disease of the salivary glands.* The use of denture adhesive can compensate for the compromised retention in the absence of healthy saliva and has the potential to reduce dislodgment of the prosthesis and the onset of ulcerations. Patients with xerostomia must be educated, however, that the adhesive-bearing denture will need to be deliberately moistened (e.g., with tap water) before it is seated in the otherwise dry mouth to initiate the actions of the material.

APPLICATION OF DENTURE ADHESIVES

Obtaining the greatest advantage from the use of an adhesive product is dependent on its proper usage; the dentist should educate the patient about denture adhesives: their use, abuse, advantages, disadvantages, and available choices.

- The denture's tissue surfaces should be cleaned and dried before application of the adhesive. A proper amount of adhesive should be used. For the maxillary denture, three or four pea-sized increments of the adhesive cream can be applied to the anterior ridge, midline, and palate. For the mandible, three pea-sized increments to different areas of the base should be sufficient. When using powder adhesive, the base of the denture should be wet before application. Pad adhesives should have the correct size and be trimmed to fit the shape of the denture, if needed.
- The denture should be seated independently and held in place firmly for about 10 seconds. Excess adhesive should then be removed. The patient then should bite firmly, and any further excess should be removed as well.
- Daily removal of adhesive product from the tissue surfaces of the denture is an essential. This is accomplished by letting the prosthesis soak in water or soaking solution overnight. If soaking is not possible before new adhesive material needs to be placed, removal is facilitated by running hot water over the tissue surface of the denture while scrubbing with a suitable hard-bristle denture brush. Clinical studies of mucosal tissues underlying adhesive-bearing dentures reveal lessened inflammation in patients who perform adequate denture hygiene daily.
- Discomfort or lack of retention will not be improved by placing copious amounts of adhesive under the denture; when pain and discomfort exist, the patient should be educated that these should be addressed by the dentist. A gradual increase in the quantity of adhesive required for acceptable fit of the denture is also a clear signal to seek professional care.

ADVERSE REACTIONS TO DENTURE ADHESIVE

There have been virtually no longitudinal reports of local tissue reactions to denture adhesive products. However, there have been several reports that excess of zinc intake from denture adhesive results in bone marrow suppression (myelopolyneuropathy and pancytopenia). These hematologic abnormalities are due to zinc-induced copper deficiency; copper supplementation with removal of the external zinc source, which was identified as zinc-containing denture adhesive, promptly resolved the symptoms. Copper deficiency has the potential to induce neurological disorders in humans and animals, but this requires relatively long duration of exposure to zinc. Zinc-containing formulations of dental adhesives are being phased out of the market; however, the adverse effects resulting from improper use of denture adhesive emphasize the importance of patient education when using these materials.

SUMMARY

The premise in preparing this review chapter is that dentists should possess sufficient knowledge of the properties of the different materials they deal with, so that they can exercise prudent judgment in their selection. The process is hopefully based on evidence-based information plus large scale, long-term clinical trials to ensure treatment efficacy and effectiveness. The profession clearly needs more concise definitions of biocompatibility issues together with more

*__Note:__ It must be emphasized that a denture adhesive is not indicated for the retention of improperly fabricated or poorly fitting prostheses.

information to provide researchers with alternative polymeric chemistries that can be used to produce a new generation of materials. These developments plus improvement in current techniques will ensure favorable oral tissue reactions and reduce the inherent biodegradability of many of the materials used in the fabrication and maintenance of complete dentures.

Bibliography

Athar Z, Juszczyk AS, Radford DR, et al: Effect of curing cycles on the mechanical properties of heat-cured acrylic resins, *Europ J Prosthod Rest Dent* 17(2):58-60, 2009.

Au AR, Lechner SK, Thomas CJ, et al: Titanium for removable partial dentures (III): 2-year clinical follow-up in an undergraduate program, *J Oral Rehabil* 27(11): 979-985, 2000.

Balkenhol M, Haunschild S, Erbe C, et al: The effect of prolonged setting time on permanent deformation of elastomeric impression materials, *J Prosthodont Dent* 103(5):288-294, 2010.

Benting DG, Pesun IJ, Hodges J: Compliance of resilient denture liners immersed in effervescent denture cleansers, *J Prosthodont* 14(3):175-183, 2005.

Bettencourt AF, Neves CB, De Almeida MS, et al: Biodegradation of acrylic-based resins. A review, *Dent Mater* 26(5):e171-e180, 2010.

Blagojevic V, Murphy VM: Microwave polymerization of denture base materials. A comparative study, *J Oral Rehabil* 26:804-808, 1999.

Boscato N, Radavelli A, Faccio D, et al: Biofilm formation of *Candida albicans* on the surface of a soft denture lining material, *Gerontology* 26(3):210-213, 2009.

Brozek R, Rogalewicz R, Koczorowski R, et al: Influence of denture cleansers on the release of organic compounds from soft lining materials, *J Environ Monit* 10(6):770-774, 2008.

Busscher HJ, Rinastiti M, Siswomihardjo W, et al: Biofilm formation on dental restorative and implant materials, *J Dent Res* 89(7):657-665, 2010.

Chung Kh, Chung CY, Chan DCN: Effects of pre-processing treatments of acrylic teeth on bonding to the denture base, *J Oral Rehabil* 35(4):268-275, 2008.

Cunha TR, Regis RR, Bonatti MR, et al: Influence of incorporation of fluoroalkyl methacrylates on roughness and flexural strength of a denture base acrylic resin, *J Appl Oral Sci* 17(2):103-107, 2009.

Da Silva L, Martinez A, Rilo B, et al: Titanium for removable denture bases, *J Oral Rehabil* 27(2):131-135, 2000.

Darvell BW: *Materials science for dentistry*, ed 9, Boca Raton, Florida, 2009, Woodhead Publishing Ltd, and CRC Press LLC, pp 108-125, 163-195.

Dovigo LN, Pavarina AC, Ribeiro DG, et al: Microwave disinfection of complete dentures contaminated *in vitro* with selected bacteria, *J Prosthodont* 18(7):611-617, 2009.

Felton D, Cooper L, Duqum I, et al: Evidence-based guidelines for the care and maintenance of complete dentures: a publication of the American College of Prosthodontists, *J Prosthodont* 20(Suppl 1): S1-S12, 2011.

Finer Y, Santerre JP: Analysis of human saliva for esterase activity and its association with the biodegradation of dental composite materials, *J Dent Res* 83(1):22-26, 2004.

Ghazal M: Wear of denture teeth and their human enamel antagonists, *Quint Int* 41(2):157, 2010.

Hedera P, Fink JK, Bockenstedt PL, et al: Myelopolyneuropathy and pancytopenia due to copper deficiency and high zinc levels of unknown origin, *Arch Neurol* 60:1303-1306, 2003.

Jagger R: Lack of evidence about the effectiveness of the different cleaning methods, *Evidence-based Dent* 10(4):109, 2009.

John J, Gangadhar SA, Shah I: Flexural strength of heat-polymerized poly methyl methacrylate denture resin reinforced with glass, aramid or nylon fibres, *J Prosthet Dent* 86(4):424-427, 2001.

Jose A, Coco BJ, Milligan S, et al: Reducing the incidence of denture stomatitis, are denture cleansers sufficient? *J Prosthodont* 19(4):252-257, 2010.

Kim H, Brewer JD, Monaco E: Internally weighted mandibular denture fabrication using a processed denture base, *J Prosthodont Dent* 102(2):123-125, 2009.

Kimoto S, Yamamoto S, Shinomiya M, et al: Randomized controlled trial to investigate how acrylic-based resilient liners affect masticatory ability of complete denture wearers, *J Oral Rehabil* 37(7):553-559, 2010.

Malmström HS, Mehta N, Sanchez R, et al: The effect of two different coatings on the surface integrity and softness of a tissue conditioner, *J Prosthet Dent* 87(2):153-157, 2002.

Marra J, Desouza RF, Barbosa DB, et al: Evaluation of the bond strength of denture base resins to acrylic resin teeth: effect of thermocycling, *J Prosthodont* 18(5): 438-443, 2009.

McCabe JF, Carrick TE, Kamohara H: Adhesive bond strength and compliance for denture soft lining materials, *Biomaterials* 23:1347-1352, 2002.

Mese A, Guzel KG: Effect of storage duration on the hardness and tensile bond strength of silicone and acrylic resin-based resilient liners to a processed denture base, *J Prosthodont Dent* 99:153-159, 2008.

Nations SP, Boyer PJ, Love LA, et al: Denture cream: an unusual source of excess zinc, leading to hypocupremia and neurologic disease, *Neurology* 71(9):639-643, 2008.

O'Brien WJ: *Dental materials and their selection*, ed 4, Chicago, 2008, Quintessence Publishing Co, Inc, pp 75-90, 91-113.

Park SE, Blissett R, Susarla SM, et al: *Candida albicans* adherence to surface-modified denture resin surfaces, *J Prosthodont* 17(5):365-369, 2008.

Peracini A, Davi LR, de Queiroz N, et al: Effect of denture cleansers on physical properties of heat-polymerized acrylic resin, *J Prosthodont Res* 54(2):78-83, 2010.

Perezous LF, Stevenson GC, Flaitz CM, et al: The effect of complete dentures with a metal palate on *Candida* species growth in HIV-patients, *J Prosthodont* 15(5): 306-315, 2006.

Pero AC, Marra J, Paleari AG, et al: Measurement of interfacial porosity at the acrylic resin/denture tooth interface, *J Prosthodont* 19(1):42-46, 2010.

Phoenix RD: Denture base resins. In Anusavice KJ, editor: *Phillips' science of dental materials*, ed 11, St Louis, 2003, WB Saunders, pp 721-757.

Phunthikaphadr T, Takahashi H, Arksornnukit M: Pressure transmission and distribution under impact load using artificial denture teeth made of different materials, *J Prosthodont Dent* 102(5):319-327, 2009.

Powers JM, Sakaguchi RL: *Craig's restorative dental materials*, ed 12, St Louis, 2006, Mosby Elsevier, pp 269-312, 513-553.

Powers JM, Wataha JC: *Dental materials, properties and manipulation*, ed 9, St Louis, 2008, Mosby Elsevier, pp 172-195, 286-309.

Salinas TJ: Treatment of edentulism: optimizing outcomes with tissue management and impression techniques, *J Prosthodont* 18(2):97-105, 2009.

Shay K: Denture hygiene. A review and update, *J Contemp Dent Pract* 1(2):28-41, 2000.

Shen C: Impression materials. In Anusavice KJ, editor: *Phillips' science of dental materials*, ed 11, St Louis, 2003, WB Saunders, pp 205-254.

Shibayama R, Filho HG, Mazaro JVQ, et al: Effect of flasking and polymerization techniques on tooth movement in complete denture processing, *J Prosthodont* 18(3): 259-264, 2009.

Stober T, Henninger M, Schmitter M, et al: Three-body wear of resin denture teeth with or without nanofillers, *J Prosthodont Dent* 103(2):108-117, 2010.

Stober T, Johnson GM, Schmitter M: Accuracy of the newly formulated vinyl siloxane elastomeric impression material, *J Prosthodont Dent* 103(4):228-239, 2010.

Taguchi N, Murata H, Hamada T, et al: Effect of viscoelastic properties of resilient denture liners on pressures under dentures, *J Oral Rehabil* 28(11):1003-1008, 2001.

Takahashi Y, Chai T, Takahashi T, et al: The bond strength of denture teeth to denture base resins, *Int J Prosthodont* 13(1):59-65, 2000.

Takayama Y, Takishin N, Tsuchida F, et al: Survey on use of titanium dentures in Tsurumi University Dental Hospital for 11 years, *J Prosthodont Res* 53(2):53-59, 2009.

Tan HK, Woo A, Kim S, et al: Effect of denture cleansers, surface finish and temperature on Molloplast B resilient liner, color, hardness and texture, *J Prosthodont* 9(3):148-155, 2000.

Walker MP, Rondeau M, Petrie C, et al: Surface quality and long term dimensional stability of current elastomeric impression materials after disinfection, *J Prosthodont* 16(5):343-351, 2007.

Wataha JC : Biocompatibility of dental materials, In Anusavice KJ, editor: *Phillips' science of dental materials*, ed 11, St Louis, 2003, WB Saunders, pp 171-201.

Clinical Protocols for Diverse Treatment Scenarios

PART IV

Maxillary and Mandibular Substitutes for the Denture-Bearing Area

CHAPTER 8

Rhonda F. Jacob, George Zarb

Dentists must understand the maxillary and mandibular tissues as they relate to maintaining support, stability, and retention of the dentures. Dentures contact mucosa with a continuum of compressibility and movement that varies between each arch, among areas within the arch, and among patients. Contact and extension of the static intaglio and cameo surfaces of the dentures is a composite of the adjacent tissues at rest and in function. Short-term and long-term health of the contacting tissues is influenced by the methods used to capture these tissues and the final adaptation of the denture bases in function. Maximum extension of the denture base increases surface area and spreads the "pressure" of mastication and tooth contacts during swallowing over a greater surface area. One can regard the intaglio surface of a denture as comprising two areas: a stress-bearing (or supporting) area and a peripheral (or limiting) area.

ANATOMY OF SUPPORTING STRUCTURES

The foundation for dentures is made up of bone and covering soft tissues. The denture base rests on the mucous membrane, which serves as a cushion between the denture base and the supporting bone. Primary and secondary stress-bearing areas have been denoted in the maxilla and mandible (Box 8-1). The primary stress-bearing areas generally have thicker mucosa and/or underlying bone that is less subject to resorption because it is cortical bone. The residual ridge is generally a secondary stress-bearing area as it is made up of cancellous bone and is subject to resorptive remodeling after dental extraction and with long-term denture wear. The total area of support from the mandible is significantly less than from the maxillae. The average available denture-bearing area for an edentulous mandible is 14 cm^2, whereas for edentulous maxillae it is 24 cm^2. Therefore the mandible is less capable of resisting occlusal forces than the maxillae are, and extra care must be taken to maximize the available contact. Factors that influence the form and size of the supporting bone include the following:

- The original size and arch form before extractions
- The severity of periodontal disease
- Amount of alveoloplasty at the time of tooth extraction
- Forces developed by the surrounding musculature
- Forces accruing from the wearing of dental prostheses
- The relative length of time different parts of the jaws have been edentulous
- Unknown genetic predisposition to bone resorption

Box 8-1 Maxillary and Mandibular Stress-Bearing Areas

Maxillary
1° firm tuberosities
1° hard palate on either side of palatal raphe
2° alveolar ridge
2° rugae

Mandibular
1° buccal shelves
1° retromolar pads
2° alveolar ridge

MUCOUS MEMBRANE

The mucous membrane is composed of mucosa and submucosa. The submucosa is formed by connective tissue that varies in character from dense to loose areolar tissue and also varies considerably in thickness. The submucosa may contain glands, fat, or muscle fibers and transmits the blood and nerve supply to the mucosa. Where the mucous membrane is attached to bone, the attachment occurs between the submucosa and the periosteal covering of the bone.

In the edentulous person, the mucosa covering the hard palate and the crest of the residual ridge is classified as masticatory mucosa and is characterized by its well-defined keratinized epithelium and lack of tissue movement. The mucosa of the residual ridge is formed by keratinized stratified squamous epithelium and the adjacent narrow layer of connective tissue known as the lamina propria. These ridge crest tissues are from remnant gingival tissues and are excellent stress-bearing tissues. The width of this band of keratinized tissue varies with the height of the attached gingiva at the time of dental extraction. The surgeon should pay attention to maintain all of this available gingival tissue when closing the extraction sites. The mucous membrane covering the crest of the ridge in a healthy mouth is firmly attached to the periosteum of the bone by the connective tissue of the submucosa. The thin submucosal layer is still sufficiently thick to provide adequate resiliency to support the denture.

The quality of the attachment of the keratinized mucosa varies considerably, and with greater resorption of the cancellous residual ridge, the submucosa is loosely attached to the bone, creating an unfavorable denture situation. The soft tissue overlying the ridge may be moveable from buccal to lingual, especially in the mandible. The tissues also may become quite compressible over the ridge because of resorption of underlying bone. The thickness of the submucosal layer also is variable. When the submucosal layer is thin, the soft tissues will be less resilient, and the mucous membrane will be easily traumatized. When the submucosal layer is loosely attached to the periosteum or it is inflamed or edematous, the tissue is easily displaceable.

As the mucous membrane extends from the crest along the slope of the residual ridge to the vestibular reflection, it loses its firm attachment to the underlying bone. The more loosely attached mucous membrane in this region has a nonkeratinized or slightly keratinized epithelium, and the submucosa contains loose connective tissue and elastic fibers. This tissue does not withstand the forces of mastication as well as the mucous membrane covering the crest of the ridge.

Histologic studies of the effect of wearing dentures on the keratinization of the mucosa of the crest of the residual ridges and the palate have produced conflicting results. However, most studies indicate that wearing dentures does not seem to be harmful to the epithelium, but reduced thickness of the keratinized surface is noted. Cytologic studies indicate that increased amounts of keratinized material are present in edentulous ridges when the clinical quality of the dentures is good, an indication that well-fitting dentures may be important in maintaining the normal histologic condition of the mouth. Stimulation of the mucosa of the residual ridge through toothbrush physiotherapy also increases the presence of keratinized material. Histologically, removing the dentures from the mouth at night, for 6 to 8 hours, allows keratinization to increase and the signs of inflammation, evidenced in the submucosa, to be dramatically reduced.

RESIDUAL RIDGE

The shape and size of the residual alveolar ridge is dependent on the anatomic contour of the patient's dentate arch. Therefore U, V, and square arch forms are seen in the edentulous patient. After dental extraction, the width and height of the residual alveolar ridge change. In the first 6 to 12 months the resorption is greatest, but it continues at a reduced rate throughout life. If the patient has been edentulous for many years, the residual ridge may become small, and the crest of the ridge may lack a smooth, cortical bony surface under the mucosa. There may be large, nutrient canals and sharp bony spicules. Because the maxillary anterior alveolar ridge is proclined, the resorption of the ridge creates a smaller maxillary prosthetic base. The mandibular dentition is positioned significantly lingual to the basal bone of the mandible; therefore resorption of the residual ridge creates a denture-bearing area that is in a more buccal position with a flatter and wider mandibular prosthetic base. This is sometimes referred to as "outward positioning of the mandible and inward positioning of the maxillae." This change in the relationship of the ridges can make many patients' jaw relationships appear prognathic (Figs. 8-1 and 8-2). The ridge crest is a secondary supporting area. The lateral walls of the ridges are covered in the final denture because they give stability against lateral displacement and create the peripheral seal.

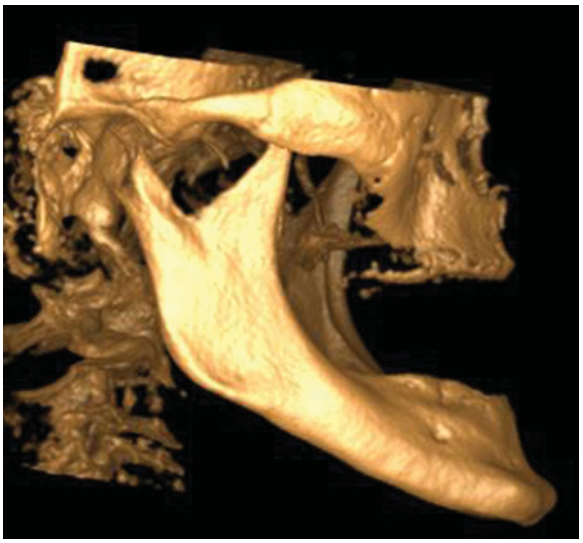


Figure 8-1 Three-dimensional reformation reveals a class I ridge relationship and moderate ridge resorption 3 years after dental extraction.

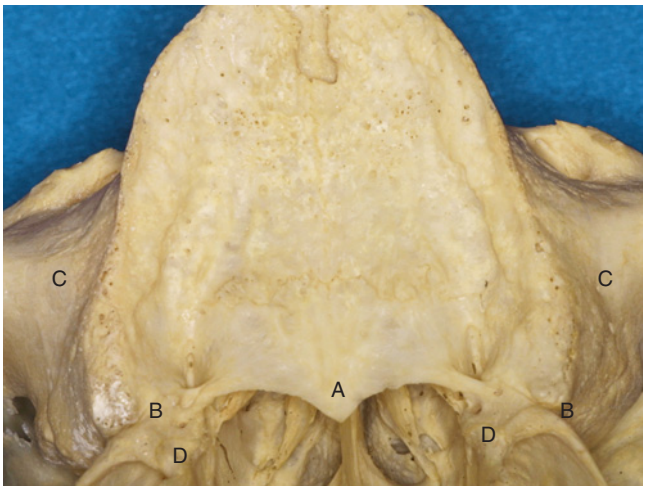


Figure 8-3 The residual ridge is extremely knife edged. In this patient the posterior nasal spine *(A)* extends posteriorly as far as the hamular notch *(B)*. The ridge has almost resorbed to the zygomatic process *(C)*. The hamulus *(D)* is medial and posterior to the notch.



Figure 8-2 Lateral cephalometric radiograph reveals severe resorption in the maxilla and mandible with loss of the alveolar ridge down to basal bone. The patient now has a class III ridge relationship and extensive loss of facial support.

Box 8-2 Areas Requiring Relief in Impression

2° stress-bearing areas
Palatal torus
Median palatal raphe
Mandibular tori
Retromylohyoid ridge
Undercuts or sharp boney prominence on ridges

MAXILLA

The ultimate support for a maxillary denture is the bone of the *two maxillae and the palatine bone*. The palatine processes of the maxillae are joined together at the medial suture (Fig. 8-3). The two palatine processes of the maxilla (anteriorly) and the palatine bone (posteriorly) form the foundation for the hard palate and provide considerable surface area and support for the denture.

The palate is covered by soft tissue of varying thickness, even though the epithelium is keratinized throughout. In the region of the medial palatal suture, the submucosa is extremely thin, with the result that the mucosal layer is in close contact with the underlying bone. For this reason, the soft tissue covering the medial palatal suture is nonresilient and may need to be relieved in the impression or in the denture to avoid trauma from the denture base (Box 8-2). Anterolaterally, the submucosa contains adipose tissue, and posterolaterally, it contains minor salivary gland tissue. This tissue is displaceable, and although it contributes to the support of the denture, the horizontal portion of the hard palate lateral to the midline provides the primary support area for the denture. In the area of the rugae, the palate is set at an angle to the residual ridge and is rather thinly covered by soft tissue and is a secondary stress-bearing area. The submucosa covering the incisive papilla and the nasopalatine canal contains the nasopalatine vessels and nerves.

The *incisive foramen* is located beneath the incisive papilla, which is situated on a line immediately behind and between the central incisors. It lies nearer to the crest of the ridge as resorption progresses (see Fig. 8-3). Thus the

location of the incisive papilla gives an indication as to the amount of resorption that has taken place. The nasopalatine nerves and blood vessels pass through the foramen, and care should be taken that the denture base does not impinge on them. The bilateral posterior palatine foramina often have a sharp, spiny overhanging edge that may irritate the soft tissues as a result of pressure from the denture.

The *tuberosities* often are dense fibrous connective tissues with minimal compressibility. In this situation, considerable support is offered to the denture. If maxillary teeth remain unopposed, the tuberosities and posterior alveolar arch can hypererupt below the occlusal plane, interfering with placement of the mandibular prosthetic dentition. When the maxillary teeth are extracted, the need for a surgical tuberosity reduction should always be evaluated.

The *torus palatinus* is a hard bony enlargement that occurs in the midline of the roof of the mouth in a small percentage of patients. The torus is covered by a thin layer of mucous membrane that is easily traumatized by the denture base, unless the area is relieved on the intaglio surface. With even a slight amount of resorption of the alveolar ridges, the denture will rest heavily on the torus, disrupting previous retention. Often disclosure of the torus with pressure paste and minor adjustment will improve the retention again. If the torus extends posteriorly to the vibrating line, it may need to be surgically reduced in order to achieve a posterior palatal seal and adequate denture retention.

PERIPHERAL BORDER TISSUES AND CONTOURS

The limiting structures of the upper denture can be divided into three areas: (1) the labial vestibule, which runs from one buccal frenum to the other on the labial side of the ridge; (2) the right and left buccal vestibules, which extend from the buccal frenum to the hamular notch; and (3) the vibrating line, which extends from one hamular notch to the other across the palate (Fig. 8-4). The mucosa of the vestibular spaces is classified as lining mucosa. It is normally a nonkeratinized layer with loose submucosa and an elastic lamina propria. This mucosa forms the covering of the lips and cheeks, the alveololingual sulcus, the soft palate, the ventral surface of the tongue, and the unattached gingiva found on the slopes of the residual ridges.

The *labial vestibule* is divided into a left and right labial vestibule by the labial frenum, which is a fold of mucous membrane at the median line. It contains no muscle and has no action of its own. It starts superiorly in a fan shape and converges as it descends to its terminal attachment on the labial side of the ridge. The labial notch in the labial flange of the denture must be just wide enough and just deep enough to allow the frenum to pass through it as the patient moves the upper lip. The main muscle of the lip, which forms the outer surface of the labial vestibule, is the *orbicularis oris*. It receives support from the labial flange and the position of the anterior teeth. The fibers of the orbicularis

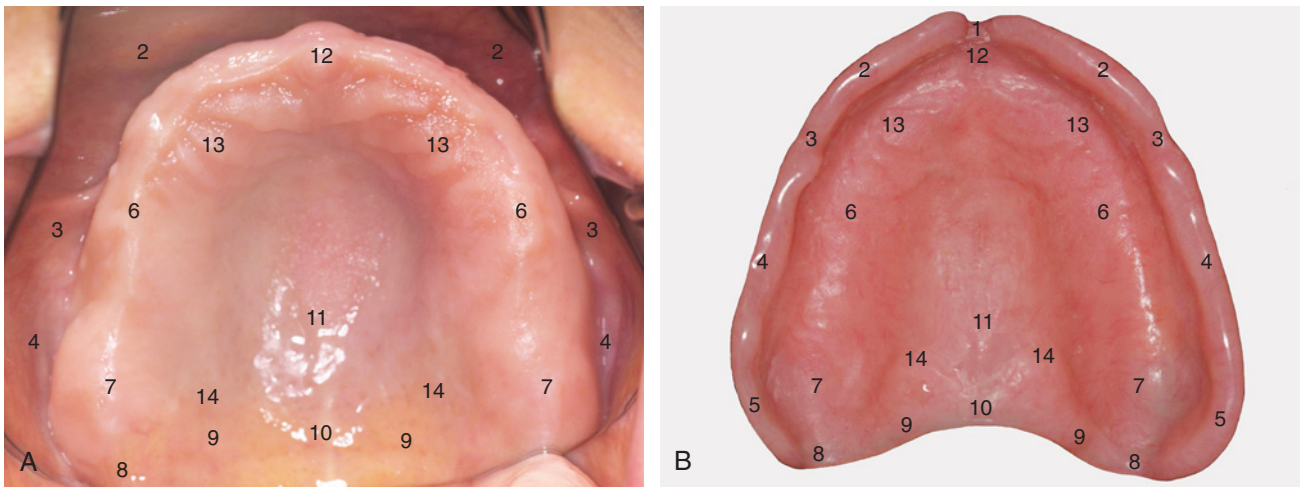


Figure 8-4 **A,** Maxilla: *1,* labial frenum (not visible); *2,* labial vestibule; *3,* buccal frenum; *4,* buccal vestibule; *5,* coronoid bulge; *6,* residual alveolar ridge; *7,* maxillary tuberosity; *8,* hamular notch; *9,* posterior palatal seal region; *10,* foveae palatinae; *11,* median palatine raphe; *12,* incisive papilla; *13,* rugae; *14,* displaceable soft and hard palate. **B,** Maxillary denture shows the corresponding landmarks: *1,* labial notch; *2,* labial flange; *3,* buccal notch; *4,* buccal flange; *5,* coronoid contour; *6,* alveolar groove; *7,* area of tuberosity; *8,* pterygomaxillary seal in area of hamular notch; *9,* area of posterior palatal seal; *10,* foveae palatinae; *11,* median palatine groove; *12,* incisive fossa; *13,* rugae; *14,* "butterfly" outline of posterior palatal seal.

oris pass horizontally through the lips and anastomose with the fibers of the buccinator muscle. Because the fibers run in a horizontal direction, the orbicularis oris has only an indirect effect on the extent of the denture. The *buccal frenum* forms the dividing line between the labial and buccal vestibules. The frena may be a single or double fold or even a broad-fan shape. The levator anguli oris muscle attaches beneath the frenum, affecting its position. The orbicularis oris pulls the frenum forward, and the buccinator pulls it backward. Thus it requires more clearance for its action than the labial frenum does.

The *buccal vestibule* lies opposite the tuberosity and extends from the buccal frenum to the hamular notch. The size of the buccal vestibule varies with the contraction of the buccinator muscle, the position of the mandible, and the amount of bone lost from the maxilla. The size and shape of the distal end of the buccal flange of the denture must be adjusted to the ramus and the coronoid process of the mandible and to the masseter muscle. When the mandible opens or moves to the opposite side, the width of the buccal vestibule is reduced. When the masseter muscle contracts under heavy closing pressures, it reduces the size of the space available for the distal end of the buccal flange. The extent of the buccal vestibule can be deceiving because the coronoid process obscures it when the mouth is opened wide. Therefore it should be examined with the mouth as nearly closed as possible. This space usually is more superior than any other part of the border. The mucous membrane lining the buccal vestibule is similar to that lining the labial vestibule. Distal to the buccal frenum and palpable superior to the vestibule is the root of the zygoma, which is located opposite the first molar region. With increasing resorption of the residual ridge the denture may require relief over this area to prevent soreness of the underlying tissue.

The *hamular notch* forms the distal limit of the buccal vestibule; it is situated between the tuberosity and the hamulus of the medial pterygoid plate. It can be palpated with a mouth mirror or T-shaped burnisher (Fig. 8-5; see Fig. 8-3). The mucous membrane of the hamular notch consists of a thick submucosa made up of loose areolar tissue. The tensor veli palatini muscle runs horizontally through this notch, where it ends in an aponeurosis from the contralateral muscle. The muscle is attached to the horizontal shelves of the palatine bone. The pterygomandibular raphe, covered by mucosa, extends from the hamulus inferiorly into the retromolar pad of the mandible. The raphe moves forward when the mouth is opened wide and creates a vertical indentation in the posterior border of the denture distal to the tuberosities and may even flatten the denture border immediately lateral to the notch. These tissues in the notch should be displaced by the posterior palatal border of the denture to achieve a posterior palatal seal, but overextension causes trauma to the mucosa.

The *vibrating line* (Fig. 8-6) marks the beginning of motion in the soft palate when an individual says "ah," and the soft palate elevates. This motion is barely perceptible at the anterior of this line and is made up of the aponeurosis and muscle fibers of the tensor veli palatini muscles, glandular tissue, and mucosa, all of which can be displaced with the denture. Moving a few millimeters posteriorly, there is more motion and greater elevation of the soft palate. The vibrating line is more of an area and is always on the soft palate. Its lateral border terminates through the hamular notches. At the midline, it usually passes 1 to 2 mm anterior to the fovea palatinae. The distal end of the denture should extend to the vibrating line.

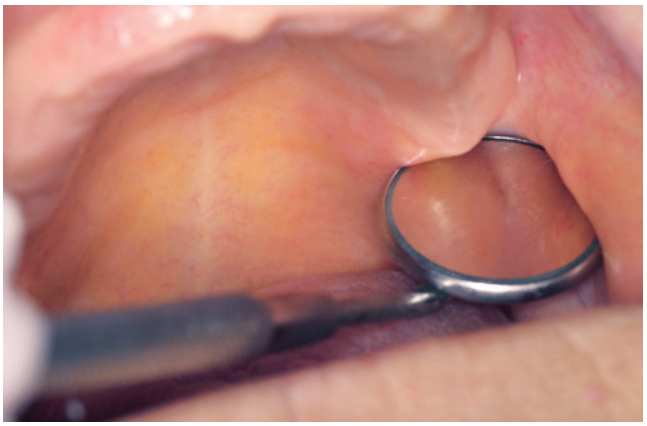


Figure 8-5 A mouth mirror or ball burnisher can be used to palpate the hamular notch and displaceable soft and hard palate. Slide the mirror posteriorly along the crest of the ridge and the tuberosity. The mirror will fall into the notch.

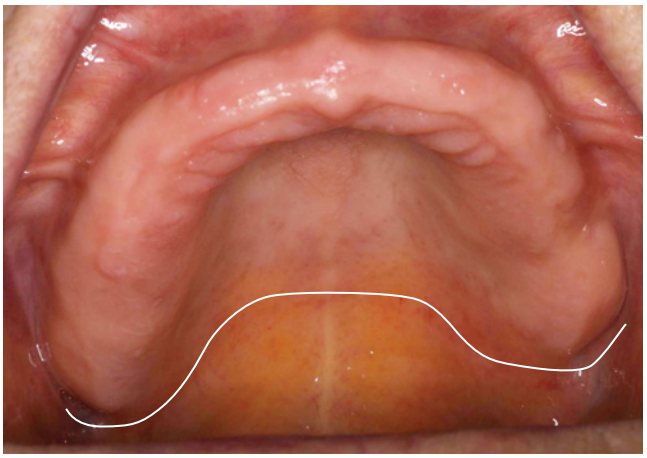


Figure 8-6 The vibrating line is located on the soft palate, and it elevates slightly when the patient says "ah." Anterior to this line there is no movement on phonation.

MANDIBLE

The *buccal shelf* is the area between the mandibular buccal frenum and the anterior edge of the masseter muscle. Medially it is bound by the crest of the ridge and laterally

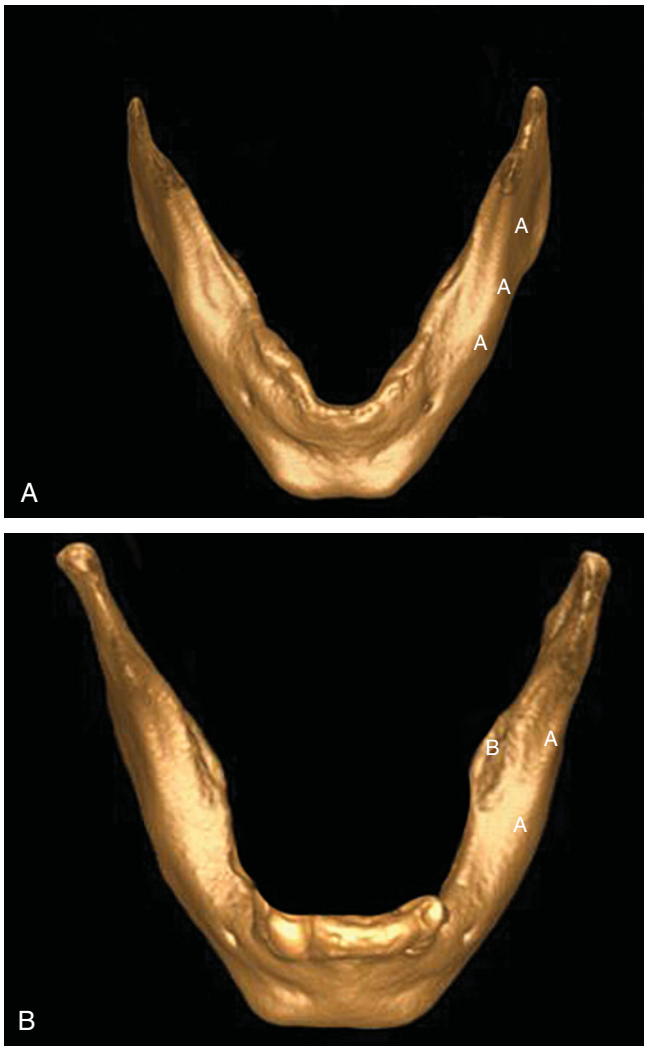


Figure 8-7 **A,** The buccal shelf is a dense cortical bone. The external oblique ridge *(A)* is the bony line where the buccinator muscle attaches. There is height of the alveolar ridge medial and superior to the external oblique ridge. **B,** This partially dentate patient has more resorption of the posterior alveolar ridge crest; therefore the mylohyoid ridge *(B)* and external oblique ridge *(A)* are now at the crest of the ridge. This denture intaglio surface would be flat rather than having the characteristic convex ridge contour.

by the boney external oblique ridge and distally by the retromolar pad (Fig. 8-7). The buccinator muscle fibers attach horizontally along the boney oblique ridge. As resorption of the ridge occurs, the buccal shelf does not resorb because of its muscle attachments on the posterior and lateral borders. The alveolar ridge of the mandible is significantly medial to the inferior border of the mandible; therefore, as the ridge resorbs, the denture-bearing surface becomes flatter and widens towards the buccal shelf. The shelf is dense cortical bone and lies at right angles to vertical occlusal forces, and is therefore a primary stress-bearing area



Figure 8-8 The sublingual and submandibular glands are above the crest of the severely resorbed ridge when the patient elevates the tongue and mylohyoid muscles. The denture will have compromised lateral stability.

for the denture. With resorption of the ridge, the moveable lingual tissues can come to lie on the superior aspect of the denture-bearing surface, making the adaptation of the patient a priority to denture success (Fig. 8-8).

The *mylohyoid ridge* (see Fig. 8-7) is a boney prominence along the lingual aspect of the mandible; the magnitude of the prominence varies among patients. Anteriorly the mylohyoid is attached to the inferior border of the mandible (Fig. 8-9), but continuing posteriorly the mylohyoid is attached to this ridge and is nearer the level of the alveolar ridge. The posterior aspect is usually most prominent near the retromolar pad and is present on the mandible at the same level as the external oblique ridge (Fig. 8-10). This posterior prominence often requires relief in the denture and may require surgical reduction if combined with a posterior torus.

The *mental nerve* exits the *mental foramen* below the alveolar ridge, but with continued resorption of the ridge, the mental foramen can become positioned at the crest of the ridge and be compressed by the denture. This causes pain or even altered sensation in the lip (Fig. 8-11).

The *genial tubercles* are a dense cortical prominence at the inferior border of the mandible at the lingual midline. They represent the muscle attachment of the genioglossus muscles. They only become relevant in the denture border when there is extensive resorption of the residual ridge (see Fig. 8-9, *B*)

Mandibular tori are lingual bilateral prominences of dense cortical bone in the premolar area, but they may extend posterior to the molar area. They may be covered with keratinized nonmobile tissue or nonkeratinized tissue that may be mobile. They usually require removal before a denture can be fabricated, or they will severely limit the extension of the denture in the floor of mouth. Smaller tori may only require relief in the denture.

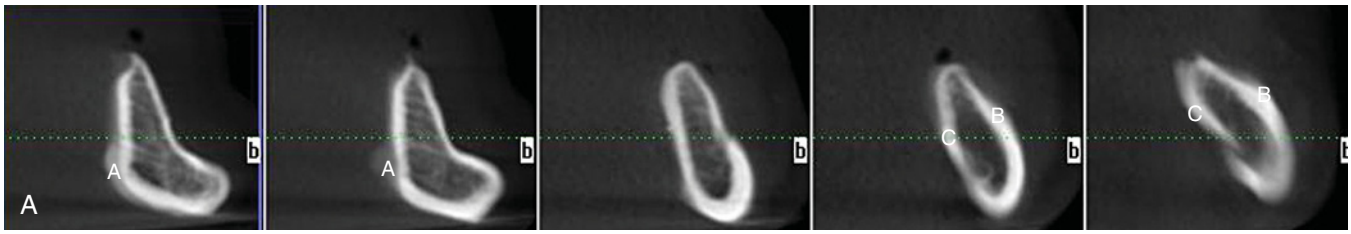




Figure 8-9 **A,** Genial tubercles *(A),* external oblique ridge *(B),* mylohyoid ridge *(C).* These serial sagittal cuts through the right side of the patient's mandible from anterior to posterior reveal the anterior attachment of the mylohyoid muscle low upon the genial tubercles, but moving posteriorly the mylohyoid attachment is parallel with the external oblique ridge. **B,** The view from inferior of the mandible of the same patient. The prominence of the mylohyoid ridge *(C)* towards the midbody and posterior extension can be very undercut, and the horizontal pull of the mylohyoid elevates and somewhat flattens the denture border and pushes the denture border medially. *A,* Genial tubercles.



Figure 8-10 The posterior buccal flange and posterior lingual flange are often the same length as the external oblique and mylohyoid ridge in this area, and are at the same level on the mandible. There can be some contact of the flange with the buccinator and the mylohyoid muscles, but both muscles shape the length of the flange.

PERIPHERAL BORDER TISSUES AND CONTOURS

The *labial vestibule* extends from the labial frenum to the buccal frenum. The mucolabial fold extends from the inner aspect of the lip to the mandible. The mentalis muscle inserts very close to the crest of the ridge in this area and limits the border extension in length and width. The frenum contains fibers of the orbicularis oris muscle. Both of these muscles are very active and opening the mouth wide will thin the dimensions of the denture border (Fig. 8-12).

The *buccal vestibule* extends posteriorly from the buccal frenum to the posterior lateral aspect of the retromolar pad. The denture is very wide in this area. The buccinator muscle extends from the modiolus anteriorly, and its fibers end in the pterygomandibular raphe and are attached laterally along the external oblique ridge. The fibers are horizontal to the denture, and depending on the vertical position of the mucobuccal fold, the denture may cover the entire external oblique ridge. The distobuccal border of the buccal vestibule is bordered by the vertical fibers of the masseter muscle, originating on the zygomatic arch, and attaching to the mandible lateral to the buccinator fibers. Occlusal forces activate the masseter muscle and cause a bulge in the buccinator muscle, creating the *masseteric notch* in the posterior lateral denture border. During border molding this muscle can be activated by pushing downward on the patient's chin while the patient attempts to close the mouth against this pressure (Fig. 8-13).

The distal extension of the denture (see Fig. 8-13) is limited by the ramus and the pterygomandibular raphe that is composed of buccinator fibers and the superior constrictor fibers. The sharpness of the internal oblique ridge (mylohyoid ridge) and the external oblique ridges meet at the ascending ramus. Contacting the ascending ramus with the denture border will traumatically trap tissues against the ramus. The retromolar pad is a triangular pad of tissue

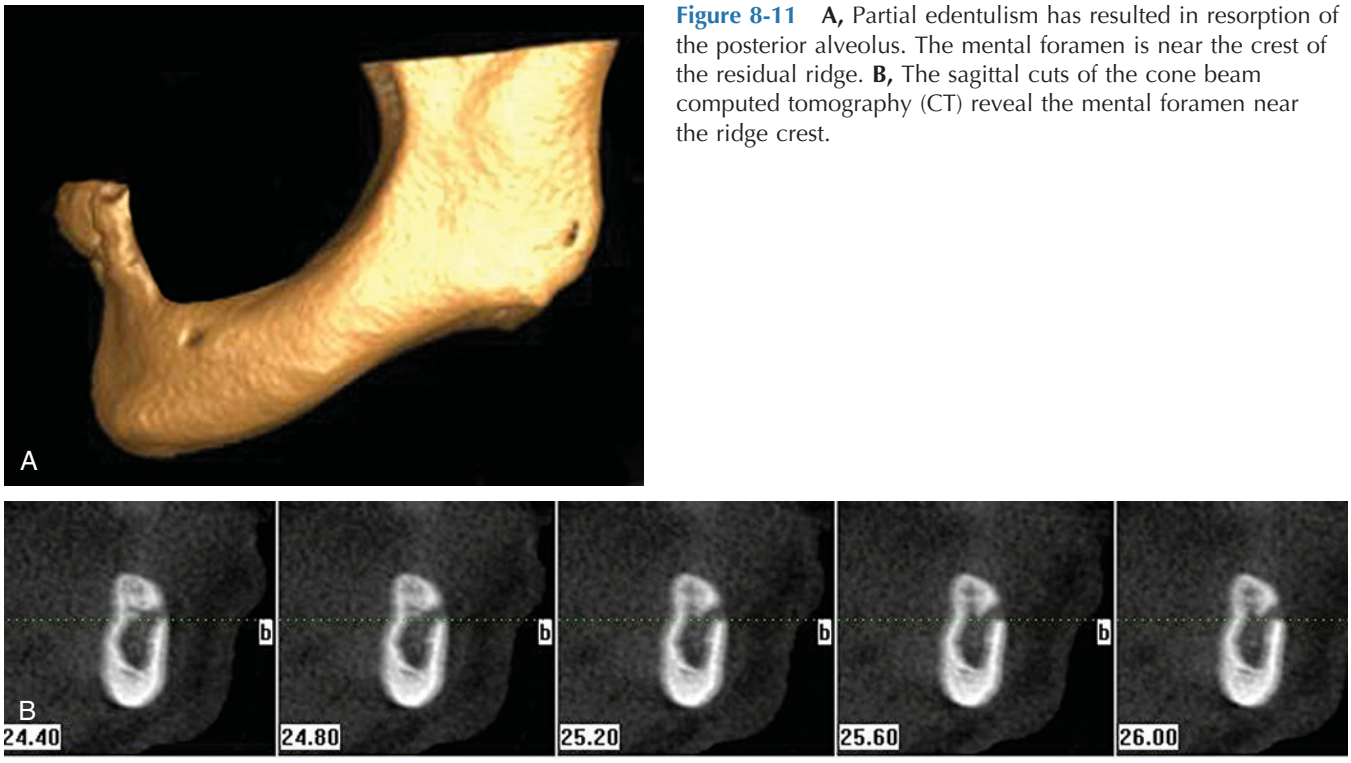


Figure 8-11 **A,** Partial edentulism has resulted in resorption of the posterior alveolus. The mental foramen is near the crest of the residual ridge. **B,** The sagittal cuts of the cone beam computed tomography (CT) reveal the mental foramen near the ridge crest.

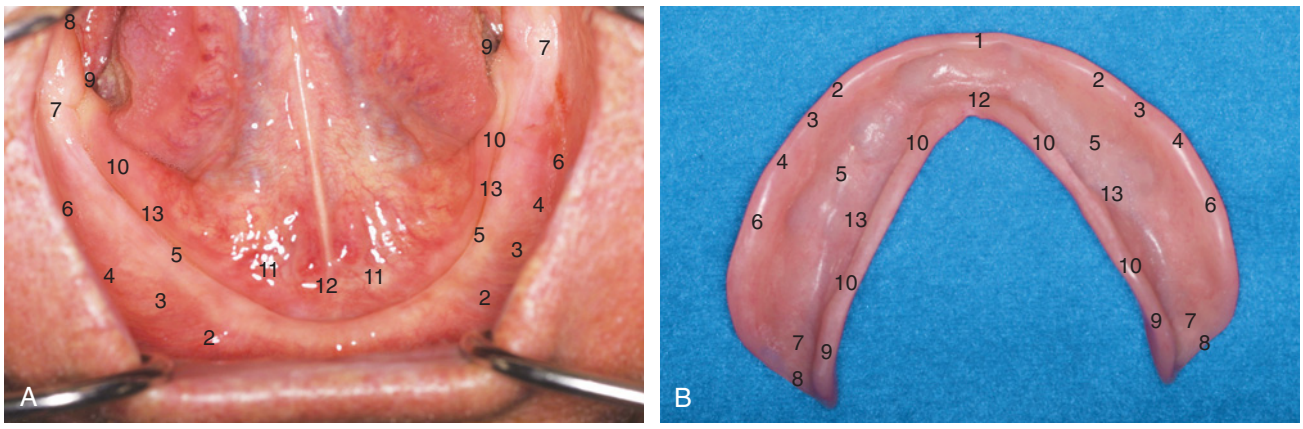


Figure 8-12 **A,** The anatomy and related denture form is noted here. *2,* labial vestibule; *3,* buccal frenum; *4,* buccal vestibule; *5,* residual alveolar ridge; *6,* buccal shelf; *7,* retromolar pad; *8,* pterygomandibular raphe; *9,* retromylohyoid fossa; *10,* alveololingual sulcus; 11, sublingual caruncles; *12,* lingual frenum; *13,* region of premylohyoid eminence. **B,** Mandibular denture revealing *1,* labial notch; *2,* labial flange; *3,* buccal notch; *4,* buccal flange; *5,* alveolar groove; *6,* buccal flange, which covers the buccal shelf; *7,* retromolar pad; *8,* pterygomandibular notch; *9,* lingual flange with extension into retromylohyoid fossa, 10, lingual flange; 12, lingual notch; 13, area of premylohyoid eminence.

at the distal end of the residual ridge. The anterior portion of the triangle is keratinized tissue of the remnant gingiva of the third molar called the pear-shaped pad. The posterior aspect of the triangle is composed of thin, nonkeratinized epithelium; loose connective tissue; glandular tissue; fibers of the temporalis tendon and of the buccinator and superior constrictor muscles; and the pterygomandibular raphe. The underlying bone is dense cortical bone because of the muscle attachments and is resistant to resorption. The denture should cover the retromolar pad because of the support and lack of long-term cortical bone resorption. To avoid displacement of the denture, the muscles should be activated during border molding by opening wide and closing against pressure (Fig. 8-14).

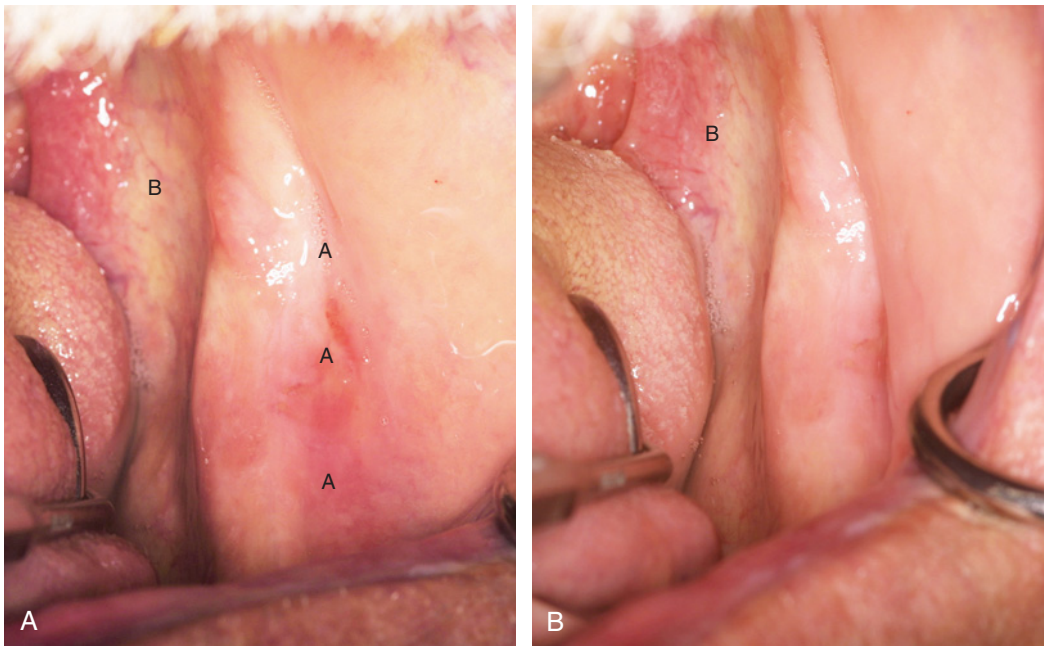


Figure 8-13 **A,** Cheek is retracted and the attachment of the buccinator muscle can be seen where it attaches along the external oblique line *(A)*. This patient also has a denture ulceration due to overextension of his existing prostheses. **B,** When the cheek is relaxed it can be seen that the horizontal fibers of the buccinator will lap over the external surface of the denture flange, aiding peripheral seal. The retromylohyoid fossa (*B*) is noted.



Figure 8-14 No extension was attempted in the retromylohyoid fossa because of the excellent ridge height and slight undercuts on the lingual of the ridge. The undercuts will require additional relief where the compound is showing through on the lingual borders. Negotiating the denture into the fossa would not be possible because of conflicting undercuts.

The lingual border is defined by the mylohyoid muscle along the entire length of the mandible. Posteriorly, resorption of the alveolar ridge effectively brings the internal oblique ridge and its muscle attachments to a position nearer the residual ridge crest. Along the lingual border the mylohyoid muscle is at right angles to the border, and it therefore flattens the border with its muscle action and also can slightly pull the border away from the boney lateral wall of the mandible. In the anterior, the muscle meets in the midline in a fan shape. The lingual border is a composite of the motion of the mylohyoid muscle. In the anterior the sublingual gland overlies the mylohyoid muscle. The denture border can be quite wide in the midbody where the mylohyoid begins to attach closer to the ridge crest. The raising of the tongue will allow the impression material to flow under the tongue slightly, and when the tongue retracts again, it rests on the denture border (Fig. 8-15). The tongue should be protruded to lick the upper and lower lip, and the lateral cheek. Pushing the tongue tip against the operator's thumb also can aggressively activate the anterior muscle attachments. Having the patient move the tongue beyond these limits is not really a functional movement and can decrease the lateral border extension of the denture, particularly when advanced resorption has already limited lateral mandible contact. The value of the border's maximum lingual border extension is lateral stability of the denture and reduction of food collection under the denture.

The mandible is usually undercut inferiorly and posteriorly to the posterior mylohyoid ridge and is called the *retromylohyoid fossa* (Figs. 8-16 and 8-17). The mylohyoid muscle no longer acts on this area of the border. The posterior border of this fossa is the mucosa covering the palatoglossus muscle and deep to that is the superior constrictor muscle. The denture flange turns laterally into the

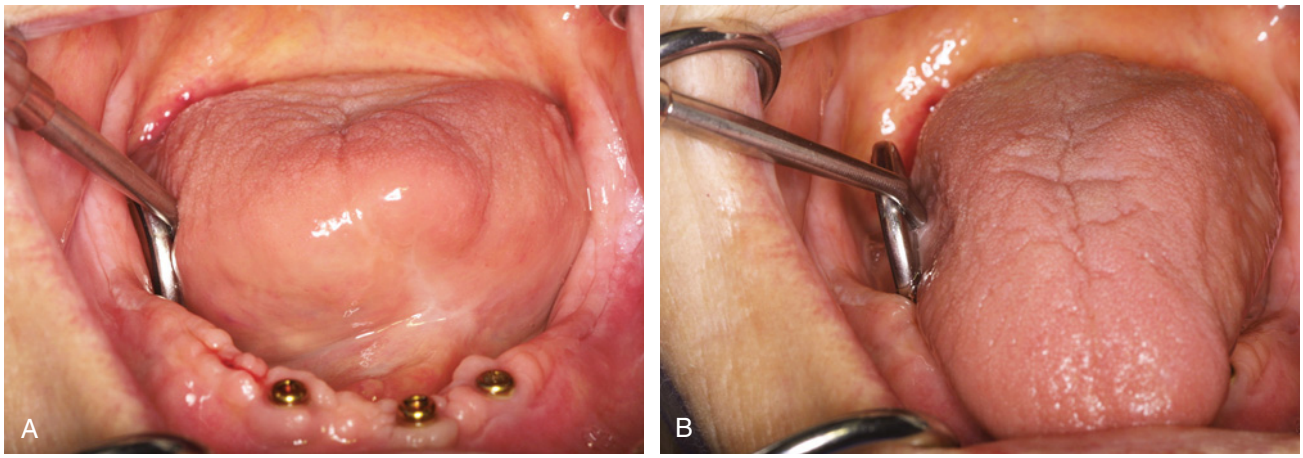


Figure 8-15 **A,** Use of a mirror in the posterior mylohyoid area and asking the patient to protrude the tongue will diagnose the ability to gain extension into the posterior mylohyoid area. The tongue should be protruded only to the lips. **B,** This patient has slight elevation of the mouth mirror.



Figure 8-16 Alginate impressions can easily extend into the retromylohyoid fossa for preliminary and final impressions.

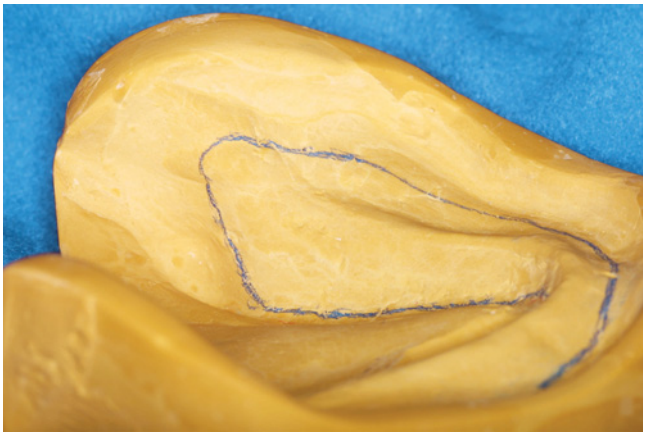
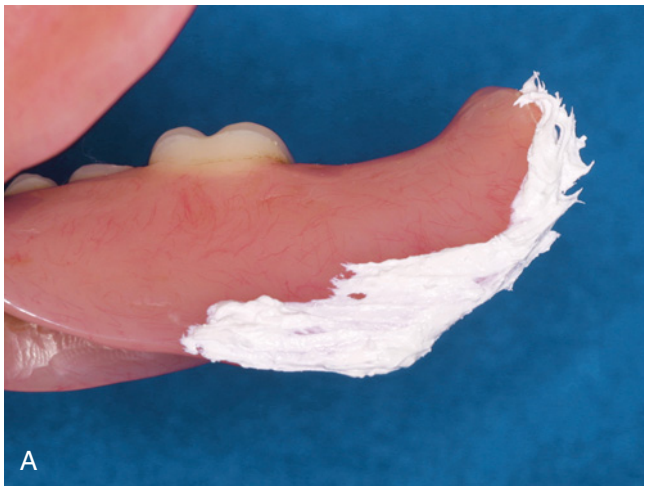


Figure 8-17 The denture border outline reveals the very overextended preliminary denture impression.

retromylohyoid fossa. This turning of the denture and the curvature in the anterior and midbody of the floor of the mouth is said to create an S shape, although it is not readily apparent in all denture impressions. The medial pterygoid muscle lies behind the superior constrictor muscle. Contraction of the medial pterygoid muscle can cause a bulge in the wall of the retromylohyoid curtain in the same way that contraction of the masseter muscle can cause a bulge in the buccinator muscle. Swallowing moves the superior constrictor and palatoglossus muscle forward, and denture patients may complain of pain on swallowing. Protruding the tongue also elevates the curtain in this area and will unseat the denture. Overextension in the fossa or along the mylohyoid muscle in a denture retained with implants may cause an ulcer because the denture cannot "unseat" (Fig. 8-18).

PRINCIPLES AND OBJECTIVES OF IMPRESSION MAKING

The objectives of impression making are to capture all potential denture-bearing surfaces and tissues to provide support, retention, and stability for the denture under function. The final denture base also should act as a foundation for improved appearance of the lips. A denture's retention is enhanced considerably if the denture extends peripherally to record the resiliency of the surrounding limiting structures, which includes creating appropriate length and width of the final denture borders. Although impression techniques, methods, and materials have varied over the years, they all comply with the impression axioms of using safe,





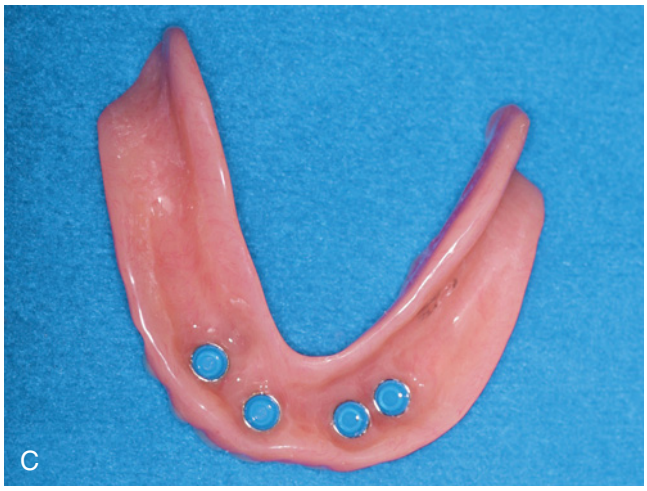


Figure 8-18 **A,** This patient complained of an overextension after delivery. It was evaluated with thick pressure paste. **B,** Because the patient had implants and the denture was maintained in position, this slight overextension caused discomfort. **C,** Considerable extension was achieved into the posterior mylohyoid area.

dimensionally stable materials and that the final denture base contours result from a thorough understanding of form and function.

To make an ideal impression, the following concepts should be adhered to, irrespective of the selected technique:

1. The tissues of the mouth must be healthy.
2. The impression should extend to include the entire basal seat within the limits of function of the supporting and limiting tissues.
3. If redundant tissue or boney projections of the ridge cannot be surgically removed, space for them must be created within the denture.
4. Proper space for the selected impression material should be provided within a properly fitting impression tray.
5. A guiding mechanism should be provided for correct positioning of the impression tray in the mouth.
6. A physiological type of border molding procedure should be performed by the dentist or by the patient under the guidance of the dentist.
7. The external shape of the impression must be similar to the external form of the complete denture.

IMPRESSION PROCEDURES

The dentist can make use of a combination of rigid, thermoplastic, and resilient materials used in various additive or subtractive techniques during the impression procedure. These variations in the working properties of these materials make it possible to devise different techniques for controlling the position and shape of the oral tissues. Some techniques are intended to record the shape of the tissues with a minimum of displacement; others are intended to displace the border tissues to a predetermined extent. Still others are devised to obtain controlled displacement of the tissues under the denture. Impressions that record the tissues with minimum displacement are described as mucostatic, whereas those that displace the tissues are classified as mucodisplacing. There is, however, no evidence to indicate that one technique produces better long-term results than another or that practitioners can perform a single technique throughout the entire impression-contacting surface due to skill, material forces, and differences in mucosal resiliency throughout the arch. The choice is made by the dentist on the basis of the oral conditions, concept of the function of the tissues surrounding the denture, and ability to handle the available impression materials.

Regardless of the type of impression being made, the tray is the most important part of the impression-making procedure. If the tray is too large, it will distort the tissues around the borders of the impression and will pull the soft tissues under the impression away from the bone, distorting the dimensions of the sulcus in the process. If it is too small, the border tissue will collapse inward onto the residual ridge. This too will distort the accurate recording of the

border extension of the denture and prevent the proper support of the lips by the denture flange. A properly formed tray enables the dentist to carry the impression material to the mouth and control it without distortion or with minimal distortion that can be corrected in the denture fabrication process.

Individual or custom trays have borders that can be adjusted so they control the movable soft tissues around the impression and do not distort them. At the same time, space can be provided inside the tray so that the shape of the tissues covering the denture-bearing area may be recorded with minimal or selective displacement in the primary denture-bearing areas. These requirements are difficult to achieve when making the impression with stock trays. Therefore most impression procedures involve making the preliminary impression in a stock tray. The resulting cast is used to construct a rigid custom tray with appropriate relief within the tray. The final impression is made with the custom tray.

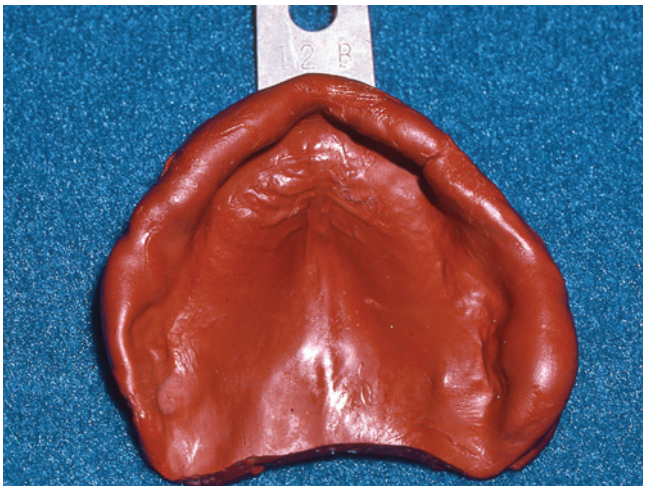


Figure 8-19 A compound preliminary impression of the maxilla. It can be modified to become a tray for border molding a final impression.

PRELIMINARY IMPRESSIONS: TRAYS, MATERIALS, TECHNIQUE

Stock trays are constructed in either metal or plastic and may be perforated or unperforated. Although they are available in a range of shapes and sizes, they rarely fit the jaws without tissue distortion. The space available in the mouth for the upper impression is studied carefully by observation of the width and height of the vestibular spaces with the mouth partway open and the upper or lower lip held slightly outward pulled against the tray. An edentulous stock tray that is approximately 5 mm larger than the outside surface of the residual ridge is selected. The dentist places the tray in the mouth and initially positions it by centering the labial notch of the tray over the labial frenum. In the maxilla, the distal extension covers to the vibrating line, allowing space and coverage of the tuberosities. The mandibular tray should extend to the ascending ramus.

The preliminary impression should be as accurate as possible and overextension of peripheral borders is preferred to underextension as ultimately a slightly underextended custom tray will be fabricated on this overextended preliminary cast. Using this strategy, the final impression procedure will be brief and require minimal addition of border material.

Therefore when the preliminary impression is made, it is advisable to select an impression material that has a relatively high viscosity, thereby allowing the material to compensate more easily for the deficiencies of the tray. The most suitable materials are alginate (irreversible hydrocolloid), silicone putty, or impression compound.

The *irreversible hydrocolloids* (see Fig. 8-16) detail accurately and are the most universally used impression materials for primary edentulous impressions. Because they do not absorb the mucous secretions from the palate, they can exhibit defects in the area of the palate. They must be poured immediately. The weight of the stone, if they are not supported by the borders of the tray, may be sufficient to distort the borders of the impression. Wax or compound may be added to the stock tray border before impression making to extend the borders. Also using a higher viscosity alginate will successfully carry the material into the peripheral areas that are the most difficult to capture, which is commonly the distal buccal of the maxilla and the mylohyoid fossa of the mandible.

Silicone putty impression material has a high viscosity. It will flow beyond the tray to compensate for underextension of the stock tray, and once set, it will support itself in this position. It exhibits some degree of elasticity and so will record undercuts with reasonable accuracy. Its high viscosity often records surface detail poorly.

Impression cake compound is a thermoplastic material with a high viscosity (Fig. 8-19). Like silicone putty, the material will flow beyond the tray to compensate for underextension and will maintain position after it is chilled. Therefore it is not necessary to correct any underextension of the stock tray before using this material. Also, additions can be made to it if part of the impression is deficient. Its high viscosity means that it records surface detail poorly. In addition, it is nonelastic and will cause trauma in severe boney undercuts, but it can often be rotated from these anatomic areas unless they are sharp and bilateral. This impression can be removed from the tray, the borders trimmed and heated with a torch, and the periphery successively molded to the correct width and depth. In addition, tissue undercuts and relief areas can be cut from the tissue surface of the tray. Stick compound can be added to the periphery in deficient areas, followed by an elastomeric impression material or impression wax, or some practitioners use the compound as the final impression. They

consider that the epithelial detail is not desired in the intaglio acrylic resin denture surface.

The wax and tray are covered with adhesive. To avoid voids and an underextended impression, less viscous alginate may require preloading with injection or wiping of material into the floor of mouth or posterior buccal vestibules of the maxilla. The loaded tray is placed and rotated from one tuberosity and then rotated from that lateral side to the other lateral side and tuberosity. This decreases the risk of trapping air and allows the material to flow to the peripheries. The denture is supported and the patient is asked to suck and pull the cheeks and lips down. The mandible is moved right and left to capture the coronoid space. The mandibular tray and alginate are placed in the mouth with the tongue raised. The tray is slipped between the tongue and ridge and the patient then relaxes the tongue as the tray is seated. After seating the tray, the patient can suck their lips inward, open the mouth wide, and protrude and move the tongue laterally. The impression should appear very similar to the shape of the final denture.

If impression compound or silicone putty is used for making the preliminary impression, the technique is the same except that the borders of the stock tray do not require modification. There is no need to use a tray adhesive for impression compound, although one is necessary for silicone putty. Preloading of material in the mouth is usually not required. The tray is loaded with the impression material and seated in the mouth in exactly the same manner as for alginate impression material.

Patients often present with existing dentures. Putty can be placed inside the dentures to create a cast, or if minimal undercuts are present in the denture, stone can be poured inside the dentures.

FINAL IMPRESSIONS: TRAYS, MATERIALS, TECHNIQUE

Health of the oral tissues is paramount. There should be no distortion or inflammation of the denture foundation tissues. These must be eliminated before the impressions are made; otherwise, the new dentures will not fit the tissues once they are no longer distorted by the denture compression and edema. The most effective way of resolving the inflammation is to ensure that patients leave their dentures out of the mouth during the night and for at least 24 hours before the impressions are made, although a longer period often is required to resolve the problem completely. Many patients object to leaving their dentures out because it is extremely disfiguring. The use of tissue conditioners is an effective alternative, although patients should still be encouraged to leave their old dentures out as much as possible before the impressions are made (Figs. 8-20 and 8-21).

The borders of the *custom tray* are determined by outlining the impression with an indelible marker on the impression at chairside, or the outline is marked on the cast in the laboratory. The completed impression should be observed next to the patient's mouth and the junction of the attached and unattached mucosal tissue visually identified on the border of the impression. The impression is poured in artificial stone, and the custom tray outline should now be evident on the cast. With the patient not present during marking of the cast, clinical experience and previous observation of the patient are used. The border is marked 2 to 3 mm short of the intended denture border. Generous relief should be made for the frena, and the border should extend to the vibrating line and hamular notch area. Since the tray will be "tried-in" the patient before the final impression, overextensions can be reduced at that time.

Baseplate wax, approximately 1 to 2 mm thick, is placed on the cast within the outlined border to provide space in



Figure 8-20 This patient has pressure from the posterior palatal seal of his existing denture, petechiae on the palate, and redundant tissue on the left anterior alveolus. He had a relief chamber in his existing dentures over the anterior palate, which is quite healthy. Tissue conditioning is required.



Figure 8-21 This patient had anterior dental extractions performed 8 weeks earlier. She will be informed that a reline is likely necessary after her dentures are completed.

the tray for the final impression material. The secondary stress-bearing areas and sharp undercuts may be relieved with additional baseplate wax on the cast, or holes can be drilled through the tray in these areas to allow the impression material to escape and reduce pressure on the tissues (Fig. 8-22). The posterior palatal seal and the buccal shelf areas on the cast are not covered with the wax spacer before the completed custom tray will contact the mucous membrane across the posterior palate and on the buccal shelves. The wax spacer should be removed from the remaining periphery of the tray approximately 2 to 3 mm to allow placement of the border molding material. The wax spacer is left inside the body of the tray and assists in proper placement of the tray in the mouth while refining the borders of the tray.



Figure 8-22 Relief over the secondary stress areas of the rugae and midpalatine suture can occur with the vent holes. Vent holes were used in addition to a wax spacer.

The tray should be made of a rigid material and be approximately 3 to 4 mm thick. The anterior handle should be vertical and not interfere with border molding of the lip. Some dentists prefer creating an occlusal rim made of wax or tray material to act as a handle and to support the patient's facial musculature during the impression procedure. In either option, the handle should not restrict muscular movement.

Compound is the most commonly used material for *border molding* (Table 8-1), but impression waxes and polyether and silicone materials can be used with success. The advantage of compound is its low cost and the ability to place it incrementally, observe the surface and trim it back or add more material, and then readapt the same periphery. Each addition and section of the tray border can be seamlessly adapted to the previous compound. The muscular movements can be made by the patient exclusively, or the dentist can assist in movements on the buccal peripheries by manipulating and pulling the cheeks and lips (Fig. 8-23, *A*). If the patient has tissue attachments high on the ridge and denture border coverage is limited, it may be desirable

TABLE 8-1 MAXILLARY AND MANDIBULAR BORDER MOLDING

Maxillary	
Labial	The patient makes aggressive movement of the lips: puckers, sneers, opens wide, grimaces, and smiles. Prominence of frenum should be noted and duplicated.
Posterior lateral	Move mandible right and left. Width and height should be noted and duplicated.
Hamular notch	Push compound into the notch. Then patient opens wide and closes against hand on chin. Vertical notch of pterygomandibular raphe should be noted in impression.
Posterior vibrating line	Observe line with patient saying "ah" and trim compound to this line or area. Palpate the displacement bilaterally onto the displaceable tissues that border the hard palate and soft palate junction and place compound in a butterfly-shape border seal.
Mandibular	
Labial	The patient makes aggressive movement of the lips: puckers, sneers, opens wide, grimaces, and smiles. Prominence of frenum should be noted and duplicated.
Buccal shelf	The patient opens wide, grimaces, and puckers.
Masseteric notch	The patient closes against the hand on the chin.
Retromolar pad	The patient opens wide and closes against the hand on the chin.
Retromylohyoid fossa	Push compound into fossa area; the patient licks lower lip and right and left cheeks, and swallows.*
Lingual border and lingual anterior border	The patient licks lower and upper lip and right and left cheeks and pushes tongue against the handle of the tray or the clinician's thumb. The border will gently curve under the tongue at midbody (premylohyoid area).

*The patient may not be able to swallow during border molding, but should swallow with disclosing paste on denture border to determine possible overextension in the retromylohyoid fossa.

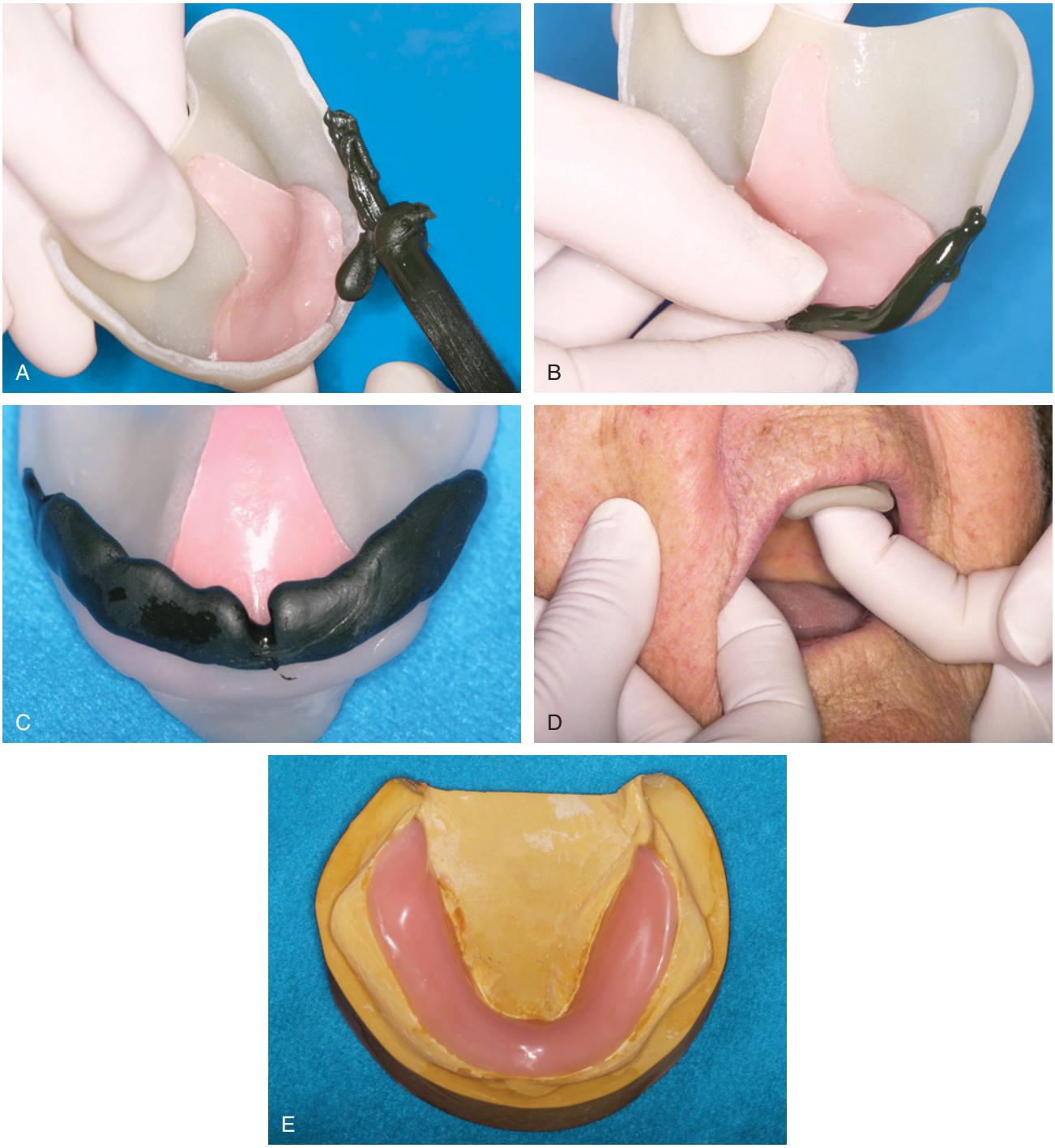


Figure 8-23 **A,** Compound is placed on the tray that is approximately 2 mm short of the border. **B,** After placement of compound, it can be positioned beyond the expected height of the vestibule, heated, tempered in hot water, and placed in the mouth. If the tray was made too underextended, the compound can carry beyond 3 mm if carefully handled. **C,** The labial and buccal frenum are quite prominent and multiple in this patient. She border molded the area herself with instruction. **D,** The dentist can border mold the buccal tissues by gently pulling the lips and cheeks. The tray handle ideally is vertical, so as not to impinge on muscle movement. **E,** A maxillary irreversible hydrocolloid material in a stock tray was used for the impression. This denture has been waxed up to "educated and observed" contours at the instruction of the dentist.

for the patient to perform the movements, so that the dentist will not move the tissues further than the patient might during function. Tongue movement should be limited to licking the upper and lower lips, rather than maximum protrusion of the tongue. Using the compound border molding technique gives the dentist a profound understanding of the patient's anatomy, which serves well in educating the dentist and patient about the "pitfalls" of the patient's edentulous anatomy as they both proceed through the serial additions of the peripheral seal. The dentist will become more aware of anatomic problems and functional deficits that might have been overlooked in the initial workup, making him or her a better edentulous diagnostician by the time he or she becomes an expert in handling these materials (see Fig. 8-23, *A* to *D*).

If polyethers or silicone materials are used, the entire periphery must be captured at once. They can be injected onto the entire periphery of the tray. Similar border molding procedures are required, and if material appears deficient, the dentist can push material into the vestibule and then continue border molding. Voids and underextensions can be corrected with the addition of a new mix of material and replaced in the mouth. Overextensions require cutting away of the material, which is not as easily accomplished as with compound.

Stability and retention should be maximized during border molding, with continued revision of the border extensions until the peripheral seal is ideal. No matter what the material, if the tray shows through the molding, the tray is overextended and must be reduced and molded in that area again.

A number of materials are available for making the *final impression*. Plaster of Paris and metallic oxide impression pastes were once widely used as final impression materials. The plaster of Paris and metallic oxides require no spacer in the tray because they have minimal viscosity and therefore have minimal tissue displacement; however, because of the limited viscosity and lack of spacer, it is more difficult for the dentist to control seating pressure and accuracy of seating the tray. These materials have a rigid set, so use in patients with severe undercuts is contraindicated. They also are less tolerated in patients with dry mucosa or "burning mouth."

Elastomeric impression materials are the current choice for final denture impressions. Accuracy of the impression material requires a spacer in the tray. To avoid displacing the border tissues, a less viscous irreversible hydrocolloid is used for making the final impression compared with that used for the preliminary impression. The wax spacer should be removed. The internal aspect and undercuts in the molding material should be reduced/beveled with a scalpel or bur (silicone materials) to eliminate the "stair-step" that might have occurred from the wax spacer. The length and external width of the borders should not be reduced because this will become an intimate part of the final impression. The posterior palatal seal should not be reduced to allow the posterior border seal to remain intact and slightly displace the tissues. The holes should be drilled in the tray at this time if there are areas where the tissue is mobile and distortion is likely.

The final impression material of choice is mixed according to the manufacturer's instructions and uniformly distributed within the tray. All borders must be covered. The tray is then positioned in the mouth using the labial frenum and tray handle as a reference. The tray should be gently seated as described in the preliminary impressions. The clinician may elect to place gauze over the holes immediately after seating to decrease the continued escape of material. After reviewing the impression, there may be incomplete seating revealing thick and thin areas on the impression, severe and multiple areas of tray may show through in the impression, or the borders may reveal thick and thin areas. These faults are due to incorrect positioning of the tray. There are occasionally voids in the material that may require remake. If the voids are small, they may be repaired with impression wax.

Dentists also may use stock trays with *irreversible hydrocolloid impression* material for final denture impressions. This technique has been used in a dental school environment to reduce patient visits. Processed bases were fabricated for the jaw record appointment further reducing the number of patient visits. The students were carefully supervised by faculty to assure that the outline of the functional anatomy was delimited on the cast for the processed base. The retrospective chart review study revealed that the number of visits were less for overall fabrication and adjustments, and the need for relines was no different in the group receiving dentures from the hydrocolloid impression in a stock tray compared with the group receiving dentures made with the conventional primary and secondary impressions and conventional trial base technique in the same dental student environment. The key to the success of this abbreviated method was deemed to be overextended alginate impressions in carefully selected stock trays, and understanding denture anatomy for denture base fabrication space (Fig. 8-23, *E*).

POSTERIOR PALATAL SEAL

The purposes of the tissue-displacing nature of the posterior palatal seal are to

1. Recess the denture border in the posterior to minimize the end of the denture to the patient's tongue during swallowing and speaking.
2. Create a border seal to decrease the risk of dislodgment of the denture upon speaking and mastication.
3. Counter the polymerization shrinkage that occurs in processing of the denture that pulls the processed base away from the cast along the palate.

The posterior palatal seal is created at the posterior periphery of the denture, by creating pressure on the soft



Figure 8-24 This patient had a class III soft palate form. The ridge is V shaped and he has very high buccal frenum attachments. The palatal seal was placed on the displaceable hard palate to gain retention.

tissues of the hamular notch, the anterior soft palate along its attachments to the horizontal hard palate, and onto the hard palate on either side of the posterior nasal spine. The submucosa of the hard palate on either side of the median palatal suture is glandular tissue, as is the tissue of the soft palate. The tissue can be displaced several millimeters anterior to the vibrating line in a butterfly shape on either side of the palatal suture, thereby increasing denture retention. House described three classifications of soft palates, which related to the drape and movement of the soft palate. A class I palate is the most favorable for denture retention. The soft palate drapes gently horizontally, and for several millimeters posterior to the vibrating line, the soft palate remains horizontal upon phonation. These several millimeters of soft palate can be contacted and slightly displaced at rest and in function, giving a broader surface area for contact and retention. A class III palate exits, with a more vertically draped palate at rest, and severe and immediate elevation of the soft palate almost coincident with the vibrating line. The border extension in this area must be more exacting and should have almost no length posterior to the vibrating line. The border seal will be broken if it is overextended on the soft palate. The class III patient is often associated with a V-shaped palatal vault. The dentist should carefully evaluate displaceable tissue on the hard palate to gain a border seal. The correct extension into the hamular notches is paramount in all soft palate classifications (Fig. 8-24).

The posterior palatal seal should be created in the border molding process. The vertical notch of the pterygomandibular raphe should be noted in the border molding, and the contours of the displaceable hard and soft palate should be created (Fig. 8-25). Retention can be evaluated in the tray and the palatal classification determined. The dentist should achieve maximum retention and not move

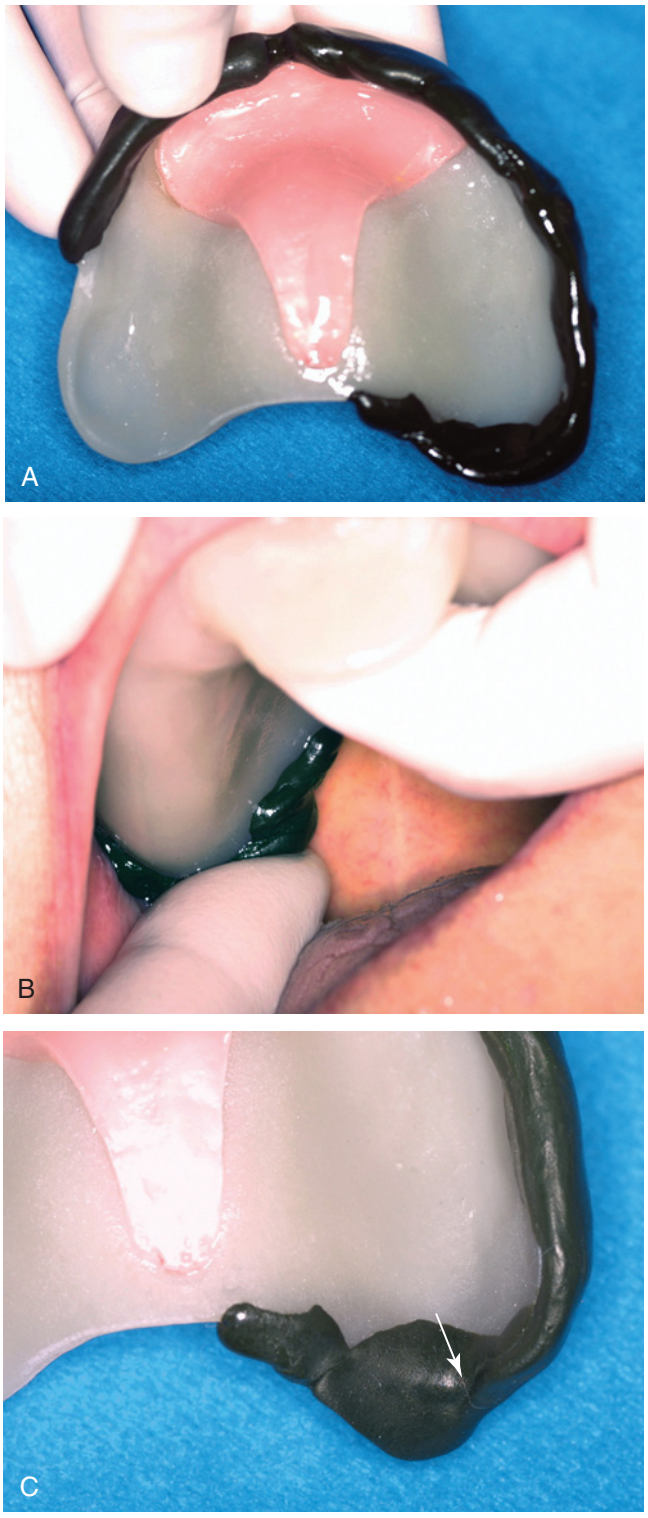


Figure 8-25 **A,** The posterior palatal seal in the area of the tuberosity is positioned into a slightly overextended position. **B,** The custom tray is seated and the compound is pushed into the hamular notch and then the dentist and patient border mold the area. **C,** The notch of the pterygomandibular raphe can be noted. The excess material hanging vertically is trimmed.

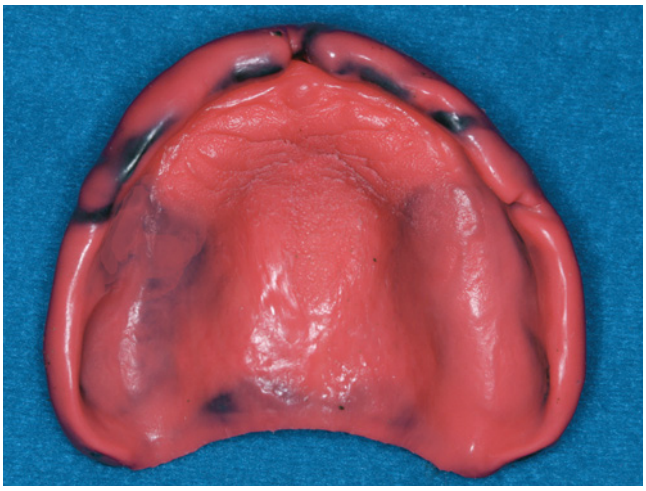


Figure 8-26 The final impression from the border molding in Fig. 8-25 reveals excellent capture of the anatomy of the posterior palatal seal in the hamular notches. The impression was cut back to the border molded palatal seal that denotes the definitive extension of the denture. The area of the wax spacer shows no pressure, but the left maxillary ridge has excessive pressure. The decision was to relieve the denture upon delivery using pressure indicator paste.

on to the impression stage until retention is adequate. Compound should be trimmed to demarcate the desired posterior extent of the denture. This area of compound is not relieved in the impression. Following the impression, many dentists leave the overextension of impression material beyond the compound determination; however, trimming it with scissors at the very periphery of the compound assists in laboratory procedures without guesswork later as to the desired extent of the prosthesis (Fig. 8-26). Because the indelible marker is often smeared on the mucous saliva and in handling the impression, cutting the material is definitive.

Following the impression, a functional impression with impression wax can be created at the palatal seal area. This further displaces the soft tissues. The displaceable soft palate and an extension onto the hard palate lateral to the median palatal raphe can be outlined on the cast with a marking pen. Impression wax can be painted onto the surface within the outlines to approximately 2 mm in thickness. Wax should be carried up onto the border lateral to the pterygomandibular raphe. It should have minimal width at the median raphe. This wax requires several minutes held in the mouth to reach mouth temperature. It will still displace tissues (Fig. 8-27).

The concept of "scoring" the cast to achieve a posterior palatal seal has been a common practice for many years. Scoring about 1.5 mm in depth at the demarcated vibrating line, and also scoring the "butterfly" or scoring more posteriorly for class I and II soft palate forms has been described. The method used is likely dentist preference. Underextension compromises retention, and overextension or sharply carved borders creates soft tissue trauma. This area should

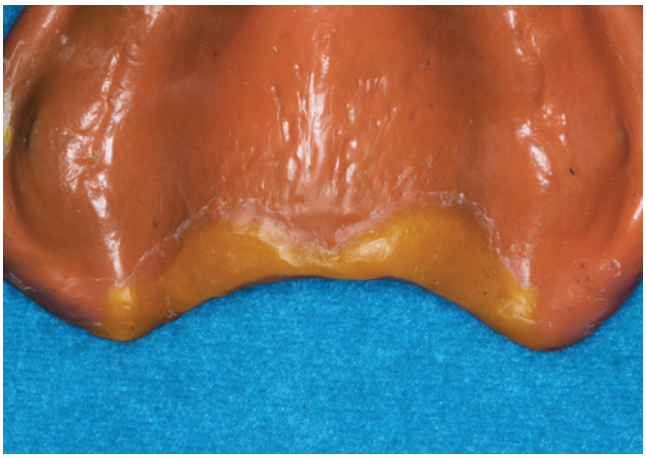


Figure 8-27 The posterior palatal seal is created with impression wax. The denture should extend to the end of the wax.

be disclosed on the periphery, having the patient swallow and phonate and open wide.

BOXING IMPRESSIONS AND MAKING THE CASTS

Great care is taken when making the final impression to record the functional width and depth of the sulcus. It is essential that this be preserved in the final cast. The procedure for preserving this form is called *boxing*.

For the elastomeric impressions, 1 to 2 strips of boxing rope wax is attached all the way around the outside of the impression, approximately 2 to 3 mm below the border and sealed to the impression with a spatula. The width of the strip is particularly important at the distal end of the mandibular impression to hold the vertical walls of the boxing away from the impressions and create a flat stone periphery on the final cast. A sheet of boxing wax is then attached to the outside of the boxing strip to form the vertical wall of the boxing. The vertical wall should extend 10 to 15 mm above the impression, so that the base of the cast at its narrowest point will be of this thickness. The sheet of wax should extend completely around the impression and be sealed to the boxing wax strip to prevent the escape of artificial stone when this is poured into the impression (Fig. 8-28).

For irreversible hydrocolloid and elastomeric impressions, a mixture of half plaster and half pumice can be made. The excess water can be removed by rolling the mixture in paper towels. The mixture can be placed on a flat pad, and the tray can be seated in this mixture. The mixture can be shaped around the periphery of the impression and in the tongue space of the mandibular impression. The mixture should be placed 2 to 3 mm below the border of the impression and allowed to set. It is then trimmed to approximately a 6-mm area around the impression. Boxing wax may be sealed around the periphery of the mixture. A separating

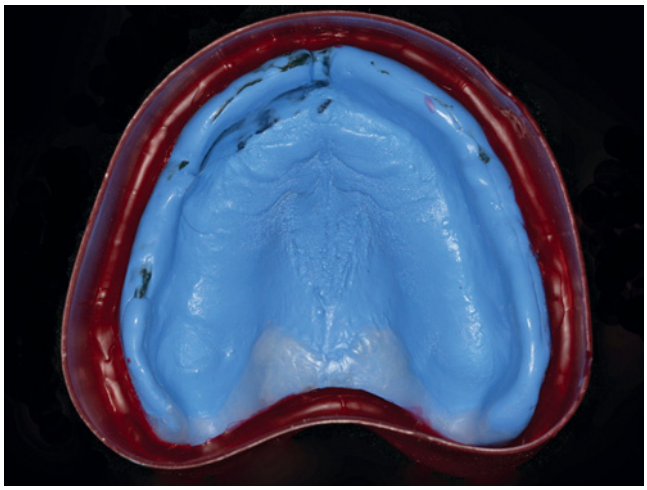


Figure 8-28 Boxing with strip rope wax and sheet boxing wax. This creates a wall to confine the stone and creates strength along the border of the cast.

medium is placed on the mixture and the cast is poured with artificial stone.

Artificial stone is mixed according to the manufacturer's instructions. The stone is poured into the boxed impression level with the top of the vertical wall of the boxing wax. After the final impression is separated from the cast, the cast must be shaped to maintain the form of the borders and a 4- to 5-mm land area on the cast.

SUMMARY

Both short-term and long-term health of dentures' supporting tissues is influenced by the methods used to replicate them. Impression techniques seek to achieve this objective by means of functionally determined and maximum extension of denture bases. The result is an intaglio surface that includes both stress-bearing (and supporting) and peripheral (or limiting) areas. The spreading out of masticatory and other occlusal pressures over a greater surface area maintains support, stability, and retention of the dentures.

Bibliography

Avant WE: A comparison of the retention of complete denture bases using different types of posterior palatal seal, *J Prosthet Dent* 29:484-493, 1973.

Barrett SG, Wheeler HR: Structure of the mouth in the mandibular molar region and its relation to the denture, *J Prosthet Dent* 12:835-847, 1962.

Duncan JP, Taylor TD: Teaching an abbreviated impression technique for complete dentures in an undergraduate dental curriculum, *J Prosthet Dent* 85:121-125, 2001.

Jani RM, Bhargave K: A histologic comparison of palatal mucosa before and after wearing complete dentures, *J Prosthet Dent* 36:254-260, 1976.

Laney WR, Gonzalez JB: The maxillary denture: its palatal relief and posterior palatal seal, *J Am Dent Assoc* 75:1182-1187, 1967.

Lye TL: The significance of the fovae palatini in complete denture prosthodontics, *J Prosthet Dent* 33:504-507, 1975.

Martone AL: Clinical applications of concepts of functional anatomy and speech science to complete denture prosthodontics, *J Prosthet Dent* 13:4-33, 1963.

Pietrokovski J, Massler M: Alveolar ridge resorption following tooth extraction, *J Prosthet Dent* 17:21-27, 1967.

Schwarz WD: The lingual crescent region of the complete lower denture, *Br Dent J* 144:312-314, 1978.

Shannon JL: The mentalis muscle in relation to edentulous mandibles, *J Prosthet Dent* 27:477-484, 1972.

Silverman SI: Dimensions and displacement patterns of the posterior palatal seal, *J Prosthet Dent* 25:470-488, 1971.

Watson IB, MacDonald DG: Oral mucosa and complete dentures, *J Prosthet Dent* 47:133-140, 1982.

Watson IB, MacDonald DG: Regional variations in the palatal mucosa of the edentulous mouth, *J Prosthet Dent* 50:853-859, 1983.

Weintraub GS: Establishing the posterior palatal seal during the final impression procedure: a functional approach, *J Am Dent Assoc* 94:505-510, 1977.

CHAPTER

9

The Dentures' Polished Surfaces, Recording Jaw Relations, and Their Transfer to an Articulator

James D. Anderson, George Zarb

Wilfred Fish, the distinguished English clinical scholar, described three denture surfaces—impression, occlusal, and polished. Their integration in the denture's design contributes significantly to prosthesis functional stability, although each surface is initially developed separately by the dentist. This chapter emphasizes the protocol of establishing a denture's polished surface on occlusion rims and the manner in which this clinical information is then transferred to an articulator for the development of the occlusal surface.

A complete denture has three surfaces: (1) an impression or intaglio surface (described in Chapter 8) that rests on the residual ridges and transmits forces directly to the denture-bearing tissues; (2) a polished surface made up of the labial, buccal, lingual, and palatal parts of the denture base material together with the nonarticulating buccal and lingual parts of prosthetic teeth surfaces; and (3) an occlusal surface that consists of the teeth's articulating surfaces, which make contact during most functional and parafunctional activities. Although all three surfaces (Fig. 9-1; see Figs. 12-1 to 12-3) are developed separately when making complete dentures, the dentist integrates them to create a stable, functional, and esthetic result. This chapter reviews the second or polished surface that also is referred to as the neutral zone, or arch form. It also describes the clinical steps leading to the use of an articulator as a laboratory analogue or simulator for the mandible's functional relationship to the maxilla.

The neutral zone, or arch form, occupies a position of equilibrium among the groups of tongue, cheek, and lip muscles that contribute to the mouth's functional role; its location is determined by reconciling intraoral anatomical landmarks with a clinical assessment of lingual and circumoral activity (Fig. 9-2). It is a three-dimensional guide for the location of a planned denture's polished surface and prosthetic teeth positions in either dental arch and is first established in the wax occlusion rims. These rims are therefore used as provisional substitutes for the teeth in complete dentures or implant-supported prostheses and are employed to record first the neutral zone or arch form and then preliminary maxillomandibular relations. Once this information is established clinically, it can then be transferred to an articulator for the laboratory exercise of setting up the selected prosthetic teeth and completing the third or occlusal surface (Fig. 9-3).

Occlusion rims are preferably made of baseplate wax, which is a very convenient and easy material to manage. They are attached to a trial denture base (TDB), which is made on the stone casts that represent the denture-supporting tissues. TDBs act as provisional substitutes for the eventual denture base and support the wax rims and must be rigid, accurate, and stable. They usually are made of hard baseplate wax or preferably of autopolymerizing (cold-curing) or light-cured acrylic resin. These TDBs are used at both the maxillomandibular registration and the try-in appointments. Infrequently, they are made of processed acrylic resin after final impressions are made, with the selected teeth eventually also processed onto them.

TDBs made in wax are usually reinforced with wire. These bases are sometimes bulky and brittle, but dentists and technicians frequently find them easier to work with when setting up teeth, especially when a restricted interarch distance exists. Autopolymerizing or light-cured resin TDBs also are extensively used (see Figs. 9-1, *B* and 9-3, *A*). Undercuts are first blocked out on the cast to avoid possible cast surface damage, and the resin in its doughlike state is molded onto the cast. An autopolymerizing resin base should be made of a relatively even thickness on the casts, which next are placed in hot water in a pressure cooker for 10 minutes under 30 lb of pressure. This eliminates excess monomer and produces rapid polymerization and a rigid, stable base that is easily contoured and polished. Acrylic resin bases are excellent for making maxillomandibular relation records because they fit accurately and are not easily distorted. Their only disadvantage is that they may take up space needed for setting the teeth, necessitating some grinding of the acrylic resin base in required areas. On the other hand, TDBs and occlusion rims made entirely of

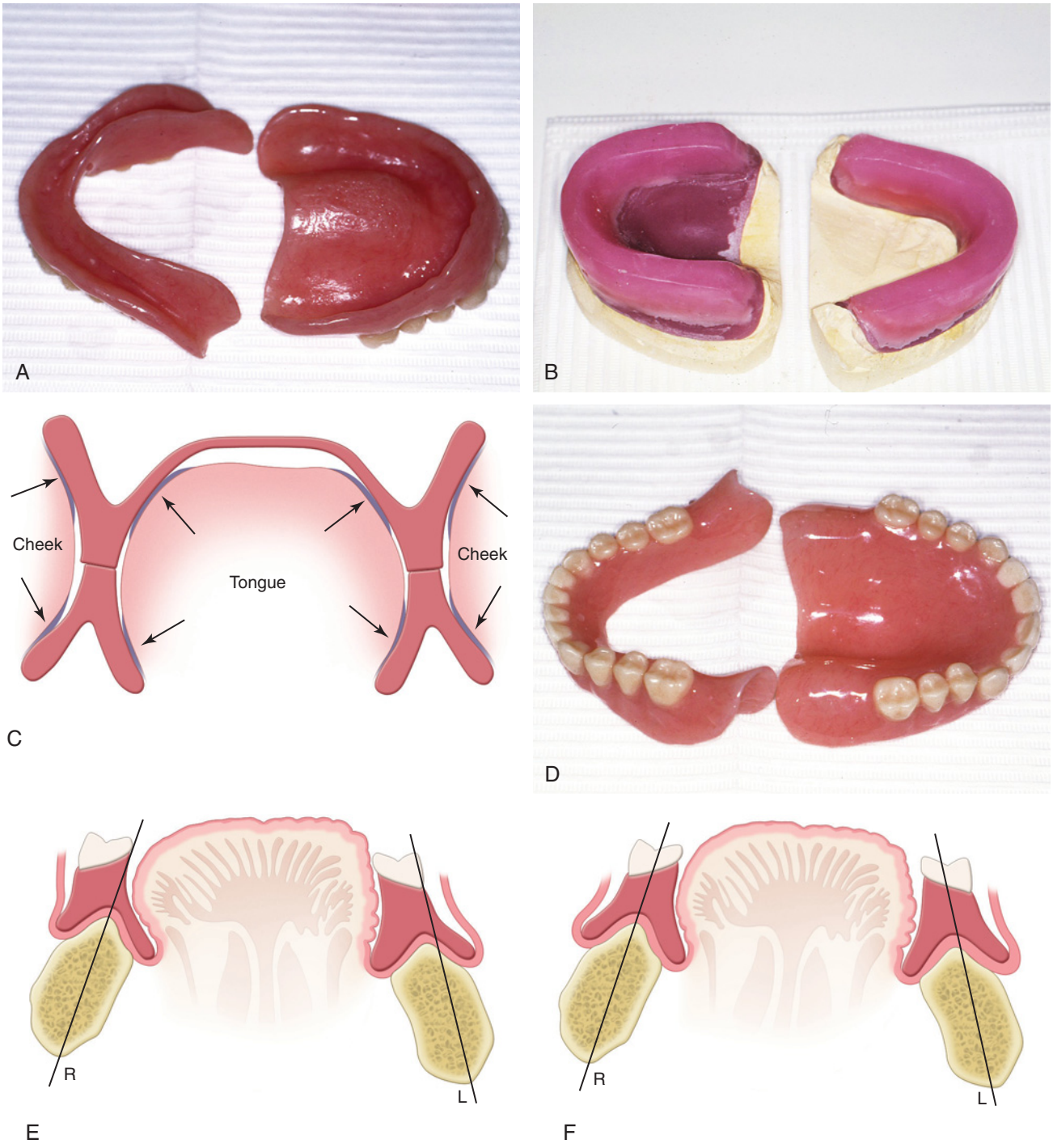


Figure 9-1 Complete dentures have three surfaces that are designed to harmonize with the oral biological and functional environment they are placed in. **A,** The impression or intaglio surfaces are fitted to the supporting basal seats. The wax occlusion rims (**B** and **C** [shown diagrammatically]) are contoured to simulate the position of the dentures' polished surfaces so that they contact and support the cheeks, lips, and tongue. The shaded area in **C** denotes the neutral zone. In **D,** the opposing occlusal surfaces of the dentures are designed to fit together. However, the mandibular teeth's position should not encroach upon the tongue's position in the neutral zone as in **E.** This would lead to instability of the complete denture base as contrasted with optimal prosthetic teeth positioning in **F.** The overall concept is also emphasized in Fig. 12-1.

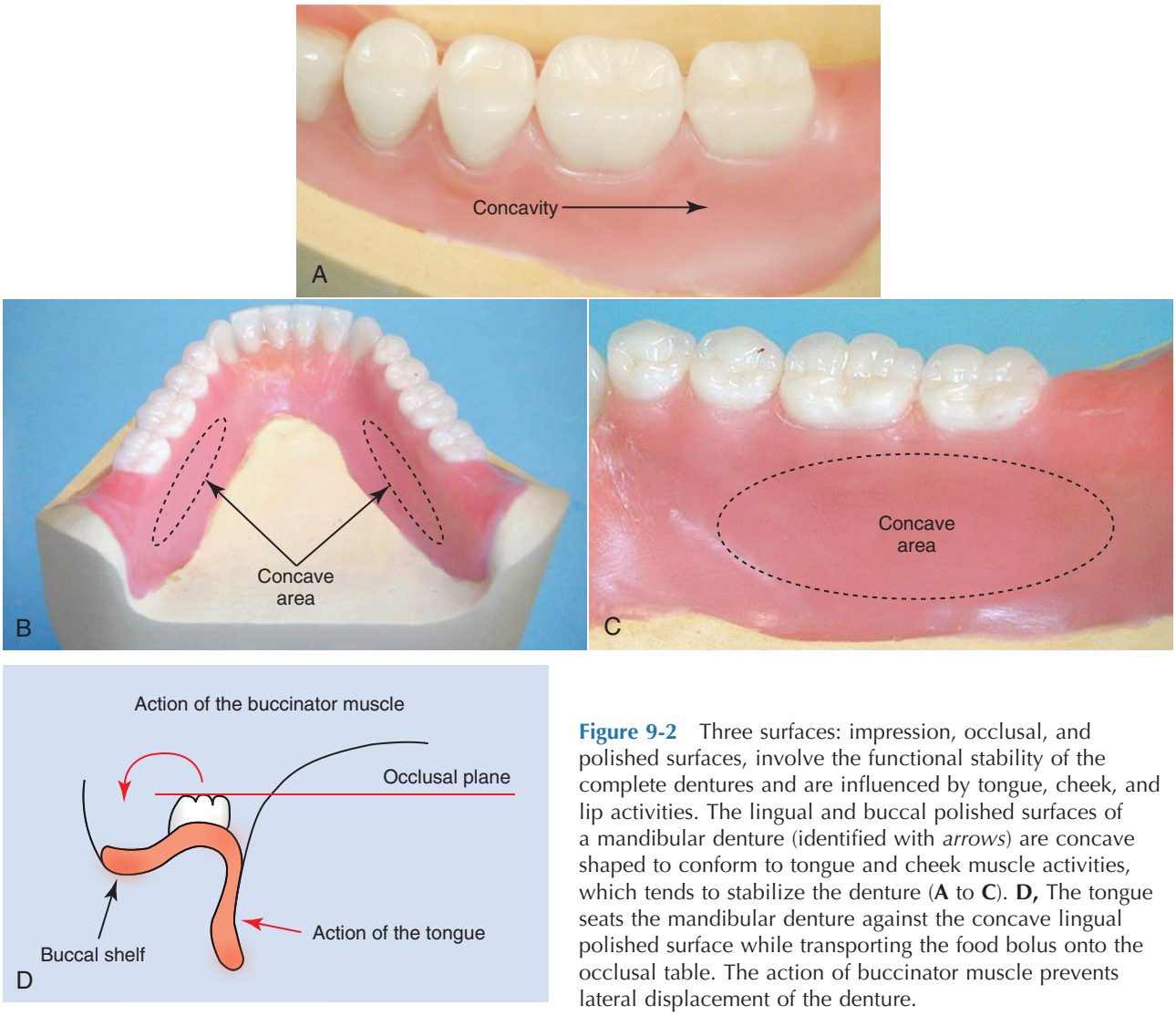


Figure 9-2 Three surfaces: impression, occlusal, and polished surfaces, involve the functional stability of the complete dentures and are influenced by tongue, cheek, and lip activities. The lingual and buccal polished surfaces of a mandibular denture (identified with *arrows*) are concave shaped to conform to tongue and cheek muscle activities, which tends to stabilize the denture (**A** to **C**). **D,** The tongue seats the mandibular denture against the concave lingual polished surface while transporting the food bolus onto the occlusal table. The action of buccinator muscle prevents lateral displacement of the denture.

baseplate wax are easiest to work with for subsequent teeth arrangement. This is because wax can be trimmed and softened to permit setting teeth directly against the underlying stone if necessary. The alternative use of a hard TDB material would require its being cut away to allow the teeth to be set in their proper places when restricted interarch space is present.

The dentist uses occlusion rims to (1) determine the neutral zone or arch form, (2) establish the level of the occlusal plane, and (3) make preliminary maxillomandibular relation records. Unfortunately, none of these objectives can be reached in a precise scientific way, and most of the knowledge concerning them is theoretical. However, clinical experience does provide successful directions or protocols to help achieve necessary clinical objectives. A preferred clinical sequence to reach these objectives is to (1) establish the neutral zone by designing an arch form on each wax occlusion rim, (2) determine the level/height of the occlusal plane on the mandibular occlusion rim, (3) modify the maxillary rim to meet the mandibular rim evenly at the desired vertical dimension of occlusion (VDO), and (4) make a preliminary centric relation (CR) record.

NEUTRAL ZONE OR ARCH FORM DESIGN

The contour of the arch form of the occlusion rims including the width of the occluding surfaces is established for each patient to simulate the desired arch form of the artificial teeth. This is an integral part of the neutral zone determination objective because it recognizes the role of the activity of the lips, cheeks, and tongue and includes preliminary consideration of circumoral and facial support. It is a useful prescription or analogue for positioning the missing teeth and their supporting tissues.

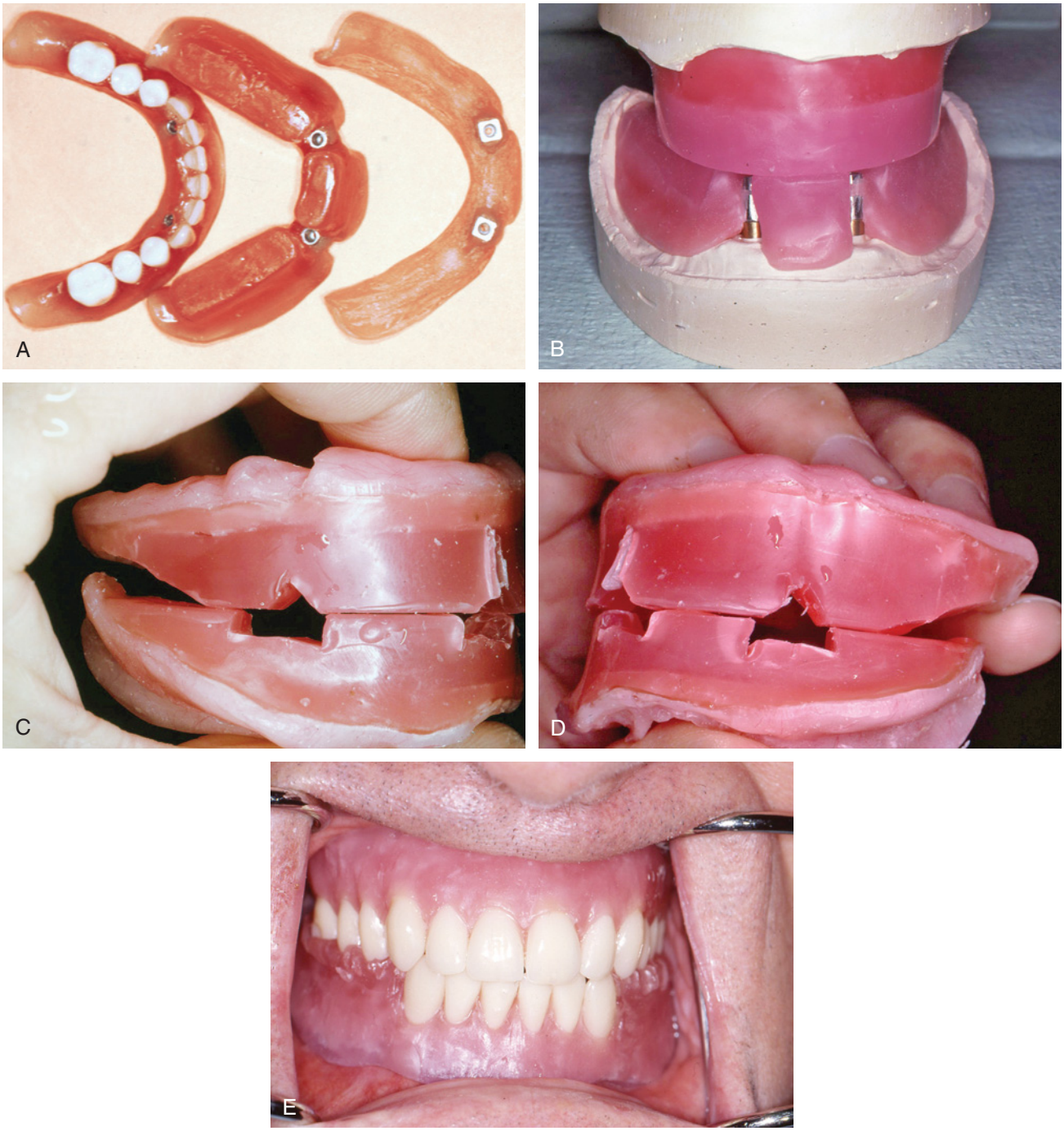


Figure 9-3 These wax occlusion rims are used as provisional substitutes for the teeth in complete dentures or implant-supported prostheses and are employed to record first the neutral zone or arch form. **A,** The clinical continuum leading to the mandibular denture's try-in stage is illustrated via an acrylic resin trial denture base, next with a wax occlusion rim (stabilized even further in this situation by means of overdenture implant abutment support), and finally the prosthetic teeth setup that conforms to the simulated neutral zone. **B,** The custom-contoured wax occlusion rims are ready to be "notched" (**C** and **D**) for recording preliminary maxillomandibular relations. They will then be transferred to an articulator for the laboratory exercise of setting up the selected prosthetic teeth and completing the third or occlusal surface. The teeth setup permits the next clinical appointment's confirmation of esthetic satisfaction and a confirmation of correct occlusal relations. **E** to **G,** The posterior mandibular prosthetic teeth are replaced with a partial wax occlusion rim at the try-in appointment because of an incorrect posterior occlusal relationship. This facilitates a new confirmatory record to be made at the predetermined VDO. A fresh articulator remount will be required before the new setup of the posterior teeth is completed for a second try-in.

Continued

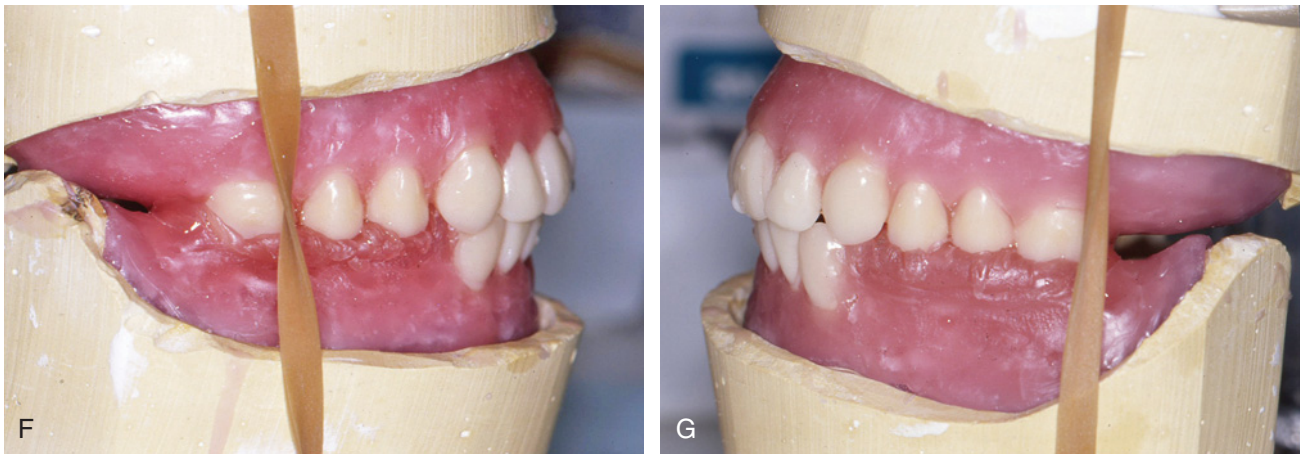


Figure 9-3, cont'd.

Above all, it is a tangible guide for instructing the technician's preliminary arrangement or setup of the artificial dentition and helps reduce the amount of chairside time spent with the patient at the subsequent try-in appointment.

Wilfred Fish first drew dentists' attention to the concept of a neutral zone in complete denture construction (see Figs. 12-1 to 12-3). He argued that natural teeth occupy a zone of equilibrium, with each tooth assuming a stable position that is the result of all the various forces acting on it. Consequently, when natural teeth are replaced by artificial teeth, it is logical to set the artificial teeth in a position as close as possible to the one the natural teeth occupied. The same forces that stabilized the natural teeth can then be used to stabilize the dentures. In the treatment of partially edentulous patients, it is common to find that sufficient natural teeth remain to provide a guide for the positions of the artificial teeth. However, when the patient is edentulous, it is not always easy to determine where the natural teeth were in relation to the partially or totally resorbed alveolar ridges. Clinical judgment must be brought to bear in such situations, and this may be quite challenging.

Certain types of dentitions are accompanied by specific patterns of soft tissue behavior. Clinical observation of patients with dentures suggests that these characteristic types of soft tissue movements persist into old age and offer a clue to the location of the preexisting natural teeth. The best guide for determining and designing the arch form is to consider the pattern of bone resorption where the teeth are lost and the use of anatomical landmarks that are relatively stable in position. Furthermore, documented clinical experience confirms that the denture space or neutral zone can be reproduced with minor variations that lie within the range of clinical acceptability.

MANDIBULAR ARCH

The occlusion rim is designed to conform to the arch form that, in the dentist's judgment, the patient had before the natural teeth and alveolar bone were lost. In the lower jaw, a larger proportion of bone loss tends to occur on the labial side of the anterior residual ridge. The loss occurs somewhat equally on the buccal and lingual sides of the residual ridge in the premolar region but appears to be primarily from the lingual side of the ridge in the molar region. The net morphological result is that the residual ridge almost invariably becomes more lingually placed in the anterior region and more buccally placed in the posterior region. Consequently, as a guide for placing artificial teeth, the occlusion rim is frequently contoured labial to the ridge in the anterior region, over the ridge in the premolar region, and slightly lingual to the residual ridge in the molar region. Lines should be drawn on the mandibular cast before the occlusion rim is tried in the mouth in order to provide a tangible guide for shaping/designing the arch form. One line is drawn from the lingual side of the retromolar pad and extended anteriorly to a point just lingual to the crest of the ridge in the premolar region. This line aids in positioning the lingual surfaces of the posterior teeth and establishes the lingual extent of the occlusion rim (Fig. 9-4). The curvatures of the occlusion rims, which simulate the arch form of the posterior teeth, follow the curvature of the mandible itself when seen from above. The anterior part of the occlusion rim is contoured to compensate for the estimated bone loss in this region, and the corners of the mouth are used as guides for determining an approximate location for the canines and first premolars. The experienced dentist learns to visualize the artificial teeth (represented at this stage by the contoured rim) as growing out of the alveolar bone and following the curvature of the bone. The end result is an arch form that is frequently not on the residual ridge but anterior or labial to it. It should be pointed out that some dentists and dental technicians have instead subscribed to a routine "tooth-on-the-ridge" teeth arrangement philosophy. Regrettably this approach can seriously undermine efforts for denture stability and esthetics by ignoring the concept of a neutral zone in arch form determination. An understanding and appreciation for patterns of alveolar ridge reduction enable the dentist



Figure 9-4 **A** and **B,** A Kennedy class I partially edentulous mandible and the removable partial denture designed for it underscore the position of the artificial posterior teeth arrangement that is compatible with the neutral zone concept. The same principle applies to a dentate (albeit a restored one) mandibular dentition **(C)** and the edentulous mandibular arch, with anterior teeth in place **(D)** as one of the landmark guides for completing the posterior teeth setup. In all these clinical situations, a virtually straight or very slightly curved line drawn from lingual of the retromolar pad to a point just lingual to the crest of the ridge in the premolar region, can act as a guide for positioning artificial posterior teeth **(E).** Note that the posterior height of the occlusal plane is approximately two thirds of the way up the retromolar pad. This corresponds to about 1 to 2 mm below the top of the anatomical landmark **(E).**

to determine the optimal arch form for the patient receiving treatment.

There also are documented techniques that employ soft waxes, impression materials, and tissue conditioners as adjunctive efforts to functionally determine the neutral zone and establish the arch form. When advanced anterior ridge reduction has been accompanied by an upward migration of the mentalis muscle attachment to the crest of the ridge, a certain amount of compromise is essential, and the rim is trimmed very thin and placed on, or lingual to, the ridge crest (note the risk of the denture's encroachment on the tongue space). If this sort of compromise creates an intolerable situation for the patient, surgical labial sulcus deepening in this area or the provision of implants may be considered to provide adequate support for the anterior segment of the denture. However, this step is rarely used nowadays, since a far more efficacious form of preprosthetic surgery—implant placement to ensure stability of a mandibular overdenture—readily overcomes this morphological challenge. Alternatively, the anterior mandibular teeth have to be set up lingually and risk encroaching on an optimal design for the neutral zone.

MAXILLARY ARCH

The tongue's size and diverse positions during function do not appear to have as profound an impact on the stability of the maxillary denture as it does on the mandibular one. However, optimal neutral zone determination is still mandatory for speech and esthetic purposes, with a little more leeway available for the latter consideration. Bone reduction usually occurs on the labial and buccal areas of the maxillary residual ridge. Consequently, the residual edentulous ridge is usually palatal to the original location of the natural teeth. The maxillary teeth should be labial and buccal to the residual edentulous ridge if they are to be placed in the neutral zone and occupy the position of their predecessors. If this pattern of bony reduction is ignored, the dentist ends up with a contracted maxillary arch form within the confines of the mandibular arch one. This oversight guarantees inadequate labial support and a suboptimal esthetic appearance. The rim is usually parallel to the interpupillary line and is at a height that accommodates the length of the natural tooth plus the amount of assessed bone reduction that has occurred. It is possible to simulate proper length and lip support by contouring the labial aspect of the maxillary occlusion rim; however, this step is difficult to visualize. It would therefore be preferable (in fact easier) for the dentist to have selected the anterior teeth for the patient's denture at an earlier clinical appointment and to have them available at this appointment. These teeth can then be readily set for proper length and lip support in the occlusion rims with the expectation that additional characterization of the anterior arrangement could then be done at the patient's next appointment when the actual try-in of the teeth setup is carried out.

The incisive papilla appears to occupy a stable locale on the palate, unless it is modified surgically. Clinical experience and anthropometric measurements indicate that the incisal edges of the maxillary central incisors are usually 8 to 10 mm anterior to the center of the incisive papilla. The papilla is circled and used as a rough guide in locating the anteroposterior position of the maxillary anterior teeth (Fig. 9-5). Also, after the natural teeth are lost, the canines should be located in a coronal plane passing through the posterior border of the papilla. A patient's old dentures, preextraction photographs, or diagnostic casts and photographs made before the dentition deteriorated should be used to assist both selection of artificial teeth and establishment of the optimal labial support for the patient. The simulated position of the posterior teeth is really a clinical judgment call. An assessment of the amount of resorption that has occurred, coupled with realization that the posterior teeth's inclinations are buccal to the ridge shape, is the guide to be followed. Furthermore, the position of the posterior maxillary teeth will, to a varying extent, also be influenced by the size of a patient's smile and the position of the mandibular teeth, while keeping in mind that the latter's position tends to be more rigidly determined.

If the patient has been wearing inadequate dentures, tooth loss will have a pronounced effect on the appearance of the lips and adjacent tissues. As a result of the loss of substance and the reduction in elastic properties, the connective tissue will not provide sufficient resistance to the activities of the orbicularis oris and associated muscles. Consequently, the effect of the degenerative changes in the skin becomes exaggerated, and the lips appear to have aged to a much greater extent than the surrounding parts. The skin becomes roughened, and deep vertical lines appear in the body and margins of the lips. There is a noticeable shortening/thinning of the lips because of a tendency for the lip margins to roll inward. The nasolabial fold changes direction to become almost continuous with the groove at the corner of the mouth, and the lips and cheeks are no longer distinctly separated (Fig. 9-6). Such a loss of well-defined demarcation tends to produce a generally disordered appearance of the lower half of the face. At this stage, it may be difficult to visualize proper lip support in an attempt to counter the changes just described. However, the dentist can and should use the occlusion rim to achieve the best balance between neutral zone determination and harmonious labial support.

Altering labial support probably does not affect cheek support as much as it affects lip support because the buccinator muscle is stretched between the pterygomandibular raphe and the modiolus muscles. It must be remembered that the longer the period of edentulism, the greater will be the loss of the muscle tone. Consequently, the relearning of the original muscle patterns and recovery of tone is likely to be insufficient even if correct dentures are provided. The more accurate the position of teeth replacement and the

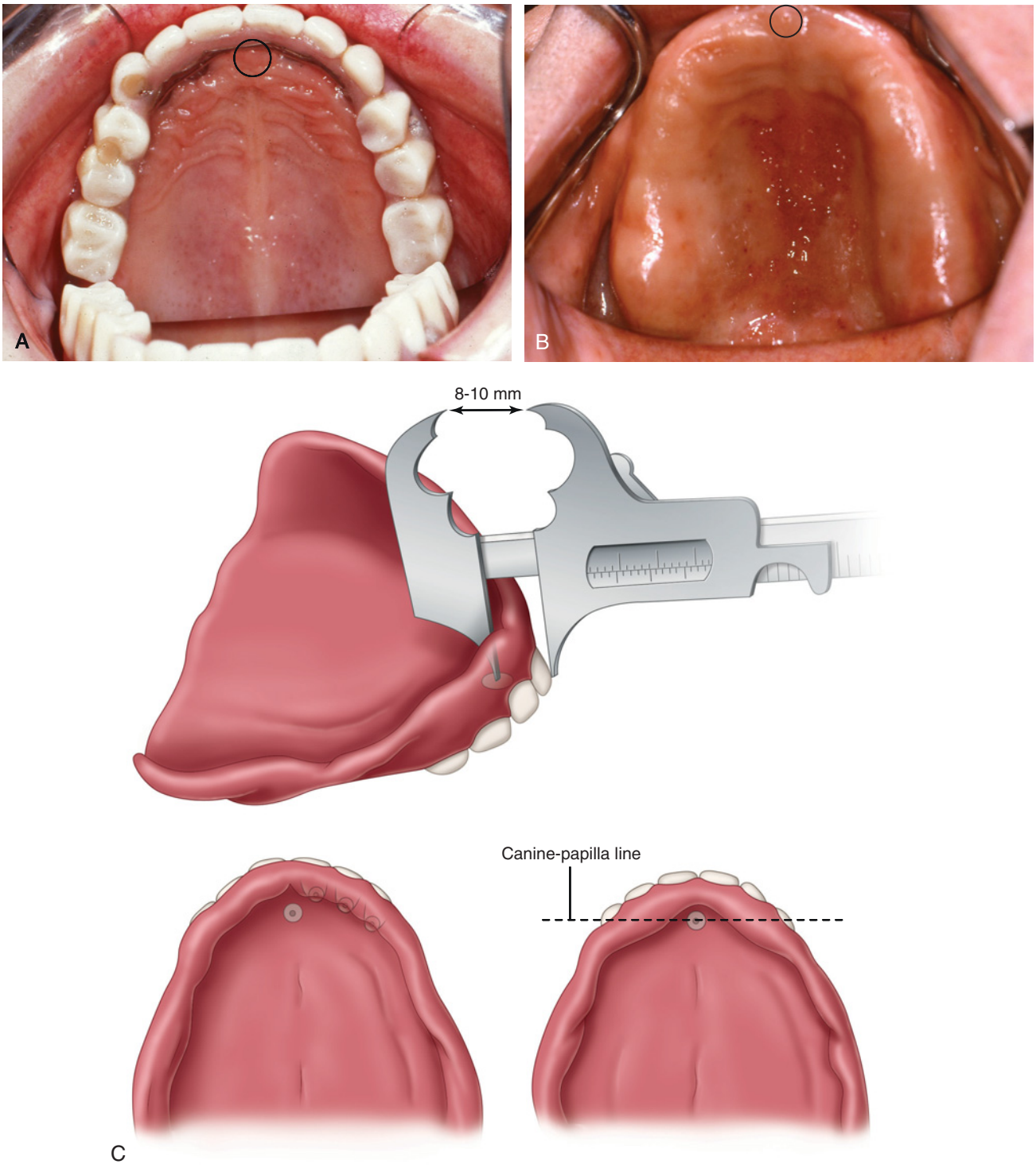


Figure 9-5 In the natural dentition **(A),** the tips of the maxillary canines are likely to be (+)/(–) 1 mm anterior to the center of the incisive papilla. Because this useful landmark's position in the edentulous maxillary arch **(B)** is rarely affected by anterior maxillary teeth extractions, it can be circled on the edentulous cast to provide a rough guide to positioning the maxillary canines. This principle is illustrated in **C.** It also should be noted that a mild inflammatory papillomatosis is present in **B.**



Figure 9-6 Age-related and degenerative skin changes can create virtual continuity between the nasolabial fold and the corner of the mouth. However, a range of such changes is encountered with edentulous patients and this varies from relatively subtle ones in **A** and **B** to overt ones in **C.**

sooner it occurs, the easier will be the task of relearning and reacquiring optimal cheek and lip support.

LEVEL OR HEIGHT OF THE OCCLUSAL PLANE

Establishing the correct level or height of the occlusal plane demands an understanding of the neutral zone concept together with lingual and specifically modiolus muscle function in denture stability. Any food bolus is triturated while resting on the mandibular occlusal surfaces (occlusal table), which is an area bounded by the cheek tissues buccally, the tongue lingually, the pterygomandibular raphe and its overlying tissues distally, and the contraction of the corner of the mouth mesially. The mesial boundary is a point where eight muscles meet at the corner of the mouth. This "meeting place" is called the modiolus ("hub of a wheel" in Latin) and forms a distinct conical prominence at the corner of the mouth (Fig. 9-7). If the thumb is placed inside the corner of the mouth and the finger outside on the prominence, and then the lip and cheek are contracted, the modiolus feels like a knot. The modiolus becomes fixed every time the buccinator muscle contracts, which is a natural accompaniment of all chewing efforts. The contraction of the modiolus presses the corner of the mouth against the premolars so the occlusal table is closed in front. Food is crushed by the premolars and molars and does not escape at the corner of the mouth unless seventh nerve damage has occurred (as in Bell's palsy) or in patients with compromised

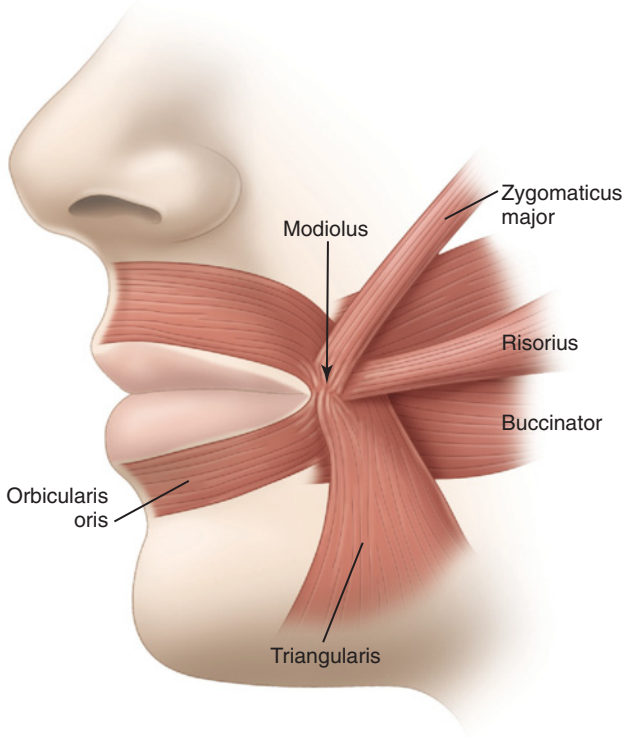


Figure 9-7 The modiolus.



Figure 9-8 **A,** A mandibular occlusion rim is tried in the mouth without the opposing maxillary rim in place. It is correctly judged to be overcontoured and insufficiently high to fulfill the objectives articulated in the text. It is important to note the resultant generalized circumoral lack of support, particularly the uneven lower lip, hence hardly visible, which is magnified by the absence of the maxillary occlusion rim. Corrective trimming and contouring of both wax rims served as an analogue for the mouth's neutral zone and culminated in optimal positions of both occlusal plane height and overall esthetic satisfaction with the position of the prosthetic teeth as seen in **B.**

neurological function (Parkinson's disease). A good reminder of the significance of this observation is the drooling that frequently occurs when a patient with an inferior alveolar local anesthesia block attempts to drink.

The practical application of this approach lies in establishing the height of the occlusal plane and developing the polished surface of the denture in the occlusion rims (Fig. 9-8). The corners of the mouth are marked on the occlusion rims to provide the dentist and technician with anterior landmarks for the height of the first premolars. The retromolar pads are relatively stable posterior landmarks, even in patients with advanced ridge reduction. The mandibular first molar is usually at a level corresponding to two thirds of the way up the retromolar pad (see Fig. 9-4). The retromolar pads are circled on the final casts, and the land of the cast (edge) is marked at points that are one half to two thirds of the height of the pad. These points will aid in determining the height of the distal end of the occlusal plane. The anterior and posterior landmarks are joined when the wax is melted to this level with a hot spatula. The resultant occlusal plane is almost invariably parallel to the residual alveolar ridges and to the interpupillary line. Its height will conform to activities of the tongue, cheek, and corner of the mouth, which tend to enhance mandibular denture stability. The maxillary occlusion rim is next adjusted to meet evenly with the mandibular rim. Following determination of the preferred VDO, one or both rims might have to be slightly augmented or reduced until an adequate functionally determined interocclusal distance is obtained. The anterior position of the maxillary occlusion rim is finally modified so that the lower lip gently caresses the rim during pronunciation of the letter F (as in counting from 50 up to 55).

There are other approaches to occlusal plane determination. For example, some dentists use a technique whereby the starting point for establishing the occlusal plane is the maxillary occlusion rim. The procedure entails shaping the occlusion rim so the incisal plane is parallel to the interpupillary line and is at a height that allows for the length of the natural tooth plus the amount of tissue resorption that has occurred. The upper lip also can be a guide if it is of average length. The occlusal plane, posteriorly, is made to

parallel the ala-tragus line on the basis of the position of most natural occlusal planes. Then the lower occlusion rim is adjusted to meet evenly with the upper rim and reduced until sufficient interocclusal distance has been obtained. This procedure is reported as adequate for many patients and usually produces satisfactory results.

ESTABLISHING THE DESIRED VERTICAL DIMENSION OF OCCLUSION

The VDO is established in the presence of a healthy natural dentition as part of the process of jaw development and maturation. However, in the course of a person's lifetime, many things can happen to the natural teeth. Some are lost to periodontal disease or damaged by caries, others are so worn down that they lose their clinical crown length, while others are restored in a manner that fails to maintain their full clinical crown length. Consequently, even patients who have retained their natural teeth may have a changed or reduced occlusal vertical dimension. As a result, preextraction vertical measurements may not be reliable indicators of the dimension to be incorporated in immediate or new complete dentures. On the other hand, any preextraction information available (e.g., old study casts, photographs or previous dentures) should be regarded as a possible clue in the determination of VDO for an edentulous patient.

The most frequently used tests that aid the dentist in establishing the correct VDO by means of occlusion rims are

1. Visual observation of the space between the rims when the mandible is in its physiological rest position.
2. Judgment of the overall esthetic facial support.
3. Phonetic tests that include observations when the "s" sound is enunciated accurately and repeatedly—the average speaking space.

It must be emphasized that these tests are particularly effective if the patient's old dentures are used for comparison. Old dentures can be valuable for prognostic purposes, especially if they are used with treatment liners to recover an optimal VDO. Old dentures also can have their facial surfaces selectively augmented with a soft wax to assist the dentist in assessing the required cosmetic support from the dentures' polished surfaces.

The mandible's physiological rest position dimension provides an indication of the appropriate VDO because it is simply a few millimeters longer. The difference between the two is the interocclusal distance or so-called "freeway space" and is usually 2 to 4 mm when observed at the position of the first premolars. This is not an exact guide; however, it can be used as a starting point for other methods in the final determination of the vertical relation of the mandible to the maxillae. One method is to have the patient sitting in an upright relaxed position and the head unsupported. After insertion of the suitably contoured wax occlusion rims, the patient swallows and lets the jaw relax. When relaxation is obvious, the lips are parted to reveal how much space is present between the occlusion rims. The patient must allow the dentist to separate the lips without moving the jaws or lips or trying to help the dentist. The interocclusal distance at the rest position should be between 2 and 4 mm when viewed at the premolar region. The interarch space and rest position can be measured by means of indelible dots or adhesive tape on the face. If the difference is greater than 4 mm, the occlusal vertical dimension may be considered too small; if it is less than 2 mm, the dimension is probably too great. The occlusion rims are adjusted until the dentist is satisfied with the amount of interarch space and until other requirements of an acceptable vertical dimension have been obtained, such as patient comfort and phonetic and esthetic considerations. It is worth noting that the presence or absence of dentures or occlusion rims in the mouth can affect the vertical dimension of physiological rest position, and this dimension is more relevant when assessed with dentures or when occlusion rims are actually in the patient's mouth. The actual method used for determining the position (e.g., relaxation, swallowing, or phonetics) also may modify its vertical level, and dentists must keep this in mind when using the rest position as a guide for establishing vertical maxillomandibular relations.

It is essential that an adequate interocclusal distance exist when the mandible is in its physiological rest position. However, results of experimental research have shown that a rapid adaptation can take place after changes of the vertical dimension, leading to another rest position and creation of a new interocclusal distance. This seems to occur even after an increase that was greater than the original interocclusal distance. Such findings indicate that the rest position alone is not a reliable basis for the determination of maxillomandibular relations and that small variations of the vertical dimension are not so critical because the adaptive capacity of the masticatory system usually is great. Nonetheless this observation must be cautiously applied, particularly in elderly patients with long-standing edentulism given the greater likelihood of their limited adaptive potential.

ESTHETICS

The vertical relation of the mandible to the maxillae also affects esthetics. A study of the skin of the lips compared with the skin over other parts of the face can be used as a guide. Normally the tone of the facial skin should be the same throughout. However, it must be realized that the relative anteroposterior positions of the teeth are at least equally as involved in the vertical relations of the jaws as in the restoration of skin tone (Fig. 9-9). The contour of the lips



Figure 9-9 The combination of favorable skin tone and correct prosthetic teeth placement as seen in **A** and **B** can provide very satisfactory and highly appreciated results for patients irrespective of their age or gender. At the initial try-in appointment for the patient in **B,** it became clear that the anterior teeth had to be reset more anteriorly to obtain the desired overall esthetic outcome. **C,** Note the more labial placement of the prosthetic teeth on the left side as opposed to the incorrect original setup's positions on the right side. This protocol provided both dentist and patient with an opportunity to compare different setup arrangements very readily and led to the preferred results in **B.**

depends on their intrinsic structure and the support behind them. Therefore the dentist must initially contour the labial surfaces of the occlusion rims so they closely simulate the anteroposterior tooth positions and the contour of the base of the denture. This contoured surface should replace or restore the tissue support provided by the natural structures. If the lips are not properly supported anteriorly, they will be more nearly vertical than when supported by the natural tissues. In such a situation, the tendency is to increase the VDO to provide support for the lips, and this can lead to excessive lower face height.

PHONETICS (SEE CHAPTER 15)

Phonetic tests of the vertical dimension include listening to speech sound production and observing the relationships of teeth during speech. The production of "ch," "s", and "j" sounds brings the anterior teeth close together. When correctly placed, the lower incisors should move forward to a position nearly directly under and almost touching the upper incisors. If the distance is too large, it means that too small a VDO may have been established. If the anterior teeth touch when these sounds are made, the vertical

dimension is probably too great. Likewise, if the teeth click together during speech, the vertical dimension is probably too great.

MECHANICS

Additional methods for determining vertical maxillomandibular relations at the occlusion rims stage include mechanical ones such as the following:

- **Relationship of Incisive Papilla to Mandibular Incisors:** The incisive papilla is a stable landmark that changes comparatively little in spite of resorptive changes in adjacent alveolar ridge. The distance of the papilla from the incisal edges of the mandibular anterior teeth on diagnostic casts averages approximately 4 mm in the natural dentition. The incisal edges of the maxillary central incisors are an average of 6 mm below the incisive papilla. Therefore the mean vertical overlap of the opposing central incisors is about 2 mm (Fig. 9-10). It is important to remember that these are average measurements with considerable individual variation noted. They should be used with caution, and they do not appear to be relevant in patients with severe residual ridge resorption.
- **Parallelism of the Ridges:** When present, parallelism of the maxillary and mandibular ridges often gives a clue as to the appropriate amount of jaw separation. Since clinical crowns of the anterior and posterior teeth have nearly the same length, their removal tends to leave the residual alveolar ridges nearly parallel to each other. This parallelism occurs frequently, provided there has been no abnormal change in the alveolar process such as previous advanced periodontal disease or grossly overerupted teeth. Ridge parallelism is favorable from a mechanical point of view because occlusal loading on the dentures is less likely to cause them to slide anteriorly or posteriorly. However, in most people, the teeth are lost at different times, and when a person finally becomes edentulous, it often is observed that the residual ridges are no longer parallel. In addition, the edentulous ridges of the mandible and maxillae will become progressively more discrepant from the standpoint of width.

When used alone, the methods just discussed will not yield an appropriate VDO reliably in all patients. It is appropriate therefore to use one or more of the methods to approximate the relationship and then to use other methods to independently test the appropriateness of the relationship initially estimated. When different methods used for determining the VDO appear to yield similar results, this (still preliminary) estimate should be regarded as the vertical height at which teeth should be set. The next step of making a horizontal centric jaw relation record will be taken at this vertical dimension for transfer to the articulator.

Of course, a further assessment and confirmation of this tentative determination will occur later at the try-in appointment, when teeth are set in the wax trial dentures and the VDO is verified in the mouth. At that time, these methods can again be used to confirm the VDO before completion of the dentures.

THE PRELIMINARY CENTRIC RELATION RECORD (BOX 9-1)

The vertical and horizontal relations of the jaws are integral components of the CR position in edentulous patients. This is made after the height of the mandibular occlusal plane has been determined, the occlusion rims have been contoured to simulate the position that will be occupied by the artificial teeth and tissues of the complete dentures, and the preferred interocclusal space has been established. The occlusion rims then are used to establish a preliminary CR record for transfer via an arbitrary mounting, or by means of a facebow, to an articulator.

There is extensive dental literature in which concepts, definitions, and methods for recording the horizontal jaw records are discussed. Even though there are many varying opinions on details, there seems to be a consensus that a correct registration of CR is essential in the construction of complete dentures. Many dentures fail because the occlusion is not planned or developed to include this position. CR is the horizontal reference position of the mandible that can be routinely assumed by edentulous patients under the direction of the dentist. It is possible for dentists to verify the relationship of casts on the articulator when they are mounted in CR. It appears that the most critical factor in addressing the denture's third or occlusal surface is an appropriate CR record and that the use or nonuse of a facebow is of minor importance. Therefore it is recommended that regardless of whether an arbitrary facebow is used or not, the CR record should be made at or very close to the selected VDO. In this way, the potential errors of not having recorded a true hinge axis are greatly reduced.

Furthermore, most clinical educators agree that the actual method of transferring a centric jaw relation record to the dentist's articulator of choice is arguably irrelevant. Several excellent methods or techniques are available, but what counts is that the record is correctly mounted on the articulator before proceeding with the setting up of the prosthetic tooth. Therefore this next clinical step, making an interocclusal CR record, is a crucial one. It must be carried out impeccably if time-consuming clinical repeat activities are to be avoided. Interocclusal records are described as static, graphic, or functional. Static records are made with a soft material interposed between the two rims. The material used (e.g., wax) hardens to provide a "checkbite" record, which is stable and very easy to use. The consistency of the recording material is of significance: it must not offer resistance during mandibular closure, or it

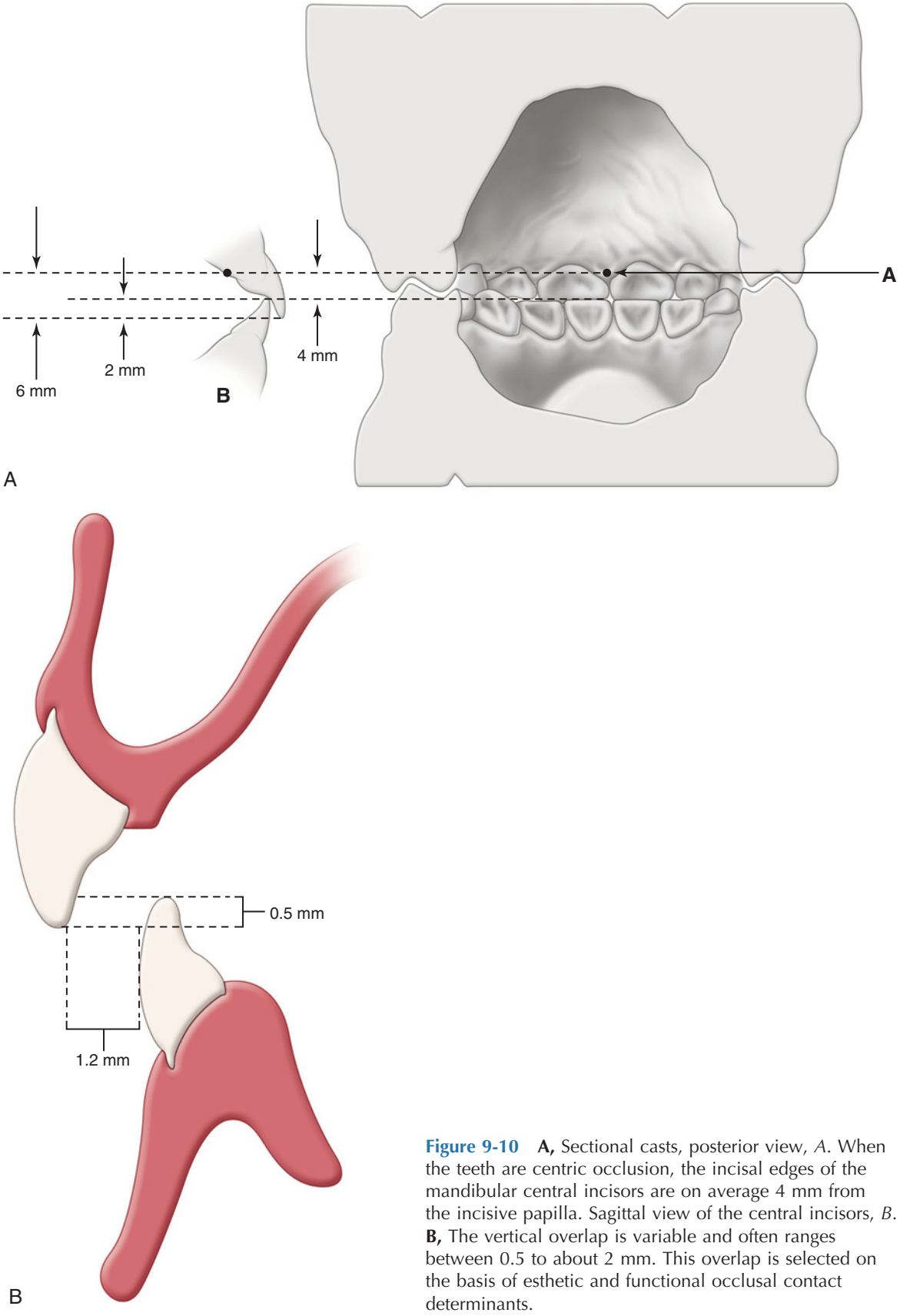


Figure 9-10 **A,** Sectional casts, posterior view, *A*. When the teeth are centric occlusion, the incisal edges of the mandibular central incisors are on average 4 mm from the incisive papilla. Sagittal view of the central incisors, *B*. **B,** The vertical overlap is variable and often ranges between 0.5 to about 2 mm. This overlap is selected on the basis of esthetic and functional occlusal contact determinants.

Box 9-1 Summary of the Clinical Steps Required to Develop the Polished Surfaces and Prepare the Occlusion Rims for Transfer to an Articulator

1. Ensure well-fitting, retained, and stable TDBs. The retention may occasionally have to be aided with a denture adhesive. Overall stability will be enhanced after design of the arch form, or neutral zone.
2. Establish the neutral zone by considering the following:
   - Arch forms' location in previous dentures (if present)
   - An assessment of the amount and pattern of bone loss
   - Use of anatomical landmarks
   - Preliminary esthetic evaluation
3. Determine the height of the occlusal plane in the mandibular occlusion rim:
   - Use corners of the mouth as the anterior landmarks
   - Use the retromolar pads (two thirds up) as the posterior landmarks
   - Join all four points with a hot, broad wax spatula
4. Establish the VDO by modifying the height of the occlusion rim while ensuring the following:
   - An even meeting of both rims in CR position
   - An interocclusal distance that the dentist judges as being functionally adequate for the patient in question
5. Prepare rims for a CR registration with grooves in the maxillary wax and opposing box-shaped areas in the mandibular wax.
6. Return the occlusion rims to the mouth for repeated trial closures. The CR record is made with the dentist's preferred registration medium. The CR record is confirmed and remade, if requested, until a repeatable CR record is established.
7. The occlusion rims are next placed on the master casts and transferred to an articulator of choice (with or without employing a facebow for the sake of convenience) and are now ready for the setup of the prosthetic teeth.

will inadvertently guide the path of the mandible as it approaches the point of the static record. On the other hand, once set, the recording material must have sufficient strength and rigidity to retain the relationship between the occlusion rims and support the models during the mounting process. Several registration materials are acceptable for this purpose, and the selection is usually made on the basis of convenience and experience. All these methods are believed to be accurate and useful but the preferred method is the static technique because of its ease of reproducibility and repeatability. The technique (see Fig. 9-3, *C* and *D*) is carried out as follows:

1. The mandibular occlusion rims are trimmed to conform to the two pairs of previously described landmarks—the right and left corners of the mouth and a point two thirds of the way up the retromolar pads. The maxillary wax rim is next melted with a hot spatula to meet evenly with the mandibular occlusion rim, and at the desired level as judged by the described clinical methods in the text.
2. Small (3 to 4 mm deep) V-shaped grooves are placed bilaterally in the first molar–second premolar region of the maxillary occlusion rim. These areas are lubricated with a petroleum jelly, and the maxillary occlusion rim is placed in the mouth. If the anterior rims are also in contact, it is possible to prepare a similar groove in the region of the maxillary central incisor.
3. Box-shaped areas (2 to 3 mm deep) in the corresponding opposing areas of the mandibular occlusion rim are next prepared and then filled with the chosen registration material (e.g., softened beeswax). The mandibular occlusion rim is next placed in the mouth.
4. The comfortably seated and upright patient has his or her head supported by a suitable headrest. The dentist guides the patient's mandible into a CR position while stabilizing the mandibular trial base with the forefinger and thumb of one hand and using the thumb and fingers of the other hand to guide the mandible. The fingers stabilizing the base also can be moved upward to stabilize the maxillary base, if required. In this manner, the base's stability is ensured, and the mandible can be guided while visibility is retained. Alternative hand positions are advocated by different clinicians.
5. The patient and bases must be kept immobile while the material is setting. This may simply not be possible for some patients, especially where mandibular residual ridge resorption is extensive or neuromuscular control is compromised. Clearly, implant or natural teeth abutment–stabilized occlusion rims solve this problem quite easily. The advantage of a wax recording medium lies in its allowing the operator to guide mandibular opening and closure into the soft wax to verify the record's accuracy.

It is prudent to rehearse the previously described maneuvers before the recording medium is actually introduced. The trial bases should be taken out of the mouth, excess recording material removed, and the distal areas of the bases checked to ensure that they do not contact distally. This is a frequent site for recording errors. The accuracy of this record should be checked and rechecked before proceeding to an articulator mounting. The use of frequent trial closures, plus a practical and meticulously applied technique, will yield accurate results. Any additional checks or tests that ensure an accurate CR record are strongly endorsed.

Infrequently, the preliminary CR record is an incorrect one and undiagnosed at this appointment. It will, however, become apparent at the try-in appointment when a new record and remount will have to be made. This is a time-consuming step and hopefully should not be required. However, it must be recalled that clinical determination of occlusal discrepancies is more readily discernible with prosthetic teeth in place than with wax occlusion rims. The problem can always be rectified, although additional chair-side and laboratory time is required.

RELATING THE PATIENT TO THE ARTICULATOR

Prosthetic teeth and their supporting denture bases are designed both to be esthetically pleasing and to enable patients to function comfortably and confidently throughout the required range of mandibular movements. The prosthetic teeth and their denture bases must therefore be arranged/designed so that the artificial dentition's occlusal surfaces can contact and glide over one another smoothly, without dislodging the denture bases.

If it were practical to do so, the patient's mouth would serve as the best articulator. However, it is mechanically impossible to perform intraorally many of the procedures involved in the construction of complete dentures. This objective is precluded by movement of the trial dentures, difficulties posed by the presence of saliva, and the patient's ability to cooperate. The convenience for the patient, the dentist, and the dental laboratory technician dictates that an analogue for jaw movements, an articulator, be used. This entails mounting the occlusion rims and their supporting casts on an articulator, which can be done in a freehand manner or else via a facebow.

FACEBOW

The facebow is an electively used instrument that carries the relationship between the maxillae and the condyles from the patient to the articulator. It is placed on the face, with the condyle rods located approximately in the region of the hinge axis, which will be near the condyles (Fig. 9-11).

The facebow is a caliper-like device that is used to record the relationship of the jaws to the opening axis and to orient the casts in this same relationship to the opening axis of the articulator. It is important to note that this is a relationship between the jaws and the axis of movement, not an anatomical relationship between the jaws and the temporomandibular joints (TMJs), except to the extent that the axis of movement might happen to be near the TMJs. (Many dentists and dental technicians also consider the facebow a convenient instrument for supporting the casts while they are being attached to the articulator.) The instrument consists of a U-shaped frame or assembly that

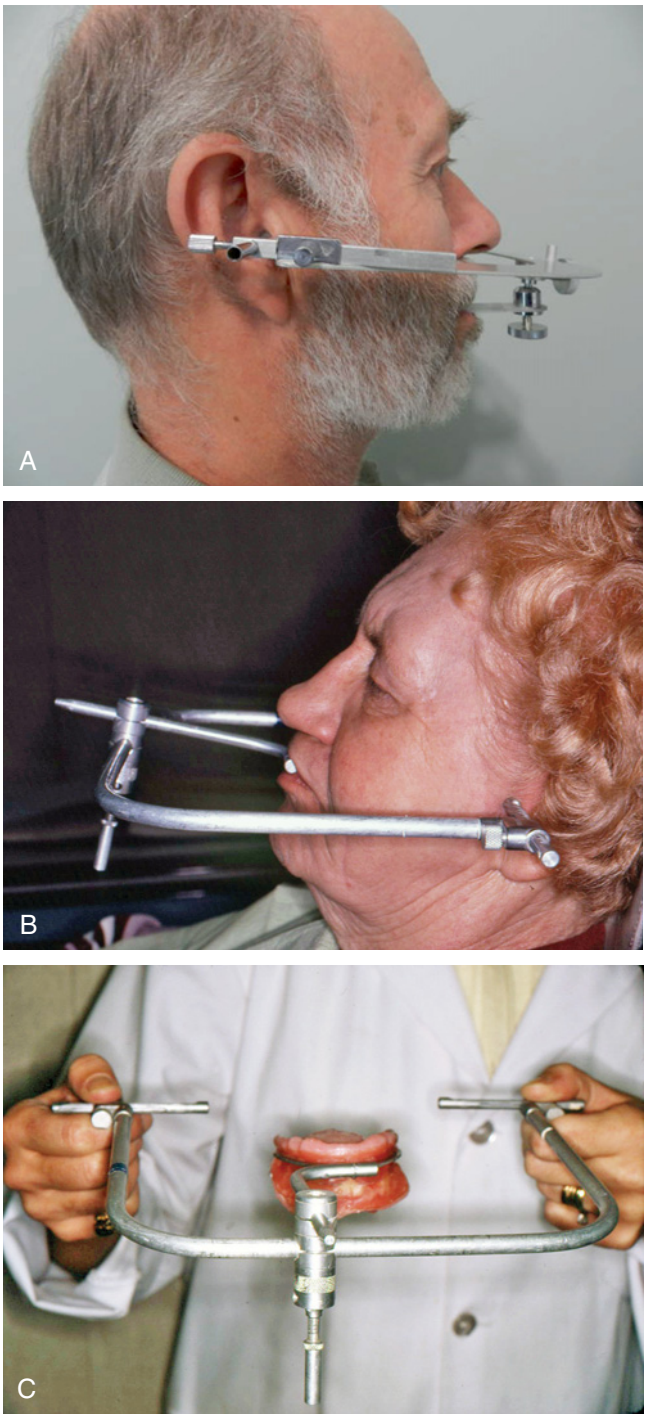


Figure 9-11 Facebows may fit directly into each ear's external auditory meatus **(A),** or else have their rods placed over an approximate location of the so-called "hinge axis" **(B).** The bite fork is placed on the labial aspect of the articulated wax occlusion rims and carried to the articulator **(C)** so as to facilitate mounting the edentulous working casts on a selected arcon-type articulator.

is large enough to extend from the region of one TMJ around the front of the face (5 to 7.5 cm in front of it) to the other TMJ and wide enough to avoid contact with the sides of the face. The parts that contact the skin near the TMJs are the condyle rods, and the part that attaches to the occlusion rim is the fork. The fork attaches to the facebow by means of a locking device, which also serves to support the facebow, the maxillary occlusion rim, and the maxillary cast while the casts are being attached to the articulator. The fork of the arbitrary facebow is attached to the maxillary occlusion rim, so the record is a simple relationship between the upper jaw and the approximate axis of the jaw opening.

Some facebows are designed to fit directly into the external auditory meatus. This type of design is easier to manipulate clinically than holding the condylar rods over the hinge axis markings while the bite fork is tightened in position. An average distance from the external auditory meatus to an arbitrary hinge axis is built into the facebow design. This distance is compensated for in the articulator by offsetting the mounting points an equivalent amount.

There is much in the prosthodontic literature that maintains that a facebow transfer is essential for avoiding errors in the occlusion of finished dentures. Indeed it is easy to acknowledge the theoretical advantages of using a facebow to orient the casts to the hinge axis of the articulator. It should be remembered, however, that these theoretical advantages might not necessarily produce a better clinical end result. Results of one of the few systematic studies made to compare patient response to variations in denture technique failed to show any significant differences between a "complex" technique involving hinge-axis location for a facebow transfer to the articulator and a "standard" technique without facebow and with an arbitrary mounting. Similar clinical results with dentures constructed by the two techniques were found at both short-term and long-term recall assessments. The investigation included dentists' evaluation of occlusion, denture stability, retention, and condition of the denture-bearing tissues with patients' satisfaction and adaptation. The results indicated that while the success of denture treatment involves many factors, the use of a facebow is not an essential one. It appears that scrupulous clinical control over establishing the three surfaces of dentures as accurately as possible via utilization of different techniques can be quite readily achieved, although a need for adjustments will be necessary with any method. The argument that a facebow is helpful in supporting the maxillary cast while it is being mounted on the articulator may be true. However, an arbitrary mounting of the maxillary cast can be accomplished on any articulator with any convenient support material by aligning the occlusal plane of the wax occlusion rim horizontally and parallel to the arms of the articulator.

The first step in this process is to mark the approximate location of the hinge axis on the skin on each side of the patient's face. One frequently recommended method is to position the condyle rods on a line extending from the outer canthus of the eye to the top of the tragus of the ear and approximately 13 mm in front of the external auditory meatus (see Fig. 9-11, *A*). This placement generally locates the rods within 5 mm of the true center of the opening axis of the jaws. The imaginary line joining the two points is an approximate hinge axis. The patient can help hold the occlusion rim firmly seated by either biting against it, using the suitably formed mandibular occlusion rim, or guiding the patient into the already achieved CR position with the mandibular occlusion rim in place. This biting or CR position is used for the practical purpose of holding the maxillary rim firmly seated

In the final clinical step, the condylar rods of the facebow are positioned over the condylar markings, thus recording the approximate hinge axis. The patient can help by holding the condylar rods in place while the clinician locks the bite fork to the facebow. This locks the relationship between the maxillae and the approximate hinge axis through the occlusion rim, the bite fork, and the facebow. This relationship can now be carried to the articulator (see Fig. 9-11, *B*).

LABORATORY STEPS

The first step in relating the maxilla to the articulator is to ensure that the articulator is locked in the CR position. The condylar balls are thus immobilized in their housings during the steps that follow. The next step is to attach the facebow ear rods to the instrument with special connections that match one to the other. This usually is done either by altering the distance between the ear rods until they fit the width of the articulator hinge pin, or the reverse, by altering the width between the articulator condylar housings until they fit the distance between the ear rods. The latter arrangement is theoretically advantageous because altering the width between the condylar balls will change the arc of rotation of the nonworking side condyle. This may be significant in fixed prosthodontics but probably is irrelevant for complete denture construction.

The ear rods on the hinge axis represent two points of attachment between the facebow and the articulator. To hold the maxillary occlusion rim and cast firmly in three dimensions, a third point of reference must be set. Some facebows use an infraorbital pointer, set to approximate the infraorbital foramen on the patient with a matching indicator on the articulator. Others use a nasion relator for the same purpose. The intent of these "third point" recording devices is to position the occlusal plane on the articulator so that the arms of the instrument are approximately parallel to the patient's Frankfort plane. However, because the articulator is designed to reproduce the movement of the mandible and not the anatomy of the maxillomandibular relations, the need for the third point becomes moot. The articulator will be programmed to move relative to the occlusal plane at any angulation within the mechanical

limits of the instrument. As a practical matter, it is easiest to work with the instrument if the occlusal plane is positioned about halfway between the upper and lower members, with the midline of the models in line with the incisal pin. The facebow can be supported on the lab bench at this level while the plaster is poured on the maxillary cast to join it to the upper member of the articulator.

Given that the use of a facebow has been found not to be essential for successful denture construction and that the articulator reproduces the movement of the mandible, not the anatomical facial relationships, the cast of the maxilla can be mounted by any convenient arbitrary method that is within the working limits of the articulator. The maxillary occlusion rim supporting the maxillary cast could be held in place by an easily molded ball of clay, while the plaster is added to the upper member to lock the cast in place. As just noted, it is usually easiest to work with the articulator if the occlusal plane is roughly parallel to the upper and lower members and about halfway between them, and the midline is approximately coincident with the incisal pin.

As noted earlier, the relationship of the mandibular cast to the lower member of the articulator is established indirectly by the relationship between the mandible and the maxilla—the CR record. This relationship is achieved very simply by inverting the articulator and relating the mandibular occlusion rim to the maxillary with the CR record. This provides support for the mandibular cast while plaster is placed to join it to the lower member.

ARTICULATORS

Articulators are instruments that attempt to reproduce the range of movement of the jaws. Maxillary and mandibular casts can be attached to the articulator, so that the functional and parafunctional contact relations between the teeth can be studied. Diagnosis of teeth and jaw relation, the arrangement of the artificial teeth, and the development of the occlusal surfaces of both removable and fixed restorations commonly employ articulators in clinical practice.

Some articulators are very simple, consisting of nothing more than a simple hinge (Fig. 9-12, *A*). These articulators do little more than simulate the hinge motion of the mandible and hold the casts in CR at the established VDO. At the other extreme, complicated articulators, requiring very complex recording apparatus, aim to simulate all the nuances of jaw movement. It should be noted, however, that no articulator exactly reproduces the full range of jaw movement, nor is the reproduction of such a range required for fabricating any kind of prosthesis. In between is a series of instruments that provides a more or less accurate reproduction of movement. The challenge for the dentist is to choose an articulator that is suitable for the purposes at hand, neither more nor less complicated than necessary. This requires an understanding of what the instrument will and will not do, as well as a grasp of the treatment objectives for the given patient.

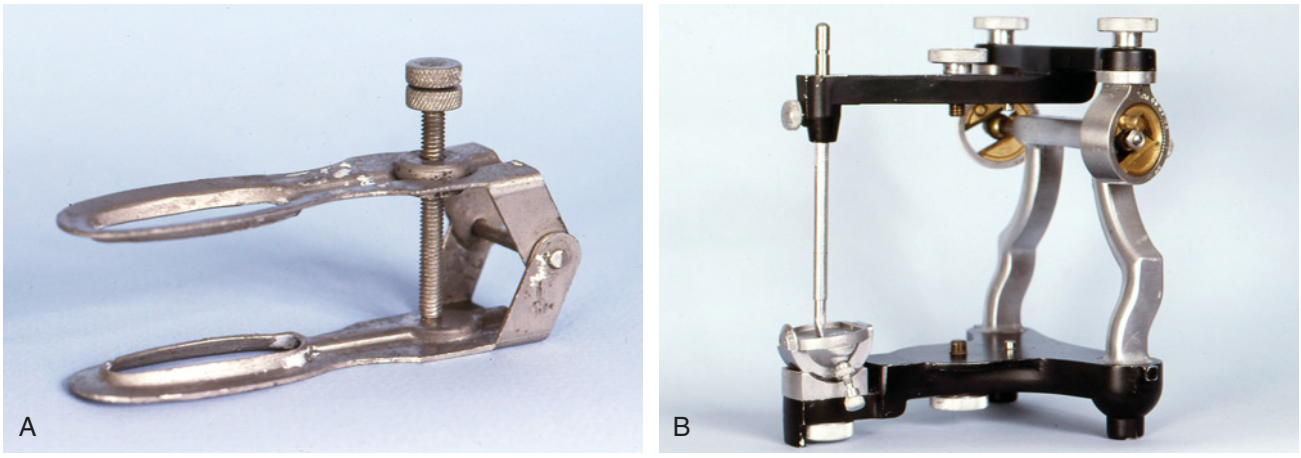
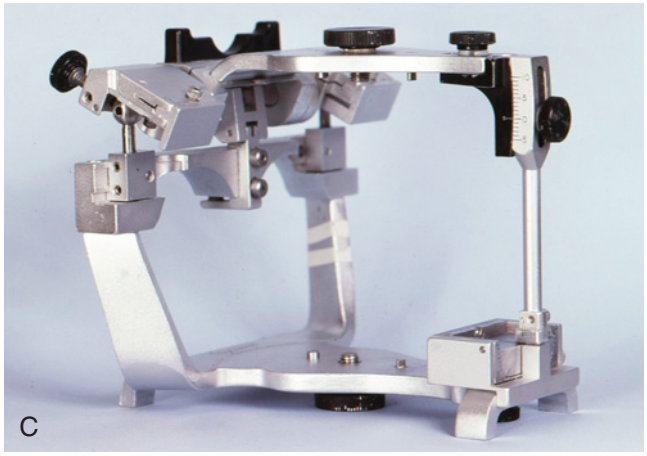


Figure 9-12 Three articulators: the simple hinge type **(A)** and arcon types that permit more accurate simulation of occlusal teeth contact determined jaw movements (**B** and **C**). The latter two also possess incisal guide tables that lend themselves to versatile use and a diversity of anterior and lateral teeth contact arrangements and designs. **D,** An arcon-type articulator superimposed upon a dry skull to suggest the theoretical merits of using a facebow for mounting the maxillary cast in a related hinge axis position. This would presumably provide an anatomical similarity of the resulting relationship between the teeth and the condyles. It must, however, be emphasized that even if this were to be the case, it would not ensure that the articulator's movements could provide a better clinical result when making complete dentures.

Continued



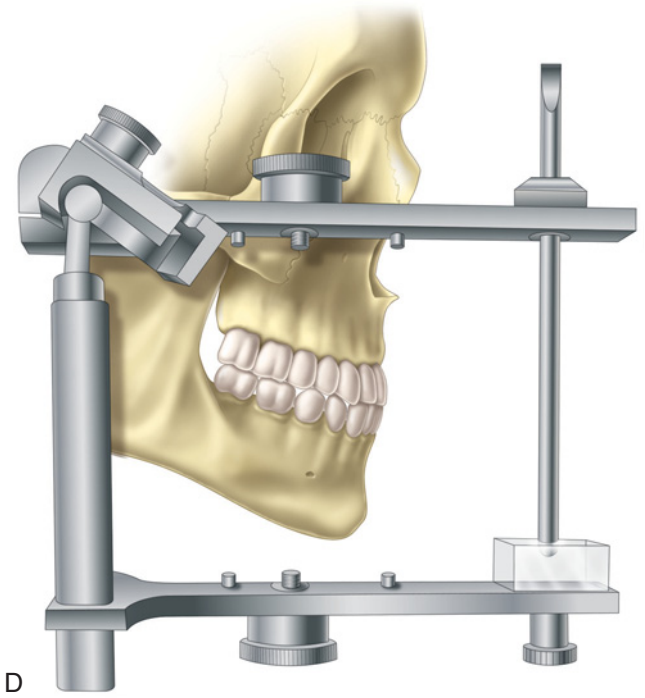


Figure 9-12, cont'd.

Most articulators in common use today are adjustable to different extents and attempt to reproduce the jaw movement of each patient's jaw by trying to reproduce the anatomy of the jaw joints and related structures (Fig. 9-12, *B* to *D*). Although this approach has the benefit of being intuitive, it ignores certain realities of the biological system. For example, the great variation in movements at the TMJs within the envelope of motion is virtually impossible to reproduce mechanically. Furthermore, the movement of the occlusion rims on the underlying ridges is not reflected on the instrument. It is important then to recognize that the adjustments done on an articulator are not attempts to make the instrument more anatomically correct, but rather they are attempts to more closely simulate the motion of the mandible regardless of the anatomical appearance of the settings that result.

TYPES OF PATIENT RECORDS

Three general classes of records are used for transferring maxillomandibular relationships from the patient to the articulator: interocclusal records, hinge-axis records, and graphic records. The simplest articulators are designed to accept only interocclusal records, whereas the more sophisticated instruments are capable of providing adjustments in response to all three types of records.

INTEROCCLUSAL RECORDS

Virtually all articulators will accept at least some interocclusal records. An interocclusal record simply provides a measure of one single positional relationship of the lower jaw to the upper jaw. That position might be CR, centric occlusion, or any point in lateral or protrusive excursions. The CR position establishes a "static" relationship of the jaws, whereas the protrusive and lateral records permit adjustment of the articulator components to perform variations in the movement pattern of the casts over one another. The instrument then interpolates between records (with varying degrees of accuracy) to provide a representation of the full range of jaw movement.

The accuracy of the articulator's movement depends on the variety of adjustments it is capable of accepting. Each adjustment adds a refinement to the path of the movement, making it slightly more faithful to the complex movement of the biological system. The mechanical features that contribute to these nuances include the following:

- Individually adjustable condylar guidances: These adjustments determine the amount the condyles move downward as they move forward. The downward movement may be relatively shallow early in the forward movement, and steeper later in the excursion, or the reverse. In other words, the direction of movement is

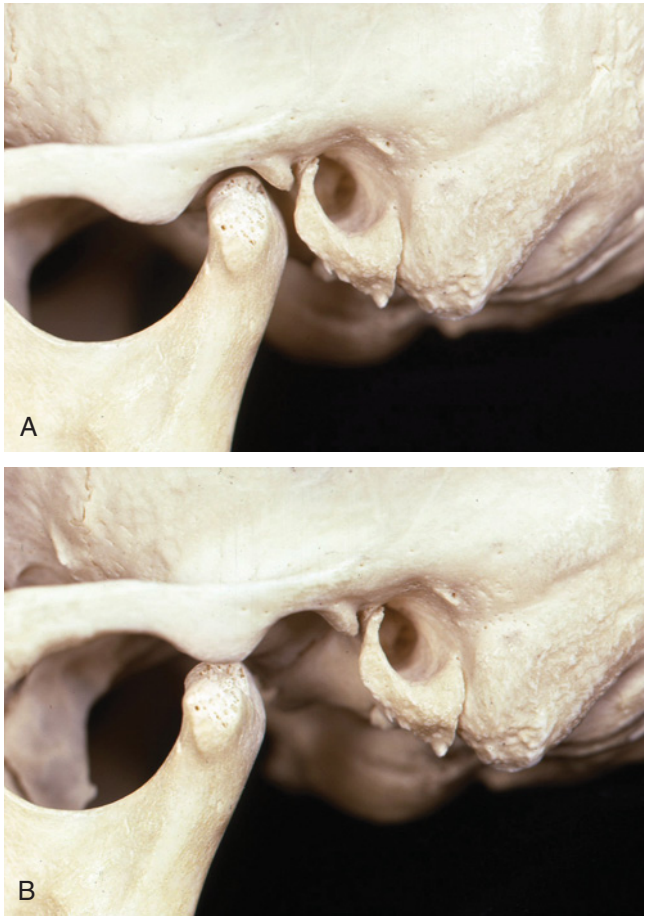


Figure 9-13 **A** and **B,** The start and end points of the resultant curved condylar movement over the fossa is suggested on these dry skull pictures. However, this movement occurs in a straight path in the vast majority of articulators in current general use, as per the point made in Fig. 9-12, *D*.

not likely to be constant throughout the full range of the excursion, and it could take the shape of a complex curve over the range. Furthermore, it could be different for each side. It is unlikely, however, that this curvature is significant in the construction of complete dentures, because other factors have a far greater influence on the movement. Most articulators in general ignore the curvature and simply provide for a straight line of movement from CR to the extremes of the border limits. It is important to note, however, that this downward movement is not a measure of the shape of the articular eminence. Rather, it is a record of the direction of movement of the condyle over the eminence (Fig. 9-13).

- Variable intercondylar distances: The intercondylar distance (something of a misnomer) is simply a measure of the radius of the arc of the rotating condyle as it moves in lateral excursions. In other words, it is not a measure of the actual distance between the condyles.
- Variable controls for the Bennett (direct lateral) shift: These controls record the amount the mandible shifts bodily in a lateral direction in addition to the rotational movement in lateral excursions. The amount of the shift may be different on the different sides of the patient. Together with the intercondylar distance, it helps define the path that the lower cusps will take in lateral movements of the mandible.
- Split-axis condylar guidance controls: These controls allow the Bennett shift in the instrument to be upward, downward, backward, or forward as the articulator is moved into lateral positions. Like the curvature in the horizontal condylar guidance, this adjustment often is ignored in complete denture construction.
- Adjustable incisal guidance controls: These controls are primarily influenced by the relationships between the incisor teeth. Thus, they may not have much influence in complete denture construction, except in situations where esthetic or phonetic demands require a deep overbite situation.

GRAPHIC RECORDS

A shortcoming of the interocclusal records is that they provide accurate relations between the casts only at the jaw positions where they were taken. The articulator must interpolate the movements between the record points. Because the border movements of the jaw typically are curved, an articulator programmed using only interocclusal records is likely to be inaccurate. Graphic records capture these curved limits, and an articulator capable of curved movements can be programmed to accept these records, thus yielding a more accurate reproduction of the jaw movements.

However, obtaining accurate records from the patient requires that the graphic writing apparatus be firmly fixed to the jaws. This is not difficult where teeth are present, but is much more problematic where the patient is edentulous and the attachment can be made only through occlusion rims. The graphic records are inaccurate as a result and therefore offer no advantage over the more arbitrary interocclusal records. The extra capability of an articulator that will reproduce curved movements is, therefore, of no use when designing complete dentures.

HINGE-AXIS RECORDS

As the patient's jaw opens and closes, the posterior border of its movement—at least in the earliest phases—is the arc of a circle. So it is with the articulator. Similarly, other movements of the jaws occur in arcs. For a faithful reproduction of those movements, the axes of those arcs should be coincident between patient and instrument, particularly where the patient's vertical dimension is to be changed. The kinematic facebow is designed to locate and record the hinge axis. However, there is evidence that this cannot be transferred to the articulator reliably, even in dentate

patients. Furthermore, as for graphic records, it is even more difficult in the edentulous patient. Consequently this step usually is ignored in complete denture construction in favor of an arbitrary location using facial landmarks. This method provides a substantially less accurate estimate of the location of the true hinge axis, but evidence suggests that there is no clinical impact from this loss of accuracy.

The compromises contained in all these factors are what drive the selection of an articulator for use in full denture construction and are the basis for the remainder of this chapter.

ON SELECTING AN ARTICULATOR FOR MAKING COMPLETE DENTURES

The large number and great range in complexity of modern articulators can make the choice of an instrument potentially difficult. However, the choice is greatly simplified if one considers the accuracy of the records obtainable and what the instrument will be required to do.

As noted earlier, it would be extremely difficult to obtain accurate graphic records, so sophisticated, fully adjustable articulators that reproduce the curves of the broader movements are unnecessarily complex. Similarly, instruments that require a kinematic facebow transfer to locate the hinge axis offer no advantage.

At the other extreme, the simple hinge articulator can be relied on to preserve the CR position precisely, provided the original interocclusal record is accurate, and the instrument itself is rigid. Occlusal contacts in the CR can thus be perfected with confidence. However, this instrument cannot be used to relate the occlusal surfaces in excursive movements because it cannot accept even simple eccentric interocclusal records. Refining nonworking side contacts for balanced occlusion is thus not possible on this type of instrument.

Between the extremes is the semiadjustable articulator, which will accept an arbitrary facebow record and interocclusal records. This instrument has individually adjustable condylar guidances both horizontally and vertically. Most such instruments in use today are arcon instruments ("Arcon" is a contraction of the words *articulator* and *condyle*), meaning that the condylar guidance is located in the upper (cranial) member on the articulator, and the ball (condylar analogue) is located in the lower (mandibular) member (see Fig. 9-12, *D*). The use of this instrument in complete denture construction is discussed in the remainder of this chapter.

PROGRAMMING THE ARTICULATOR

The CR record is an essential record that is used to mount the casts on the articulator. The instrument is thus programmed already in two significant respects: the casts are related together in CR, as well as the selected vertical dimension of occlusion (provided by the trimmed occlusion rims). It must be acknowledged that this recorded information is widely regarded as being all that is essential for fabricating complete dentures. How, or whether, the articulator is programmed beyond the basic preceding parameters will depend on the clinical records that are taken and the ability of the articulator to accept these records. It also will depend on the plans of the clinician, particularly the choice of posterior tooth mold and the overbite-overjet relations. It is important to recognize that many prosthodontic educators regard the additional time spent programming the posterior (condylar) and anterior (incisal) elements of the articulator as yielding even more accurate occlusal surface results in complete denture fabrication.

Condylar Elements (Fig. 9-14, *A*)

As the mandible moves forward in protrusive excursions, the condyles typically move downward, separating the posterior teeth. Therefore, the amount by which the posterior teeth are separated is a measure of the amount the condyles move downward as they move forward (ignoring for the moment the effect of the incisal guidance). An interocclusal (protrusive) record that captures the posterior separation between the occlusion rims in the patient's mouth can be replaced between the rims on the articulator. To make the record fit the rims again, the condylar balls will have to be unlocked from the CR positions and moved forward. They also will have to move vertically an amount that matches the downward travel of the patient's condyles. This can happen only if the condylar housings are rotated downward to permit that movement. The housings are rotated until the occlusion rims are once again firmly seated in the protrusive records at both the anterior and posterior ends of the rims. The condylar housing will then show a measure of this downward rotation expressed in degrees below the plane of the upper and lower members of the instrument.

Similarly, as the mandible rotates from side to side in lateral excursions, it also translates a small amount (the Bennett shift). Interocclusal records taken with the patient's mandible in eccentric lateral positions will record a composite of this rotation and translation. When these records are replaced between the rims on the articulator, they will fit the rims only when the condylar housings are rotated horizontally to permit the rotating condylar ball to translate medially as it rotates down and forward. The articulator will then show a measure of this horizontal translation, expressed in degrees of deviation from the sagittal plane.

With the completion of these two steps, the condylar elements of a semiadjustable articulator will be programmed. The instrument interpolates the movements between the centric, protrusive, and lateral positions to provide a representation of that range of mandibular movement. It should be emphasized that the condylar elements of the articulator are accurate only at the points that were recorded in the

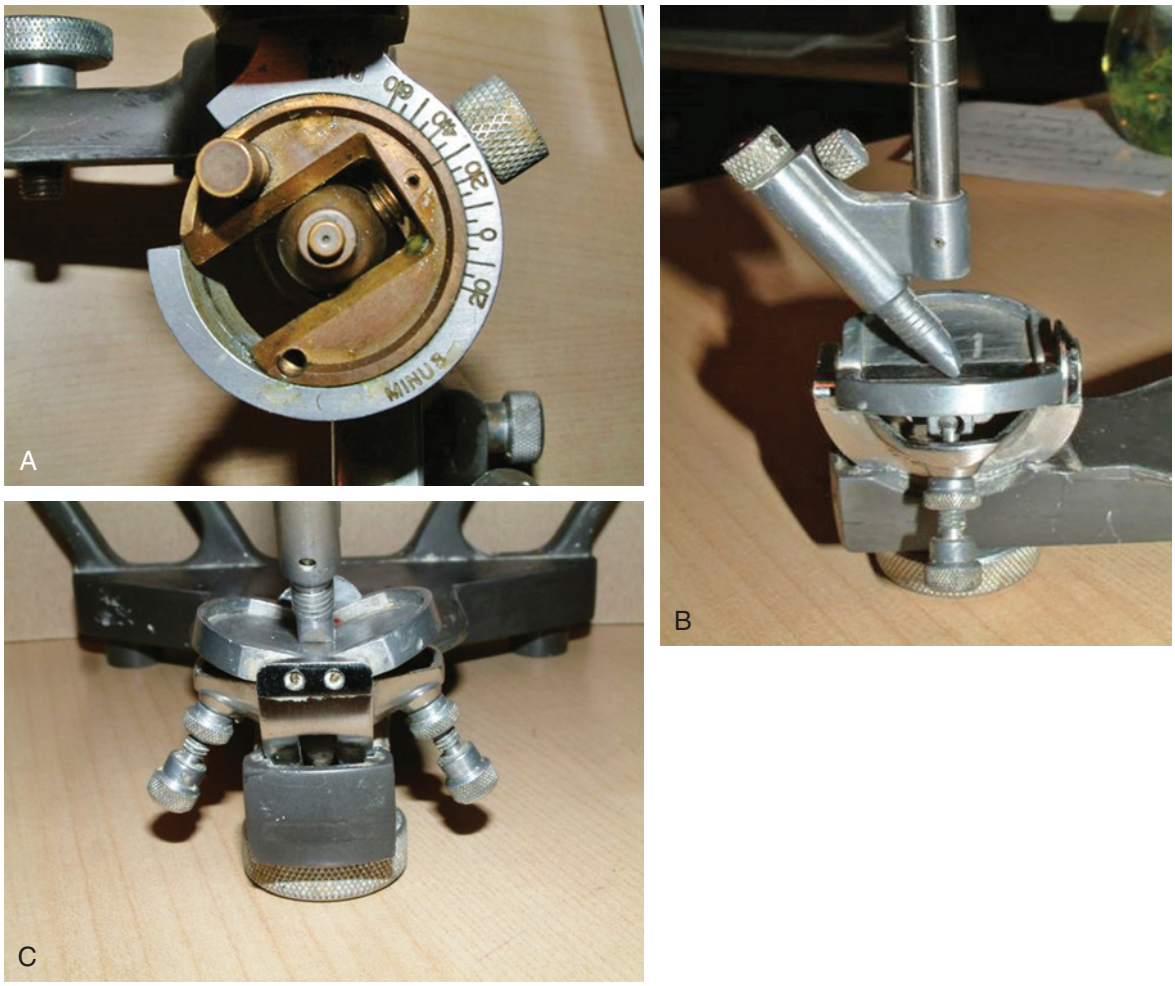


Figure 9-14 The condylar elements are set arbitrarily, or else estimated by means of a protrusive record. They are frequently set between 0 and 20 degrees, although in **A** the higher setting corresponds to a planned overlap in incisal guidance, lateral excursions, and cuspal morphological considerations. **B** and **C** demonstrate the ability of a semiadjustable articulator's incisal guide table to accommodate different angles for the lateral plates as dictated by the selected incisal arrangement.

interocclusal records. As noted earlier, although the accuracy may be limited, clinical experience suggests that greater accuracy is not needed for the complete denture patient.

Incisal Elements (Fig. 9-14, *B* and *C*)

The overbite–overjet relations of the anterior teeth are determined primarily by the esthetics and phonetics. However, as noted in later chapters, the incisal guidance also influences the separation of the posterior teeth during excursions. Therefore, the functional consequences of the incisal guidance relationship must be considered. These factors determine how the incisal elements of the articulator will be programmed.

Where no overbite is planned between the anterior teeth, the incisal guide table will be left perfectly flat. When it is set up this way, the anterior teeth will have to be arranged so that they contact only on the incisal edges (or not at all) (Fig. 9-15). Any posterior disclusion will be the result of the descending condyles.

Where esthetics or phonetics requires overlapping incisors, an incisal guidance will likely be created (which will have an impact on the posterior disclusion). The dentist has control over the steepness of that guidance by setting the incisal table. Where an incisal guidance is needed in protrusion, the table is rotated to an elevated position. As the incisal pin travels along the table, the models are separated anteriorly. Tooth contact then can be maintained in protrusion only by arranging the teeth in an overlapped position. Where a lateral guidance is sought (more common in fixed than in complete denture prosthodontics), the lateral plates of the tables can be elevated in a similar way. The result is

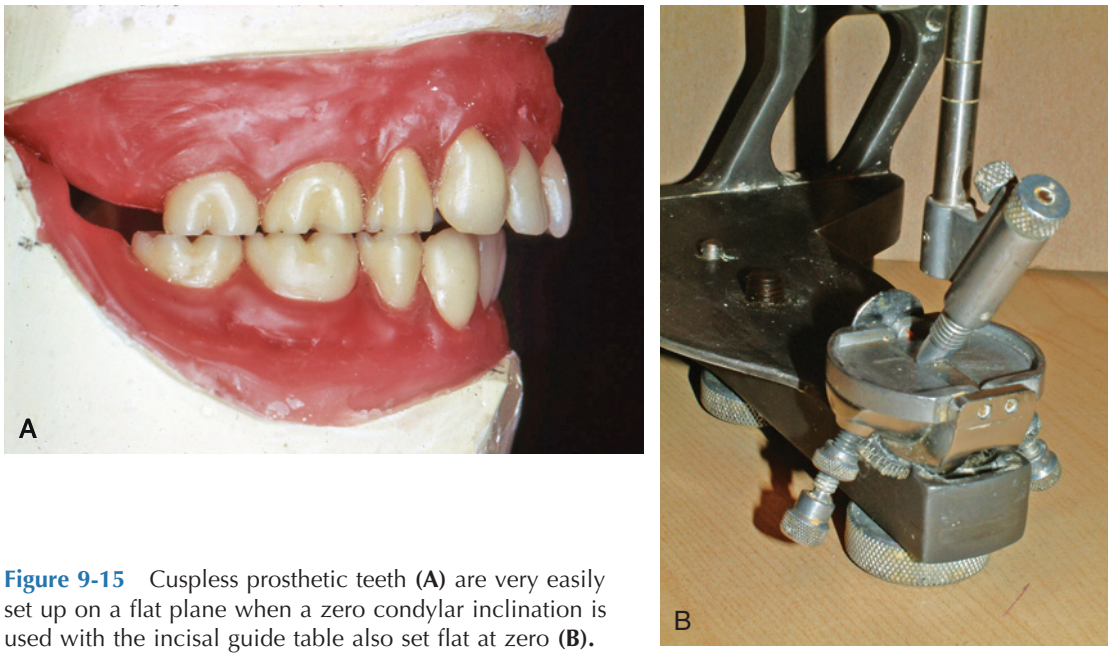


Figure 9-15 Cuspless prosthetic teeth **(A)** are very easily set up on a flat plane when a zero condylar inclination is used with the incisal guide table also set flat at zero **(B).**

an overlapping of lateral cusps and tooth guidance (typically on the canine) that the clinician intended when the tables were set.

Arbitrary Settings

As noted earlier, the theoretical advantages of using a facebow to mount the maxillary cast on the articulator are obvious, but there is evidence that the need for a facebow record is not supported clinically. Similarly, recognizing that the denture bases move on the tissue under load, an arbitrary setting of the condylar elements at zero degrees can be done. This will yield an artificially diminished separation of the posterior teeth. However, when combined with a neutral (zero) incisal guidance, and cuspless teeth, with or without a compensating curve or a second molar ramp, the tooth arrangement becomes perfectly flat with bilateral nonworking contact. When inserted in the mouth, the natural separation of the posterior teeth is largely compensated for by the compression of the tissues under the denture bases, the compensating curve, and/or the molar ramp, if necessary. The articulator is thus reduced to a simple hinge, and the arranging of the teeth is greatly simplified. The appropriateness of this tooth arrangement—and thus the choice of the articulator used—is a clinical judgment that should be made in advance. A more complex instrument is therefore not necessarily a better choice.

Any type of facebow and all articulators suffer from inherent shortcomings, as well as operator errors; they can only approximate conditions in the patient's masticatory system. This is, of course, no excuse for abandoning impeccable technique and sound principles of denture construction. Consequently, scrupulous clinical control and the acceptance of a need for adjustments at insertion are necessary with any method.

Bibliography

Bernhardt O, Kuppers N, Rosin M, et al: Comparative tests of arbitrary and kinematic transverse horizontal axis recordings of mandibular movements, *J Prosthet Dent* 89(2):175-179, 2003.

Barrenäs L, Ödman P: Myodynamic and conventional construction of complete dentures: a comparative study of comfort and function, *J Oral Rehabil* 16:457-465, 1989.

Berry DC, Wilkie JK: *An approach to dental prosthetics,* vol 2, *Pergamon series on dentistry*, London, 1964, Pergamon Press.

Carlsson GE: Critical review of some dogmas in prosthodontics, *J Prosthodont Res* 53(1):3-10, 2009.

Ellinger CW, Somes GW, Nicol BR, et al: Patient response to variations in denture technique. Part III: five-year subjective evaluation. *J Prosthet Dent* 42(2):127-130, 1979.

Fish EW: *Principles of full denture prosthesis*, ed 4, London, 1948, Staples Press Ltd.

Heydecke G, Vogeler M, Wolkewitz M, et al: Simplified versus comprehensive fabrication of complete dentures: patient ratings of denture satisfaction from a randomized crossover trial, *Quintessence Int* 39(2):107-116, 2008.

Nairn RI: The circumoral musculature: structure and function, *Br Dent J* 138:49-56, 1975.

Neill DJ, Glaysher JKL: Identifying the denture space, *J Oral Rehabil* 9:259-277, 1982.

Pound E: Controlling anomalies of vertical dimension and speech, *J Prosthet Dent* 36:124-135, 1976.

Tallgren R: The continuing reduction of the residual alveolar ridges in complete denture wearers: a mixed longitudinal study, *J Prosthet Dent* 27:120-132, 1972.

Wright CR: Evaluation of the factors necessary to develop stability in mandibular dentures, *J Prosthet Dent* 16: 414-430, 1966.

Wright SM: The polished surface contour: a new approach, *Int J Prosthodont* 4:159-163, 1991.

CHAPTER

10

The Occlusal Surfaces: The Selection and Arrangement of Prosthetic Teeth

Aaron H. Fenton, Ting-Ling Chang

This chapter is organized as two separate but related parts. The first describes anterior teeth selection, which is an interpersonal chairside responsibility. In the second part, posterior teeth selection is described together with teeth arrangement on an articulator to complete the complete denture's design—the occlusal surface. The latter is accomplished in the laboratory between patient appointments and the sum of both parts is realized at the following try-in appointment.

Both this chapter and Chapter 11 are presented in the prescriptive form usually employed in clinical manuals. This is done to facilitate the application of both chapters' content.

ON MEETING PATIENT EXPECTATIONS WHEN SELECTING TEETH

Anterior tooth selection (ATS) should be completed early in treatment and preferably before final impressions are made. It is an important stage in complete denture treatment because satisfaction with a prosthetically created smile is significant in a patient's decision to accept therapy. Anterior and posterior teeth (1 × 28) should be ordered together because bicuspids are an integral part of a smile and their color, size, and shape should complement the anterior teeth. Patients should be shown the actual teeth at the impression appointment and their approval ensured. If the teeth are not what patients think they will be, based on the shade and mold guide estimations, they can be readily reordered and exchanged at the registration appointment before they are needed for a setup in wax. This protocol helps avoid unnecessary laboratory fees and office chair time that would result from an exchange and reset of a second set of teeth.

Tooth manufacturers provide a variety of shade guides, mold guides, and measurement charts to assist dentists in the selection of anterior teeth (Fig. 10-1), and because each system can produce satisfactory results, it is suggested that a manufacturer be selected on the basis of local availability and reliable delivery. It is also prudent to find out from the laboratory of choice which tooth sizes and colors are selected most often. Future tooth repairs are easier if the prosthetic teeth are readily matched.

Although the dental profession seeks to realistically replace the missing dentition, prosthetic teeth are often slightly smaller in size and lighter in color than the range of the natural dentition. This does not seem to be a problem, and patients often prefer teeth that are lighter and object to teeth being too large or too dark.

It must be recognized that dentists too work in a consumer-oriented society, with readily visible anterior teeth and everyone entitled to an opinion. Therefore patients' family members or friends whose opinion is respected may have to be recruited for input into the teeth selection protocol. Involving significant others in the decision making may be regarded as psychologically effective therapy—giving patients what they want—and facilitates patients taking ownership of the selection decision.

A recommended protocol includes paying careful attention to what the patient says plus recording all relevant information. Listening to the patient is the first and most important step in ATS. Make sure the patient articulates a clear reason for seeking professional help. This is often achieved in the context of a patient's opinion about the existing teeth. A statement such as, "My *teeth don't show anymore*," should then be restated by the dentist as, "*If we make teeth of the same size, but lighter in color, and a little longer at the front, will that be better?*" It must be recognized that patients vary in how much they value the tooth appearance.

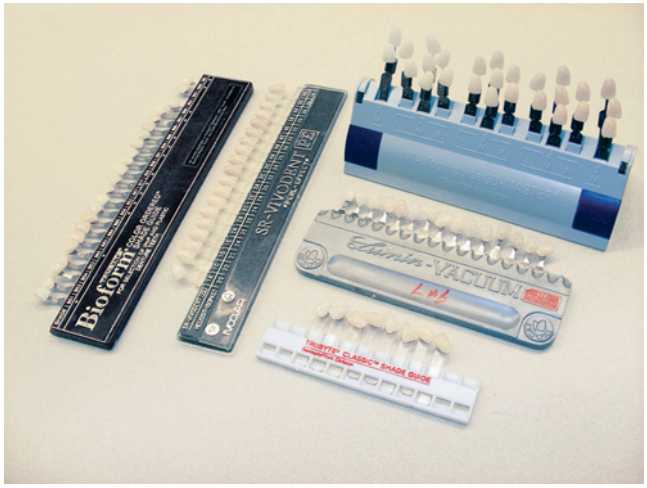


Figure 10-1 Use the correct shade guide for denture teeth. Some are porcelain-only shades.



Figure 10-2 Photos as happy student, mother, and grandmother assist in determining tooth size and position. See result in Fig. 11-20, *C*.

The importance of their response to ATS can range from the indifferent "*You're the dentist; you decide*," to unrealistic expectations that cannot be satisfied. Fortunately, almost all patients are well between these two extremes. Nonetheless it is prudent to try to routinely find out where patients are on this spectrum of interest in the appearance of their smiles.

The teeth selection should preferably be carried out in a clinical office setting where it is easy for both dentist and patient to view their faces in good light, with color-corrected lighting and window light from north side windows in the northern hemisphere and vice versa in the southern one. Recording as much relevant information as possible—current or any previous prosthetic teeth; old study casts or dentures; photographs wherein the patient is smiling, photos of preferred smiles, as well as their children's photos—is useful in guiding choices in teeth selection and arrangement. Even a picture of a direct descendant may be the closest record available of the sort of smile that could be matched and copied. Patients appear to appreciate any effort to provide the best personal service while useful clues on what a patient regards as suitable in teeth selection also are helpful. The patient in Fig. 10-2 provided numerous time-related images leading to the result in Fig. 11-20, *C*.

A recommended sequence is the following: (1) Find out what patients prefer and what they do *not* want from these previous records. (2) Make alginate impressions/plaster study casts of the current dentures, which will be a guide for tooth anatomy and a good reference at the try-in appointment. (3) Measure the existing teeth in millimeters by employing five records: the length and width of the maxillary central incisor, the total circumference of the six upper anterior teeth, and the length and height of the posterior teeth (Fig. 10-3). These millimeter dimensions are published by most tooth manufacturers and facilitate ordering teeth that are similar, larger, or smaller.

ON GUIDING PATIENT DECISIONS

The first choice to clarify is whether to make a new smile similar to or different from the existing dentures. If patients are satisfied with their smile, use these records to select teeth that are the same size and shape. The new teeth will be similar in appearance, perhaps less worn and a lighter color and demand little in terms of adapting to a new look. On the other hand, some patients may have specific dislikes about their present teeth and accommodating or meeting their expectations will entail additional efforts. In these cases, it is important to plan a "reorganized approach" where the teeth will be different on purpose. With polite questioning and guidance, seek to clarify what is wanted vis-a-vis the nine parameters of their smile's appearance:

For tooth selection, find out and agree with your patient's wishes as to:

- Tooth color—same or lighter, darker
- Tooth size—same or larger, smaller
- Tooth shape—same or curved or straight, amount of wear

After selection and agreement, tooth arrangement and processing will address:

- Midline—same or moved left/right
- Occlusal plane—same or tilted, moved up/down, more or less visible
- Dental arch—same or moved in/out, more or less curved or flat, more or less visible
- Lip support—same or too little/too much
- Unique features—same or incisal wear, chips, rotations, spaces, restorations
- Gingival color—same or less/more pigmented, custom shading



Figure 10-3 Central looks to be 8.7 mm wide **(A)** and 10.1 mm long **(B). C,** Six anteriors are 49 mm. **D,** Four posteriors are 34 mm and medium *(M)* height.

When a smile needs improvement, identify and agree on which and how much of these nine points need change. Remember that even though you agree on and plan improvements, improvements mean change. Assess the tolerance and motivation of your patients for change and work within the range that they can accept.

The easiest decision for a patient to make is the *color* of teeth they want, but remember the three processes that are simultaneously ongoing. After the perception of color (physiology), the patient is making decisions (psychology) in your supportive presence (psychology again). Being in a dental office can have upsetting memories for edentulous patients. Be aware of the effect of nonverbal communication. Your hesitancy, or raised eyebrow, may be taken as a negative reaction that you may or may not intend to communicate.

To select a good tooth color with which you are both happy, make it an event. Get your patient up and out of the dental chair and standing so that his or her face is in good light. Position the both of you so that window and overhead lighting are coming over your shoulder and onto your patient's face. Stand at arm's length, which is a normal conversational distance for observing a smile. Make sure your patient wears his or her glasses or contact lenses. Clean and give your patients a hand mirror of about 15 cm (6 inches) in diameter so that they can see how their face looks. A smaller mirror does not give an adequate image to the patient; a larger mirror makes it difficult for you to see around it. For final confirmation and agreement, use a wall mirror so that your patient can see their smile as part of their overall facial and personal appearance. Being on a wall, these mirrors often have poorer lighting onto the face.

Tell your patients that you need their help to get the best results. Explain that you have many colors and sizes of teeth to best treat your patients, but you want them to have what is best for them. A display of all of your shade and mold guides will be confusing. Reassure your patient that the decision will be simple. They will only have to tell which one of two things they prefer; in other words, make the choice simple.



Figure 10-4 A pair of tooth shades to compare. Ask your patient to point to the one that he or she prefers.



Figure 10-5 Pair comparison to identify the best mold of teeth. The two teeth on the left and the two teeth on the right are from different molds. The patient can see them in the mirror, and he is pointing to the one he prefers.

Show your patients a complete shade guide and select the two lightest and darkest tabs (Fig. 10-4). Point out how different these two are and find out which one they prefer by asking them to point to that one. Delete the rejected color, and select another shade from the preferred half of the shade guide. Repeat this pair comparison, and after two or three selections by your patients, you will have the shades that they want. In reality, your patients may be rejecting the ones that they do not want. By elimination, you will end up with what they like best. To confirm the patient's decision, reverse the sides of the pair and present them again. Try another shade that is close to the preferred shade. When patients can still select the same shade when you move it from side to side in the pair, you are getting confirmation of their decision. Note the selections used in your file. It may look something like this: *59/81x, 62/77x, 65x/62, 62/66x, 59x/62, 62/59x, 62++*. In the rare event that your patient has "second thoughts," it is a help to be able to reconstruct/repeat or search elsewhere for a tooth color.

If patients are unable or unwilling to decide on a shade, rejection decision making can help. Ask them to point out which one of the pair of tabs they notice. This noticeable color is more "different," and by default, the tab that they do not notice probably is more acceptable. They are not selecting a color, but rejecting one.

In the rare situations in which patients still cannot decide, advise them that their indecision is okay. Both shades are appropriate, and a pleasing appearance for them could be made with either one. Order two sets of teeth so that the patient can compare the actual teeth side by side before they are needed for setup. Sometimes you will select a different shade for the central incisors compared with the laterals and cuspids. With the tooth cards present, it is easy to explain to the patient that ordering two sets of teeth adds extra cost, but if that is what the patient wants, then it is worth the small additional expense.

Second, select the best *size* of tooth. Existing dentures, models of previous teeth, and photographs all give valuable input for selection of the size and shape of teeth. Teeth can be measured in millimeters and teeth of similar size selected (see Fig. 10-3). Coupled with actual measurement, again use a method of pair comparison to assist patients to decide what size of tooth they prefer. Set two different sizes of teeth on a piece of wax rope or on the tooth selector rim that some companies provide. Place this under the upper lip and find out which one the patient prefers. The decision is often not one of preference, but rejection. People note and reject the teeth that are, for example, too large, small, long, or short. By default they prefer the other set of teeth.

Third, select and agree on the *mold* of the teeth. Teeth of a similar size can appear entirely different because of their taper, contacts, and labial curvature. This can be the "finishing touch" to replicate a realistic appearance for your patient. Photographs, previous models, and existing dentures are useful. Allow your patient to select between molds of the same size but different shapes. Set two different molds on the right and left sides of a piece of wax rope and ask patients which they prefer (Fig. 10-5).

When a color and mold have been agreed upon, write down those serial numbers in the patient's file! With today's long-lived and mobile population, give your patient the name and serial number of the upper anterior mold guide. These data will be valuable when teeth need future replacement. Order the teeth, depending on the number needed. A set of anterior teeth of color "62" and size "11d" would be called in as an order of "1 by 6 of 11d and shade 62." Anteriors are ordered as "1 by 6" and posteriors (2 bicuspids and 2 molars) as "1 by 8." For a complete set of teeth for an edentulous patient, you would order "1 by 28 of mold 11d and shade 62." The posterior mold would vary depending on the occlusal anatomy you request. Once the selected teeth are agreed upon, the other parameters of their positioning will be addressed during the setup and try-in appointments. Unique characterization is provided for the try-in appointment. Any direct restorations are usually made in the teeth after processing.

ADDITIONAL CLINICAL AND TECHNICAL CONSIDERATIONS IN ANTERIOR TOOTH SELECTION

PATIENT PREFERENCES

Patients may want teeth to be porcelain or acrylic, depending on various reasons that they have heard: *"Acrylic teeth stain," "Porcelain teeth are real," "Porcelain teeth are noisy for chewing,"* or *"Porcelain teeth are heavy."* There are a variety of opinions. Listen and respond with your knowledge of dental materials. Unless the denture will be compromised by patients' requests, incorporate those wishes. Make patients aware that you are modifying your therapy uniquely for them and make a note in the chart. Again, this is an opportunity for patients to accept responsibility for their decisions.

A *high smile line* that displays a lot of gingiva would benefit from the selection of a less tapered mold with a long contact point. This minimizes the interproximal display of pink gingival acrylic, which is more difficult to make look more realistic than teeth. The resultant smile ends up being slightly more dental but with a less gingival display.

OVERDENTURES AND IMPLANT DENTURES

The bulge of underlying tooth roots or implant abutments creates areas of limited interocclusal space. Use larger square mold acrylic unilayered teeth. They can be ground thin, yet maintain their color and bond to denture base acrylic. Highly characterized or laminated teeth may become translucent or separate their veneers when ground thin over tooth roots or implants. Tapered molds have less interproximal anatomy, and porcelain teeth lose their mechanical retention if the anterior palatal pins or posterior diatoric holes are compromised.

OPPOSING NATURAL TEETH

Porcelain can be very abrasive and can contribute to the wear and destruction of opposing teeth's enamel. It is therefore preferable to use acrylic resin teeth for dentures that oppose natural teeth. These prosthetic teeth will wear on a time-determined and behavior-determined basis, but they can be readily replaced.

MATERIALS FOR DENTURE TEETH

For many years, porcelain was the first and favorite tooth material for complete dentures. It has excellent color stability and superior wear resistance. Porcelain teeth should only be used if the opposing dentition is also porcelain (as in a set of dentures) because porcelain can rapidly wear opposing enamel and restorations. Single complete prostheses and removable dental prostheses are better designed with acrylic teeth in order to minimize wear of opposing dentitions. Porcelain teeth can chip on accidental impact, and they do not bond to denture base acrylics. A thin stain line can occur at the nonbonded tooth/denture base interface, and porcelain teeth need mechanical retention. Porcelain anterior denture teeth have two small plated pins fused into them, and posterior porcelain teeth have a hollowed out center, or diatoric, so that acrylics can mechanically hold them in place.

For these many reasons, acrylic resin became the more popular denture tooth material. Because of chemical compatibility, an acrylic tooth bonds well to the acrylic of denture bases. Acrylic teeth are indicated whenever limited tooth space exists. Denture teeth sometimes have to be ground very thin either because of reduced interarch space, close arrangement of adjacent or opposing teeth, or underlying prominence of overlaid tooth roots or implant components. Acrylic resin teeth are economical to produce and they do not abrade and destroy opposing dentitions, but they certainly wear more quickly than porcelain.

Improvements such as different polymers and composites have been developed to attempt to create a more wear-resistant acrylic resin tooth. Depending on the manufacturer, acrylic composite teeth are more wear resistant, but they may not bond as securely to acrylic bases. Just before processing, dental laboratories routinely grind the internal tooth surface to expose fresh acrylic and drill diatoric holes into the composite core to enhance the composite denture tooth retention. These composite teeth are more expensive than all acrylic teeth, but have improved properties, and are a popular material for general prosthetic use. True cost depends on the method of accounting. If a set of teeth cost $150 more to process, yet the teeth wear less so that the dentures last 4 years longer before requiring reline or replacement, then the initially more expensive tooth mold is a bargain in reducing overall costs for your patient.

POSTERIOR TOOTH MOLDS AND CUSPAL ANATOMY

Until the middle 1920s, most posterior denture teeth were porcelain and similar in shape to natural teeth. Since edentulous patients wearing dentures are compromised in their chewing ability compared with intact and compromised natural dentitions, dentists have sought to improve designs for the differing function of complete dentures. Denture tooth molds are often narrower than the natural teeth they replace. This narrowing of the occlusal table accomplishes three objectives: (1) a bolus of food can be penetrated and chewed with less effort; (2) there is less displacement of the denture on mucosa; and (3) the polished surfaces of the denture can be sloped so that your patient can learn to use

his or her lip, cheek, and especially tongue muscles to help maintain the dentures in place. Dentists also designed various tooth forms to attempt to make dentures either more stable and/or more efficient, or easier to arrange. Despite many advances, changing tooth forms has had little improvement on the basic challenge of edentulism. The best of mucosal support for prostheses is inefficient compared with the biologic attachment provided by the periodontium of teeth. The improved attachment provided by titanium implants has dramatically improved the chewing ability of edentulous patients far more than any posterior tooth mold.

Posterior teeth are selected for color, an appropriate size match to the more visible anterior molds, interarch space available, material, and concepts of occlusion. When a patient smiles, he or she may display varying amounts of the posterior and anterior teeth. Check that the size and buccal contours of posterior tooth molds blend to the size and shape of the cuspid teeth. A common esthetic error is to have bicuspids that appear too small next to their adjacent cuspids.

Posterior artificial teeth are manufactured with cusp inclines that vary from 30 degrees (anatomical) to 0 degree (flat). The selected posterior tooth mold is based on one of the several advocated concepts of denture occlusion that vary in their complexity (see Table 10-2). No one protocol is superior, and comprehensive reviews by Lang and, more recently, Carlsson advocate use of the simplest procedure that will produce the desired results. The Cochrane Collaboration (2008) summary of denture occlusion literature reports that patients subjectively prefer teeth with cusps and/or a lingualized occlusal contact pattern when compared with nonanatomical teeth.

TEN LANDMARKS FOR COMPLETE DENTURE TEETH SETUP

The goals of tooth arrangement are to have the front teeth look good; allow the patient to speak clearly; and have all the teeth positioned for the best comfort, stability, and retention of the dentures. The upper anterior teeth are critical for appearance and speech. After tooth loss, the missing oral tissue volume and facial collapse vary with each patient, with the amount of ridge resorption and remodeling, and the time elapsed since tooth loss. The mandible suffers the most resorption and without a palate, it has the least anatomy. Except for the upper anterior esthetics, the rest of the dentition is designed for the best function of the mandibular denture. Complete denture tooth position is guided by anatomical landmarks recorded in the impressions/models and registrations.

Four landmarks are located on the stone models. They are the maxillary incisive papilla, the mandibular bicuspid residual ridge, and the retromolar pad (RMP) height and width. The incisive papilla location is a guide to the midline for the maxillary central incisors and the prominence of the incisors and cuspids. The mandibular bicuspid residual ridge guides the buccal-lingual positioning of the bicuspids, and the RMPs guide the height and width of the mandibular posterior teeth.

At the registration appointment, six interrelated landmarks are created with the wax rims: upper and lower labial contour, upper and lower wax rim height, the interocclusal plane, the smiling midline, the high and wide smile lip line, and the vertical dimension of occlusion. Shape the wax contours to be the best during three actions and positions—lips at rest, while speaking, and with a happy expressive smile.

Once the master casts have been mounted on the articulator, use this combination of six wax rim and four stone model landmarks to position denture teeth onto the registration bases to create the best tooth positions, arch form, and lip support (Table 10-1; also see Fig. 10-12).

The best sequence for tooth setup is to set either the upper or lower anterior teeth first, then the mandibular posteriors, and lastly the maxillary posteriors. Once the teeth are in the best position, the gingival wax is then shaped with sloping contours from the gingival "necks" of the teeth to the denture periphery that assists your patient's musculature to stabilize his or her dentures.

THE "STANDARD ANTERIOR" ARRANGEMENT

For ideal esthetics and speech, the upper anterior artificial teeth should be set into positions similar to that previously occupied by the natural teeth. The incisive papilla is located between and palatal to the central incisors. It is a good static guide to the midline position of the two upper central incisors in the denture. The wax registration rim will have your midline marked based on the appearance of the lips and face. These two midline assessments should be in close correlation. While everyone has some normal facial asymmetry, if the wax midline is not close to the midline of the incisive papilla and palate, suspect that the wax midline may need some adjustment. Extend a line marking the center of the incisive papilla forward onto the landing area of the model (Fig. 10-6).

The central incisors set on this midline will have positions similar to those of the natural teeth. The incisive papilla is also a good guide for the anteroposterior positioning of the six anterior teeth. The labial surfaces of the central incisors are usually 8 to 10 mm in front of the papillae when the residual alveolus is intact and the patient has a normal facial skeleton. It is not an absolute relationship and will vary with different orthodontic skeletal relationships, genetic profiles, and ongoing alveolar resorption. The distance from the papilla down and forward to the incisors will be greater for those patients with excessive bone loss in the maxillary anterior region (Fig. 10-7).

TABLE 10-1 TEN LANDMARKS TO FIND AND USE FOR DETERMINING DENTURE TOOTH POSITIONS

Landmark	Landmark Determines
Landmarks Identified on Stone Models	
Incisive papilla to centrals	Maxillary centrals are located on each side 8-10 mm anterior in normal medium resorption
Incisive papilla to cuspids	Maxillary cuspids are on line through the distal of incisive papilla; variable with arch form
Mandibular bicuspid residual alveolus	Resorption mainly vertical in this area. Mandibular bicuspids positioned over ridge to determine arch width, form, and space for tongue
RMP (mandibular) height	Mandibular posterior occlusal plane bisects RMP for best position for bolus placement and denture retention by tongue muscles
RMP (mandibular) width	Mandibular posterior teeth located in triangle formed from cuspids to RMP width
Landmarks Carved in Wax Rims at Registration	
Labial contour shaped to support lips	Arch form, lip support, facial contours
Average vertical dimension at cuspid sulcus starts at maxillary 22 mm and mandible 18 mm	Vertical position of teeth so that upper and lower teeth appear in normal proportion when lips just apart with mouth breathing
Trim to acceptable vertical dimension	
Anterior lateral plane of occlusion parallel to eye pupils	Anterior smile line and cuspid positions
Midline when smiling and at rest with lips apart	Symmetrical position of maxillary central incisors
Smile line height and width	Visibility of anterior teeth and gingiva

RMP, Retromolar pad.

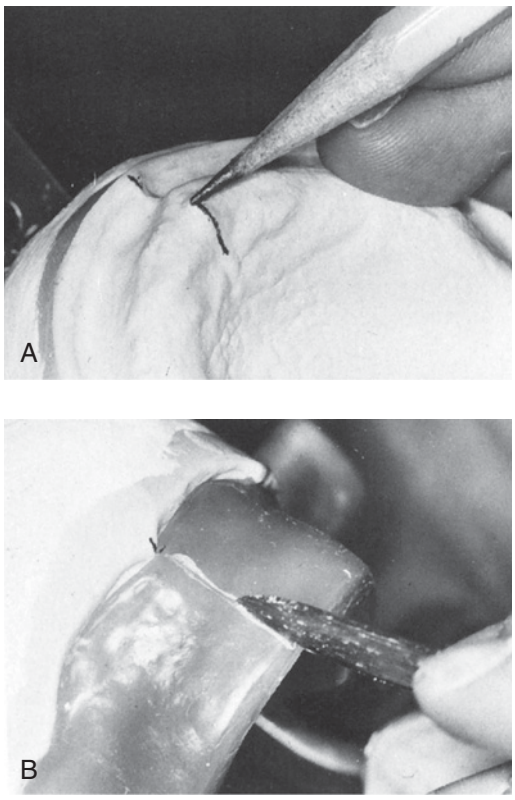


Figure 10-6 The incisive papilla is used to help locate the midline of the dental arch. **A,** A mark is made on the cast through the center of the papilla. **B,** The mark is transferred to the occlusion rim as a guide to placement of the maxillary incisors.

For a "standard setup," complete dentures generally are designed with a small overbite/overjet so as to minimize dislodging forces on excursions (Fig. 10-8). It is also preferable to set the anterior teeth just out of contact to:

- Allow for denture base movement on resilient mucosa,
- Allow small protrusive and lateral excursions without anterior guidance or "disclusion," and to
- Protect the anterior ridges from heavy chewing loads. Alveolar resorption occurs more in the anterior compared with the posterior ridges.

This anterior freedom from contact and minimal overbite/overjet is accomplished by setting the mandibular anteriors slightly down and back from the usual natural tooth overbite/overjet relationship. Setting the lower anterior teeth closer to the residual alveolus also may mean that your patient may be better able to manage their lower denture during incising and chewing.

ARRANGING THE MANDIBULAR ANTERIOR TEETH (FIG. 10-9)

To create a minimum overbite/overjet for a standard anterior setup, use the maxillary wax rim as a guide to position the mandibular teeth. You have the midline located with the upper teeth, and you know the minimal overbite/overjet you want to create. The vertical dimension of the

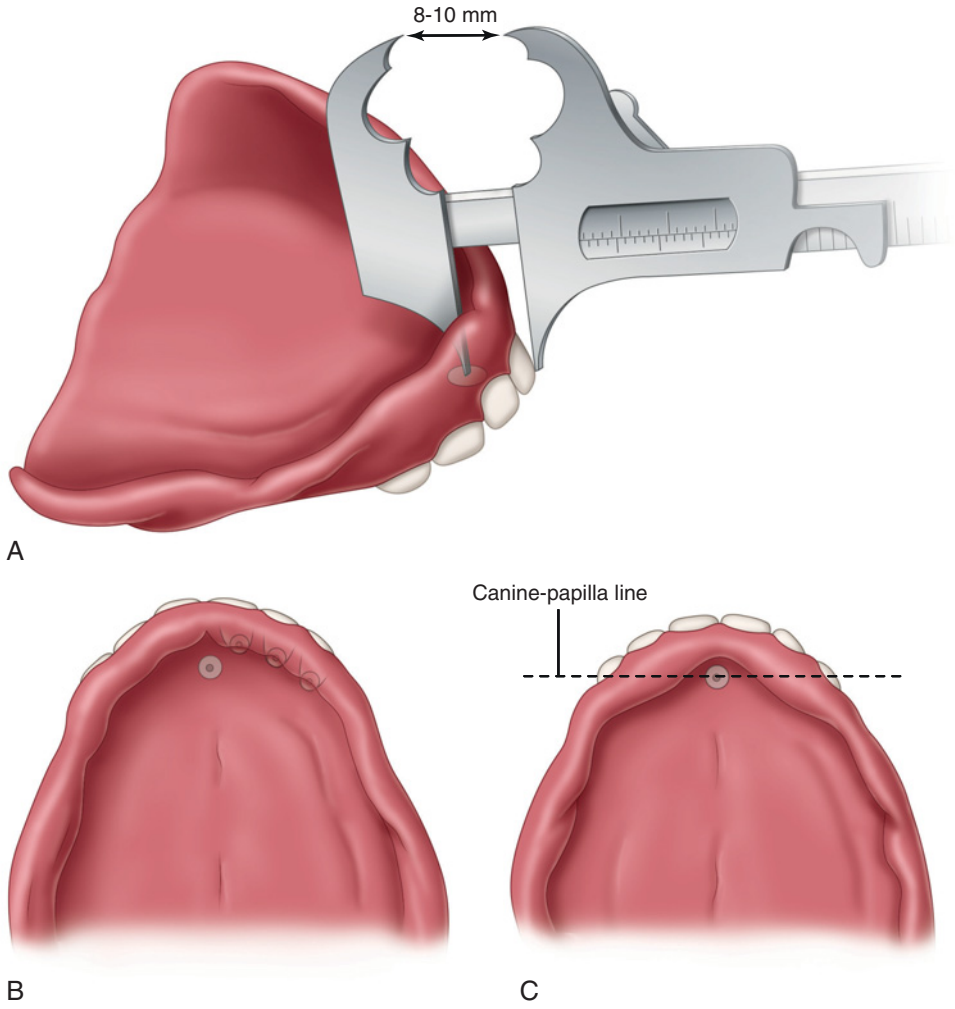


Figure 10-7 Indications of correct anteroposterior positioning of artificial anterior teeth. **A,** By measurement from the middle of the incisive fossa on the trial denture base to the labial surfaces of the central incisors. **B,** By visualization of the imaginary roots of artificial anterior teeth. The imaginary roots will be further in front of the residual ridge when a great amount of resorption has occurred. **C,** By determining the relationship of a transverse line extending between the middle of the upper canines and the incisive fossa.

mandibular anterior occlusion should be such that the teeth will be visible during speech as appropriate to your patient's anatomy. As a guide, your mandibular occlusal plane would be located at a height near the corners of the mouth so as to be visible with a "lips apart/mouth breathing" posture. Because of the intentional reduced overbite, mandibular anteriors may be less visible; however, with normal age-related facial soft tissue settling, patients show their lower front teeth more with each decade of life. With the normal phenomenon of "mesial drift" lower anterior teeth will appear natural if they have slight overlaps or rotations. It is easy to be subtle with the lower anteriors as they are the smallest teeth in the dentition. Your challenge is to set teeth that appear appropriate.

Mandibular Central Incisor Positions

The central incisors are set at the midline and tipped slightly to the labial. Direct the long axis of the tooth toward the residual ridge. Be certain that the necks of the teeth are depressed so that they are in from the edge of the record base. The incisal edges of these teeth are set at the height of the maxillary wax occlusal rim to create minimal vertical overlap with the maxillary central and canine teeth. A 1-mm to 2-mm horizontal overlap should exist between the lingual surface of the maxillary anterior teeth and the labial surface of the mandibular anterior teeth. This arrangement creates a low incisal guidance, which is exactly what one should achieve for the patient.

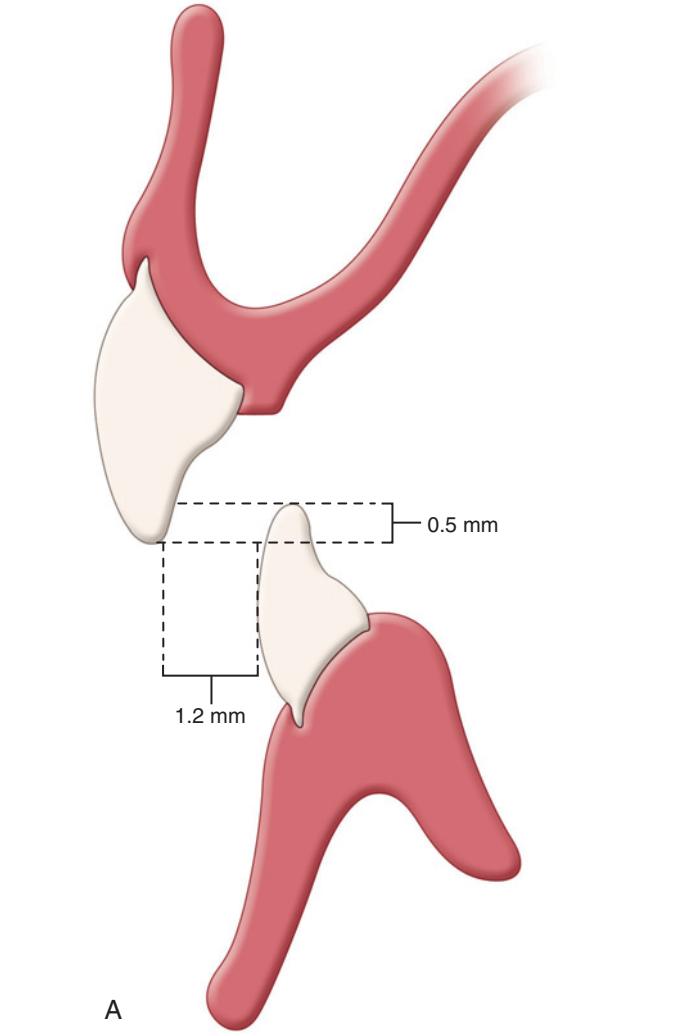


Figure 10-8 **A,** Vertical overlap of 0.5 mm and 1 to 2 mm of horizontal overlap must exist between the maxillary anterior teeth and their mandibular antagonists to achieve a low incisal guidance, which is needed for the anterior teeth to function in harmony with most posterior tooth forms. **B,** The low incisal guide angle is both esthetic and functional.

Mandibular Lateral Incisors

Position the lateral incisors next to the central incisors, with their long axes directed toward the residual ridge. The incisal edge should be at the height of the wax occlusal rim. Continue the 1 to 2 mm of horizontal overlap between the maxillary and mandibular anterior teeth.

Mandibular Canines

Place the mandibular canines with the anterior one half of the incisal edge in symmetry with the lateral and central incisors. Place the incisal tip at the same level as the lateral and central incisors. The neck of the tooth is slightly prominent and tilted to the distal. After these teeth are adjusted to this ideal arrangement, they may be altered by rotation, spacing, and tilting the teeth to create a natural effect. Seal all the teeth to the record base with pink baseplate wax and the hot # 7 spatula and then add realistic gingival contours.

SETTING THE MAXILLARY ANTERIOR TEETH (FIG. 10-10)

Remove wax from the maxillary occlusal rim on one side from the midline back to the first bicuspid area. For the maxillary anterior teeth to be set with the appropriate labial orientation, it may be necessary to grind the acrylic resin base to reduce its thickness. Do not be concerned should you create a hole in the record base because it will be covered with wax in setting the anterior teeth. This is a common occurrence in the laboratory and should always be performed before grinding on the neck of the tooth. If teeth are ground to become short and stubby, both the retention and appearance are compromised. Place some molten wax on the base of each tooth before setting them. This will hold them more securely in the wax-up.

Maxillary Central Incisors

The maxillary central incisors are the critical teeth to set. They are the most visible, establish the midline, and provide the esthetic support of the patient's lip. The proper arrangement of all teeth flows from the setting of the maxillary central incisors. Set both central incisors and thus establish the midline before setting the lateral and canine. Place a small portion of softened pink wax on the neck of each maxillary central incisor and press into place. The long axes should diverge slightly on each side of the midline. Use only the amount of wax needed for securely attaching the teeth to the record base. Excess wax should be removed so that you can see their long axes and orientation. Use a hot #7 spatula to seal the tooth into position with a hot wax spatula. Generally speaking, teeth vary in their natural inclinations and these individual differences should be incorporated into your setup to create realism. The teeth should not look like a "white picket fence" (Fig. 10-11). You

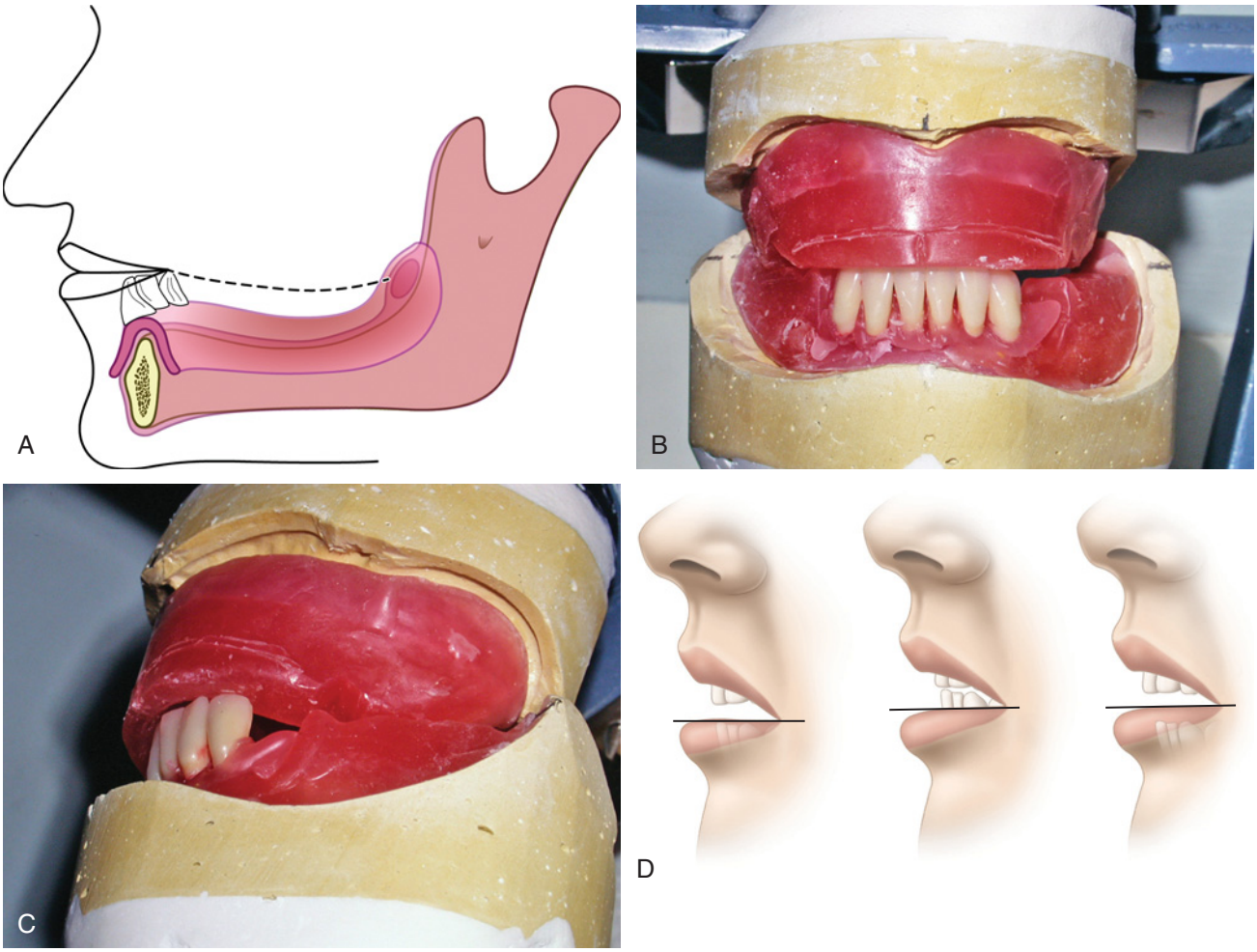


Figure 10-9 **A,** Lower anteriors set to corner of mouth are the anterior reference for the posterior occlusal plane. **B,** Lower anteriors set. **C,** Lower overbite and overjet to wax rim. **D,** Relationship of artificial lower teeth to the lower lip. *Left,* correct height; *middle,* too high; *right,* too low. *(**A,** Copyright 2011, University of Toronto.)*

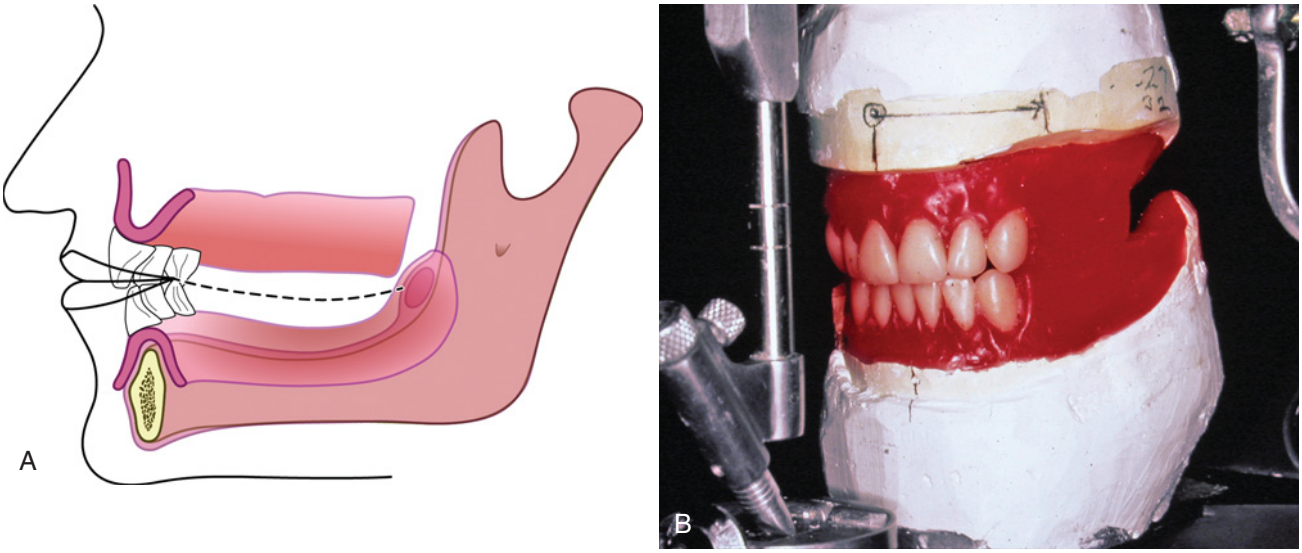


Figure 10-10 **A,** Maxillary anteriors set for best smile, lip support, and vertical dimension. **B,** Maxillary anteriors set for minimal overbite and clear overjet. *(**A,** Copyright 2011, University of Toronto.)*

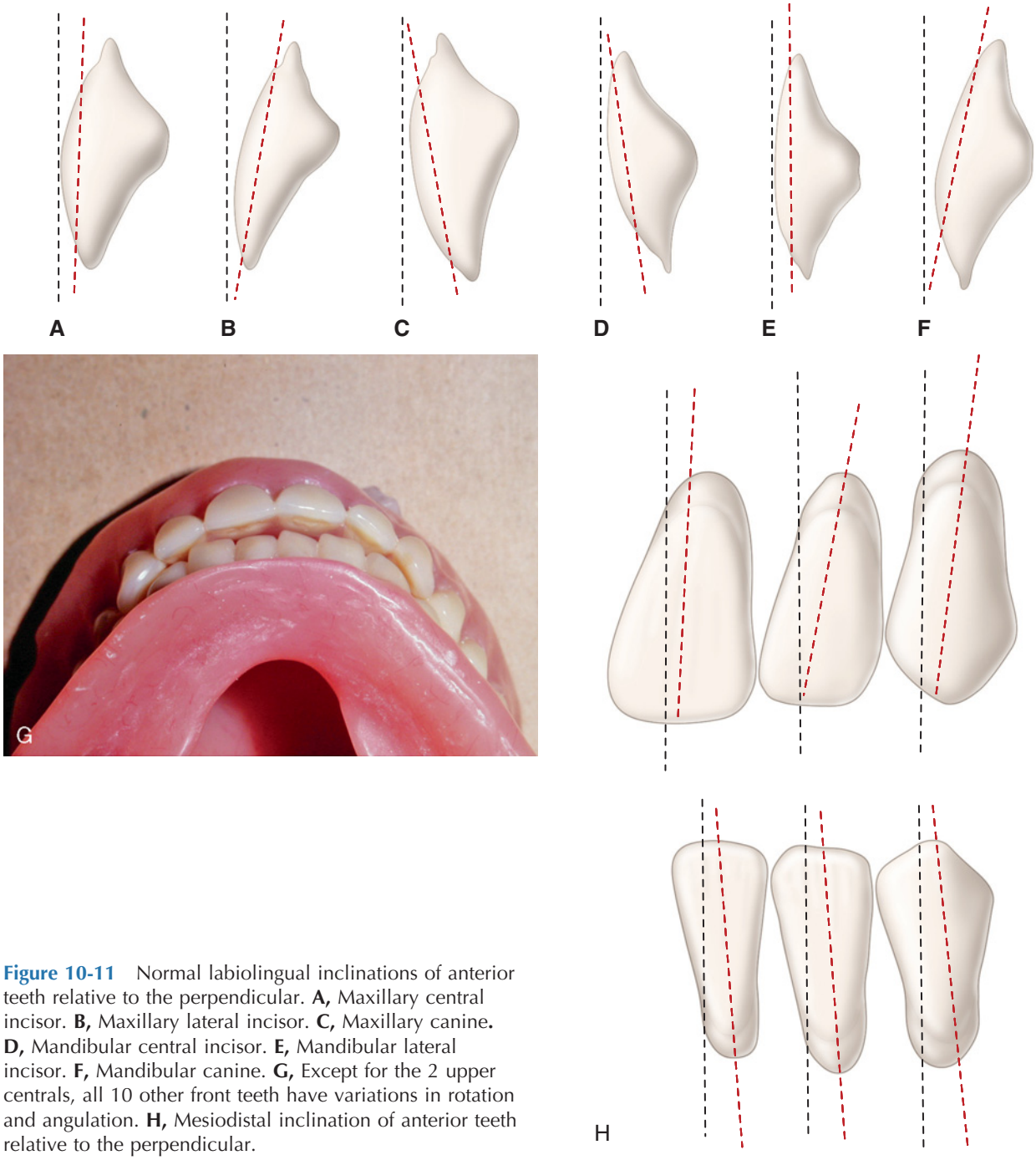


Figure 10-11 Normal labiolingual inclinations of anterior teeth relative to the perpendicular. **A,** Maxillary central incisor. **B,** Maxillary lateral incisor. **C,** Maxillary canine. **D,** Mandibular central incisor. **E,** Mandibular lateral incisor. **F,** Mandibular canine. **G,** Except for the 2 upper centrals, all 10 other front teeth have variations in rotation and angulation. **H,** Mesiodistal inclination of anterior teeth relative to the perpendicular.

will add more wax for gingival/mucosal contours after all the teeth are set into position.

Maxillary Lateral Incisors

Place the maxillary lateral incisor next to the central incisor, with the neck slightly depressed. Arrange the incisal edge in symmetry with the central incisor and with the remaining anterior occlusal rim. This incisal edge is even with the remaining maxillary wax occlusal rim and is therefore slightly elevated from the central incisor. The incisal edge is parallel with the mandibular wax occlusal rim. After this tooth is arranged in the normal position for a lateral incisor, it may be repositioned with spacing, lapping, or rotation to meet the individual esthetic requirements for the patient.

Maxillary Canines

Place the maxillary canine so that the anterior one half of the incisal edge is in symmetry with the lateral and central incisors as it curves around the labial contour of the wax occlusal rim. The neck of the tooth must be prominent and

the tooth tilted slightly to the distal. Like the central incisor, the incisal tip of the canine must be 0.5 mm below the maxillary wax occlusal rim. Again, after initially setting the tooth to these guidelines, any individual changes necessary for the creation of naturalness for the patient should be performed.

"ANTERIORS ONLY" TRY-IN

Depending on your pattern of practice, this is good point at which to have a patient appointment. Your patient and you can view and accept or modify the appearance of your anterior setup. If for some reason, the color, size, or position of the anterior teeth need improvement, it is easier to modify now. Also, you can verify your jaw relationship and articulator mounting with an anterior tooth/posterior wax rim patient try-in before setting the posterior teeth. It is easy to make a wax registration when the posterior is still wax registration rims.

ARRANGING POSTERIOR TEETH

As reported earlier, no scientific evidence exists to support the superiority of one posterior tooth form over another. Nonetheless, several occlusal concepts are practiced, each with slightly different protocols (Table 10-2). The key objective is to position the posterior teeth so that patients will not bite their tongue and cheek muscles as they chew. Since the mandibular denture covers a smaller area than the maxillary one, it requires more muscular control for its stability. When natural teeth erupt, they occupy a position that functions best with the surrounding lip, cheek, and tongue musculature. This "neutral zone" is where you want to build your denture occlusion, especially for the mandibular prosthesis. The posterior references of the center of the retromolar pads (RMPs) will place the mandibular occlusal plane at a level and width similar to the natural dentition that is familiar to the tongue (Fig. 10-12).

The height of the posterior plane of occlusion is an extension from the distal contact of the lower cuspids to the middle of the RMPs bilaterally. The buccolingual position of the posterior teeth and the posterior arch form curves from the anterior position of the canines, over the bicuspid residual ridges, and posteriorly to within the width of the RMP. The anterior and posterior tooth arches should blend into one smooth curvature. This positions the posterior teeth in the best relation to supporting bone and adjacent soft tissues. If the plane is located high, patients have difficulty managing their dentures. If the occlusal plane is too low, the upper teeth may be too visible, and the lower teeth not seen at all.

Number of Posterior Teeth Set

For mandibular denture stability, tooth contacts should be in the area where the resorbed ridge is relatively parallel to the occlusal plane. Avoid tooth contacts over the ridge where it inclines up to the retromolar pad. When teeth of adequate size to appear natural are selected, sometimes their total anteroposterior (A-P) length is greater than the space available. In this situation, delete setting the maxillary second molars (see Fig. 10-15, *H*). This maintains the natural appearance of the cuspids, blending to the bicuspids, back to the large molars. On excursions, the mandibular second molar can then act as a nonworking contact to the maxillary first molar. This bilateral occlusal contact will maintain cross-arch stabilization of the denture bases. Another option is to delete the first bicuspids. This will create an intermediate length of the occlusal table with slightly more surface area of the larger second bicuspid and both molars (see Fig. 10-16).

When the mandibular teeth are positioned best, then the maxillary posterior teeth are set to match. Small compensations may be incorporated to create the best location and function for this combined occlusion (Fig. 10-13).

Successful denture wearers are oral athletes who can learn to use their musculature simultaneously for these three complementary activities: holding a denture in place with circumoral and tongue muscles, reducing a food bolus in preparation to swallow, and yet not biting their cheeks or tongue. Your proper prosthetic design will be a big assist.

OCCLUSAL CONCEPTS FOR COMPLETE DENTURE OCCLUSION

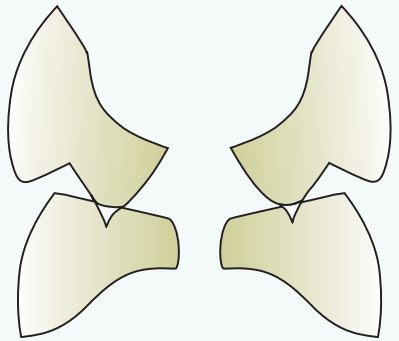
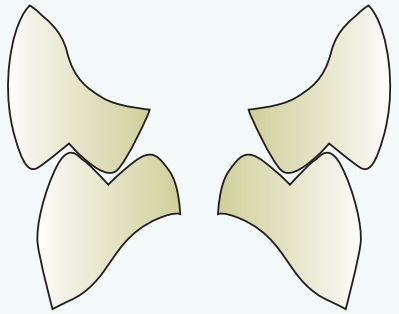
Prosthetic tooth anatomy seems to be more important to dentists than to the patients who use the teeth. In the absence of clear evidence of the benefits of one tooth anatomy compared with others, dentists should use the least complicated procedures and tooth forms that will satisfy their concepts of occlusion and articulation of a mucosal-supported dentition.

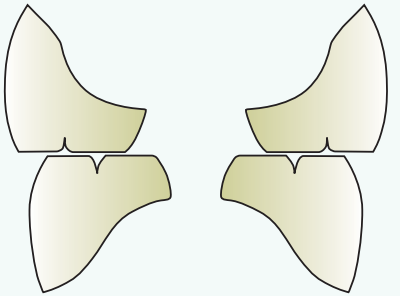
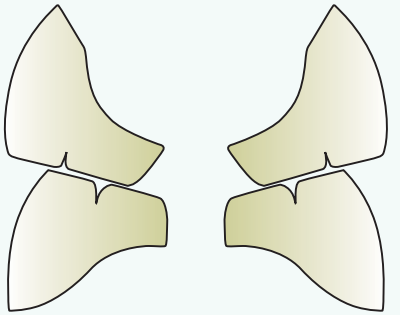
Chronologically, the three most often selected concepts of occlusion have been (1) bilateral balance, (2) monoplane or nonanatomical, and (3) lingualized articulations. Anatomical molds usually are selected for bilateral balanced articulation and nonanatomical or cuspless teeth are generally the choice for monoplane articulation: however, nonanatomical teeth can be used in a balanced concept with the use of compensating curves and/or ramps. The lingualized occlusal concept can be created with combinations of upper anatomical and lower nonanatomical molds, and several tooth manufacturers have introduced newer molds to address this philosophy.

LINGUALIZED ARTICULATION

Lingualized articulation has been advocated by some practitioners over the past 80 years. In essence, occlusal contacts are focused between the maxillary palatal cusps and the mandibular central fossae and lingual anatomy. The buccal cusps of both the maxillary and mandibular teeth appear

TABLE 10-2 TOOTH MOLDS AND OCCLUSAL CONCEPTS

Tooth Mold	Occlusal Concept	Advantage	Disadvantage	
Lingualized occlusion	• Centric jaw record • Monoplane lower posterior teeth set to retromolar pad • Anatomical upper posterior teeth set with only lingual, not buccal, cusps touching	• Upper premolars appear natural • Some range of posterior tooth position allowed • Reported slightly better chewing than monoplane teeth	• Some grinding needed to create upper cusp tip/lower fossa contacts (some manufacturers are now producing molds for this occlusal concept)	Lingualized occlusion* 
20- or 30-degree cusped teeth	• Centric jaw record, face bow, protrusive records to semiadjustable articulator • Set upper anterior and posterior teeth, then lowers to cross-arch contact or "balanced occlusion"	• Reported slightly more efficient in chewing tests • Posteriors appear more natural	• Most time and complexity of records • Limitations of anterior tooth positions • Restriction of posterior tooth positions to that allowed by cuspal anatomy	Cusped teeth 

Monoplane 0-degree teeth	• Centric relation jaw record only • Simple articulator • Set 12 anterior teeth with overjet but no overbite • Set lower teeth in flat plane to middle of retromolar pad • Set upper to match; no attempt on contact on excursions	• Simplest recording • Simplest articulator • Quick arrangement of teeth • Wide range of posterior tooth positions possible • No lateral stresses on mucosa with parafunction • Easier for patients with uncoordinated closures	• Flat premolars may appear less esthetic • Reported as less efficient in chewing tests • Anterior esthetics need more overjet and no overbite	Monoplane teeth 
Flat teeth with compensating curve or second molar ramp	• Centric relation jaw record • Semiadjustable articulator • Anterior teeth with overjet and slight overbite • Posteriors set to contact on at least 1 point on nonworking or balancing contact	• Simple to set up; allows for more esthetic overlap of anterior teeth • The posterior point contact maintains denture-base stability on excursions or parafunction	• Slightly more laboratory setup time than flat teeth • Premolars appear flat if visible	Flat teeth with compensating curve 

*Images copyright 2011, University of Toronto.

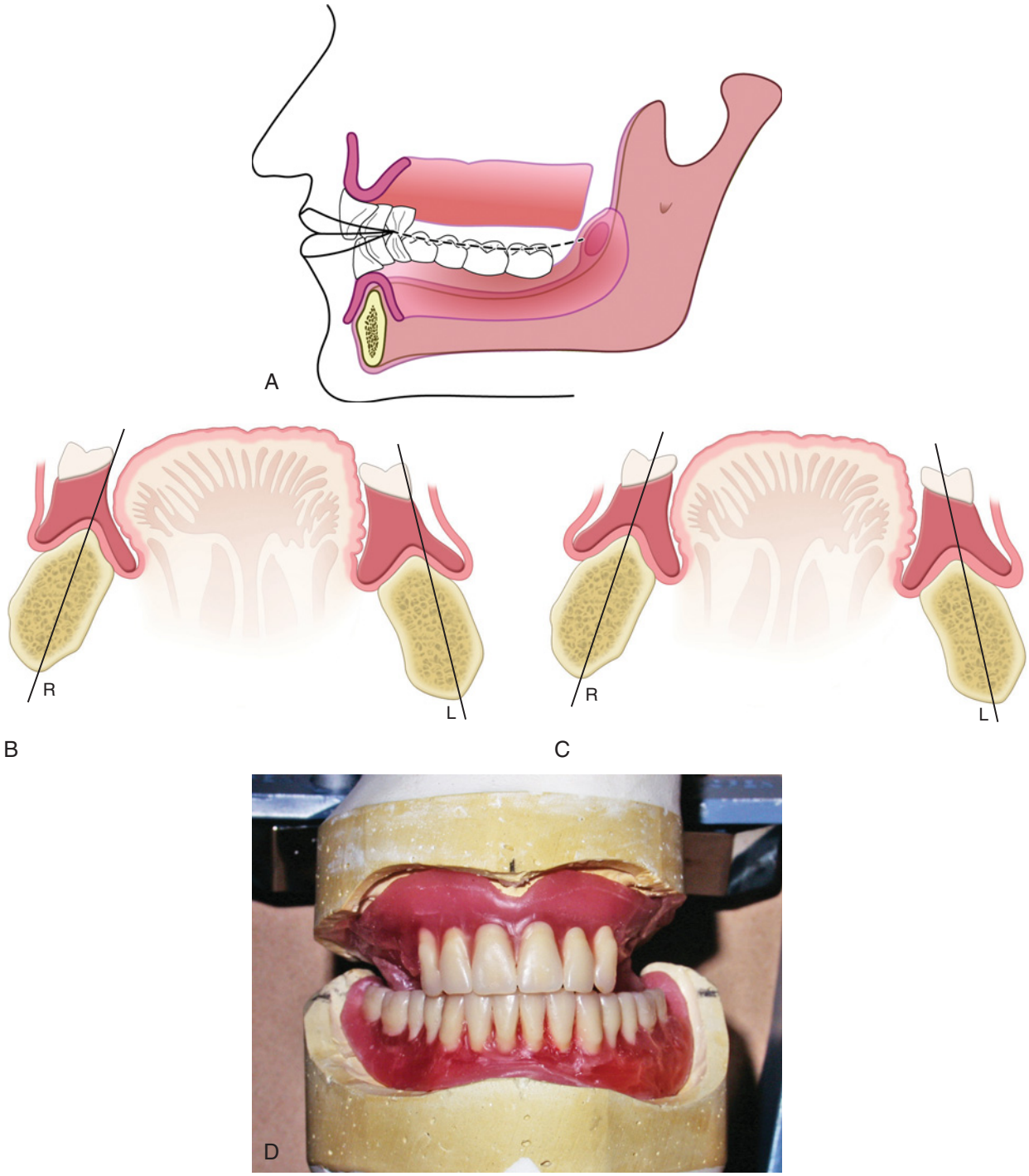


Figure 10-12 **A,** Mandibular teeth are set in the neutral zone from cuspid, over the bicuspid ridge, to the middle of the RMP. **B,** Mandibular teeth positioned too far toward the buccal of the ridge *(R)* and too far toward the lingual *(L)*. **C,** Positions of the mandibular teeth corrected from those shown in **B. D,** Maxillary posterior teeth will be set to match the mandibular teeth already set to mandibular landmarks. *(**A,** Copyright 2011, University of Toronto.)*

realistic, but they do not touch in occlusion or excursions. This halves the effective occlusal surface area, and moves contacts toward the midline. Patients subjectively report chewing to be better than a flat occlusal surface. From a position of maximum intercuspation, on excursions the maxillary palatal cusps glide over the opposing mandibular teeth to the width of the occlusal contacts.

For lingualized articulation, identify that "neutral zone" (corner of mouth to middle of RMP). Set the mandibular teeth first with anteroposterior (curve of Spee) and mediolateral (curve of Wilson) compensating curves. This can be done by touch and eye, or a compensation curve template can assist to align even cusp heights (Fig. 10-14).

Arranging Maxillary Posterior Teeth to Lingualized Articulation (Fig. 10-15)

The maxillary dentition is set with the palatal cusps in contact to the mandibular central fossae and marginal ridges. The buccal cusp tips do not touch and the

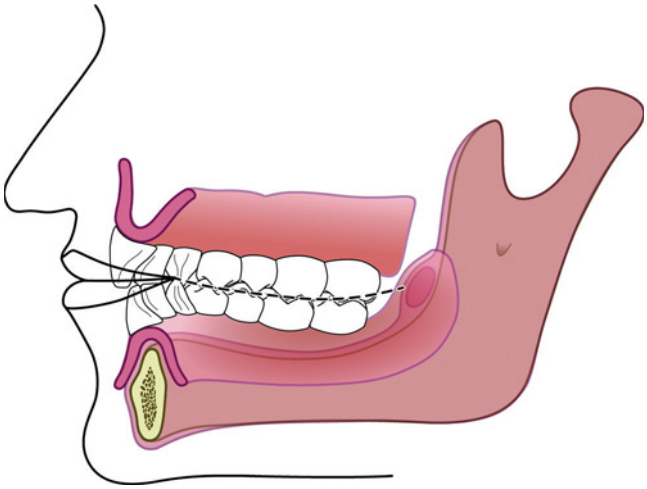


Figure 10-13 Maxillary anteriors and posteriors set. *(Copyright 2011, University of Toronto.)*



Figure 10-14 Curved plate to set mandibular posteriors on a curve to the middle of the RMP.



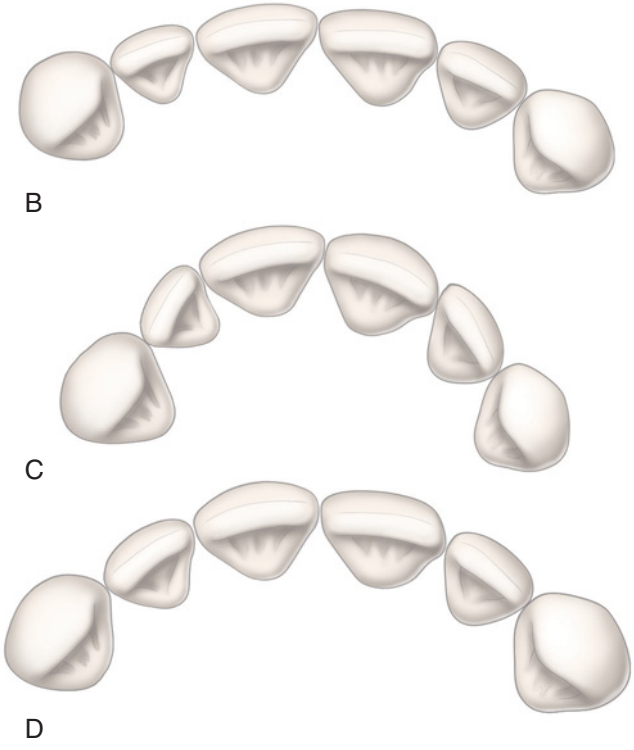
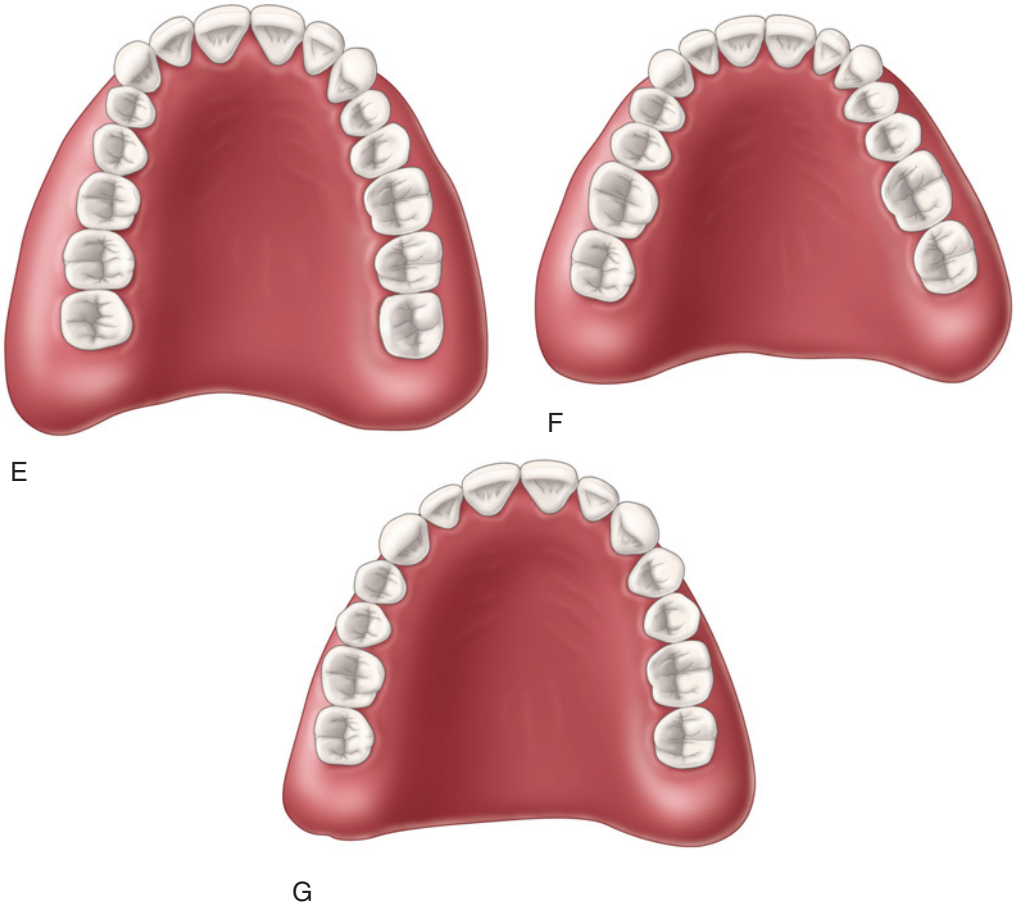


Figure 10-15 **A,** Upper setup with palatal cusps to contact lowers. **B** to **D,** Anterior arch forms: square **(B),** tapering **(C),** and ovoid **(D).**

Continued



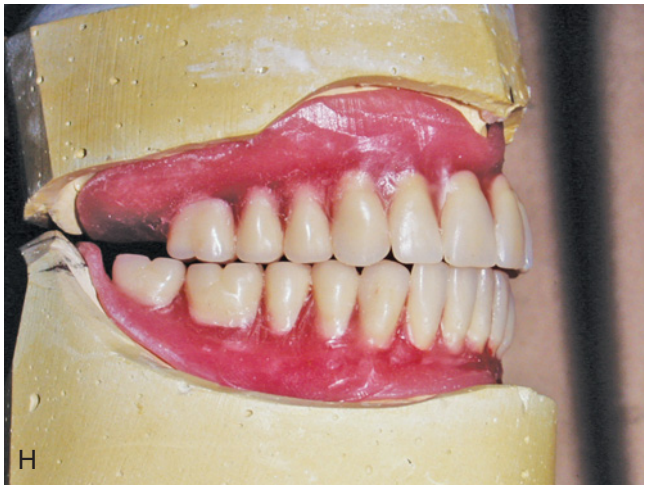


Figure 10-15, cont'd **E** to **G,** Varying shapes of the natural dental arch: square **(E),** tapering **(F),** and ovoid (**G**). **H,** Upper second molar deleted. Lingual occlusion with buccal cusps not touching.

mandibular compensating curves are followed. Assess the level length of the opposing mandibular ridge and mark its distal extent. Avoid placing occlusion on the ascending mandibular ridge by deleting the maxillary second molar if necessary. During each tooth setup and when all are in position, gently move the articulator laterally to the cuspid cusp tip contacts and protrusively to the anterior "end-to-end" positions. On these excursions, make the small adjustments necessary to create multiple working side contacts and at least one "nonworking" side contact to assist your patient on maintaining a stable denture position during chewing and parafunctional movements. While you want to create good occlusal contacts, the final occlusion will be created after processing when the teeth are secure in acrylic. At that

time, the teeth will not move and precise occlusion and articulation adjustments can be made that will not change.

ARRANGING ANATOMICAL TEETH TO A BALANCED ARTICULATION (FIG. 10-16)

For anatomical posterior molds to interdigitate precisely, the posterior contact point of the maxillary cuspids has to be a half bicuspid anterior to the mandibular cuspid posterior contact point. This limits the variation possible in the upper and lower anterior tooth setup. The anterior teeth are set with a minimal vertical overlap of 0.5 to 1 mm and 1 to 2 mm of horizontal overlap to establish a low incisal guidance (see Fig. 10-8). If the anteriors are set otherwise, then either a small space needs to set between the upper cuspid and first bicuspid, or the bicuspids sometimes have be ground smaller to allow effective interdigitation of the posteriors. Most clinicians set the mandibular teeth first to establish the ideal occlusal plane location for the stability of the mandibular denture. By comparison, the maxillary prosthesis is more stable and retentive because it usually has less resorbed ridges, a larger surface area with the palate, and a smaller peripheral circumference.



Figure 10-16 **A,** Anatomical teeth set in cross-tooth and cross-arch articulation. **B,** Anatomical teeth on left excursion with multiple right "balancing" contacts.

Setting the Mandibular Teeth First

The primary consideration in positioning the premolars is that they follow the form of the residual ridge. Mandibular resorption in the bicuspid region is almost completely vertical because of the thin cross-section of the bicuspid mandible with small bicuspid roots and buccal and lingual muscle insertions.

Set the mandibular first and second premolars over the residual ridge at a height on a line from the canine tip to 1 to 2 mm below the top of the RMP. When these lower teeth have been arranged, remove wax from the maxillary occlusal rim to set the first maxillary premolar into maximum intercuspation with the two lower premolars. Anatomical teeth are precise in their A-P cusp to marginal ridge orientation. Depending on the anterior overbite/overjet arrangement, the distal surfaces of the maxillary and mandibular cuspids may not allow for this precise A-P alignment of the upper and lower first bicuspids without some adjustment of the lower bicuspid or creation of a small diastema between the upper cuspid and first bicuspid. Once the premolars are set and properly related to each other, set the remaining mandibular posterior teeth at the correct height and buccal-lingual position to the RMP.

Set the maxillary teeth into the interarch space as necessary to achieve close articulation. Set them slightly high in softened wax, and close the articulator to push them into the correct vertical dimension. Because the teeth are longer on the buccal compared with the palatal, they often tilt out at the gingiva and out of contact on the palatal cusps. While the wax is still soft, use a hot spatula and push the necks of the upper teeth in to orient to proper buccal appearance.

Evaluating Bilateral Balanced Articulation

The presence of a balanced articulation can be inspected after all the maxillary and mandibular teeth have been arranged. Anatomical tooth molds will interdigitate precisely if they are set in an articulator that has the incisal and condylar guidances set to the same angles (e.g., 33 degrees) and if these teeth are set at the same occlusal plane and radius distance from the articulator condyles as when the teeth were designed. Patients rarely are identical to this geometry and some minor deflections will be observed. Set your teeth as precisely as possible in wax, but the final adjustment will be done after processing when the teeth are secure in the denture base acrylic. After processing, the selective occlusal adjustment by grinding can create a balanced articulation to the limits of excursions to the cusp tips and incisal edges for any of the patterns of posterior occlusion selected.

ARRANGING NONANATOMICAL TEETH TO MONOPLANE ARTICULATION (FIG. 10-17)

The technique for arranging cuspless teeth in a flat plane or monoplane occlusal concept is a distinct departure from what has been previously described. A simple articulator with zero degree condyles is used. Anterior teeth are set with the least overbite and most overjet that is esthetically acceptable. All the mandibular teeth are set in a flat plane to the ideal corner of the mouth-retromolar pad (CM-RMP) landmarks. The upper teeth are set slightly "high" in warm wax, the articulator is closed, and the tooth angulations are adjusted with a spatula tip as the upper teeth are squeezed against the flat surface of the lowers. The A-P relation of the upper and lower teeth is not critical because of the absence of cusps. Any combination of premolars or molars can be used to fill the available space. The posterior limit of the extent of these teeth is again the point at which the mandibular ridge begins to curve upward toward the retromolar pad. When patients slide their jaws in excursions, the slight resilience of oral mucosa allows the teeth to slip sideways or forward to the limits of the width of the teeth and the overjet. If the smile is not generous, this simple setup technique can produce an acceptable smile because the flatness of the teeth is inconspicuous.



Figure 10-17 **A,** Flat teeth set to a flat plane. **B** and **C,** Generous soft tissue hides flat posteriors. Diastema adds effect to minimal overbite and overjet. **D** and **E,** Anterior Angle class II division 2 smile prominence masks flat posteriors.

ARRANGING NONANATOMICAL TEETH WITH A BALANCING RAMP (FIG. 10-18)

When a simple setup is desired, and yet the anterior esthetics cannot be created with a minimal overbite, the denture stability on excursions can be improved with a "balancing side" posterior ramp. Set the teeth to a flat plane, delete an upper premolar or molar, and tilt the lower second molars at an incline to accommodate the anterior tooth overlap. On parafunctional excursions, this balancing ramp will assist your patient with working side incisive contacts.

ARRANGING NONANATOMICAL TEETH TO BALANCED ARTICULATION (FIG. 10-19)

This occlusal arrangement creates a more natural-appearing smile. The anteriors have a slight but definite overbite and overjet, and the posterior plane of occlusion has subtle curves instead of an artificially flat appearance. Nonanatomical teeth offer the benefit of A-P setup flexibility. Cusp tips and interproximal marginal ridges do not have to precisely interdigitate. Teeth can be set without any of the spacing sometimes necessary with cusped

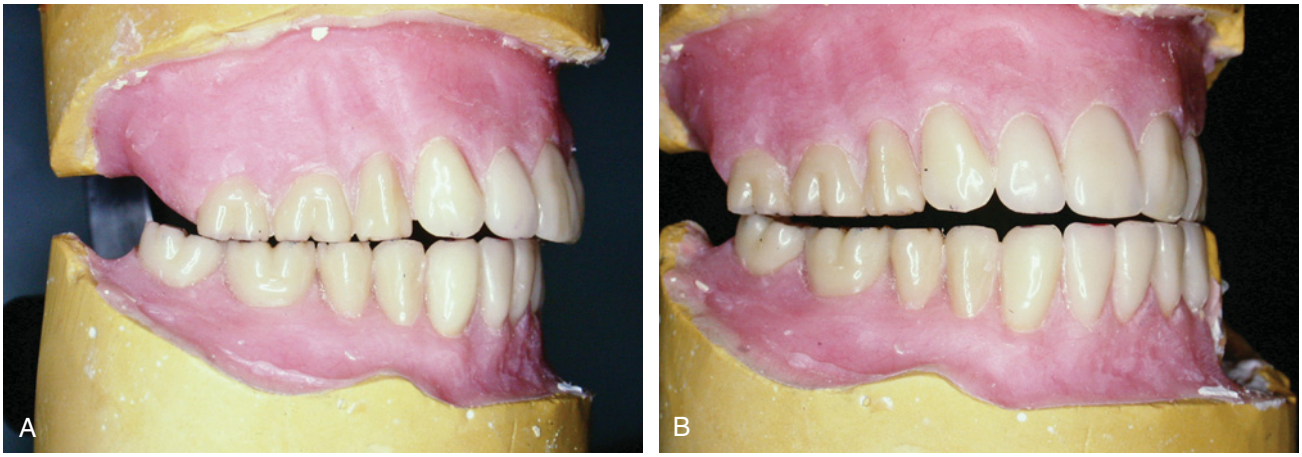


Figure 10-18 **A,** Anterior overlap, flat setup with upper premolar deleted and lower molar ramp. **B,** "Balancing side" ramp for anterior excursion stability.

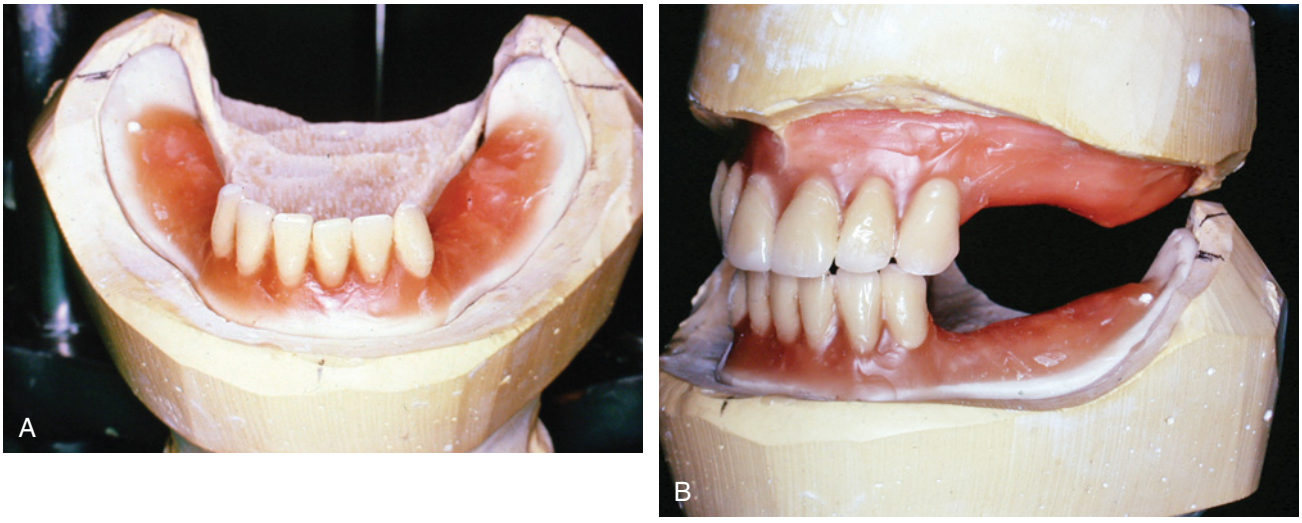


Figure 10-19 **A,** The four landmarks for the mandibular occlusal plane, distal of cuspids and the middle of the RMPs. **B,** Anterior slight but definite overbite and overjet. Nonanatomical teeth to be set on a compensating curve from the cuspids.

Continued



Figure 10-19, cont'd **C,** A point 1 to 2 mm below the top of the retromolar pad and the tip of the positioned mandibular cuspid are guides used in the placement of the mandibular posterior teeth. The central grooves of the posterior teeth are positioned on a line between the cuspid tip and the middle of the RMP. When only three posterior teeth are arranged, it is essential that the central grooves of the molars be positioned slightly to the buccal to avoid crowding the tongue. **D,** The mediolateral curve is formed by slightly elevating the buccal cusps of the posterior teeth above the lingual cusps. The curve usually does not exceed 10 degrees from the horizontal plane. **E,** The left second molars provide the "balancing" contact on a right excursion with this anterior overbite and overjet. **F,** No spacing is needed with nonanatomical teeth set in a curved occlusal plane. **G,** Wax-up ready for trying-in appointment.

tooth forms and are set to differing anterior tooth arrangements.

After the 12 anterior teeth are in position, the mandibular posteriors are set back to the middle of the RMP landmarks with A-P (curve of Spee) and mediolateral (curve of Wilson) compensating curves incorporated in the occlusal plane. On excursions, nonworking contacts are created such that the denture bases maintain their position and the need for the mucosal compensation for eccentric tooth contacts with flat teeth is minimized.

SETUPS FOR RETROGNATHIC AND PROGNATHIC FACIAL SKELETONS

During your examination and registration appointments, you will have become more aware of the skeletal relationships of your patient. Their maxillae may be more or less prominent relative to their cranial base and mandibular growth (Fig. 10-20). Their residual alveoli are not in the "standard setup" relationship, and their prostheses function best when they are modified to address these variations. The posteriors of Angle class 2 patients are similar to the standard setup but the anteriors are set with more overbite to match their skeletal reality.

If your patient previously had a prominent maxilla and/or a retrognathic mandible (Angle class 2 division I) (Fig. 10-21, *A* and *B*), they may need a setup with the same generous overbite/overjet relationship to restore their facial form, dental esthetics, and speech. The upper teeth may be so prominent that the lower lip postures behind them. The same applies for Angle class 2 division II patients (Fig. 10-21, *C* and *D*) who have a prominent maxilla and generous overbite but a minimal overjet and a shortened dental arch. The maxillary teeth are relatively prominent at the gingiva and their labial inclination is vertical or even retruded to best match the mandibular

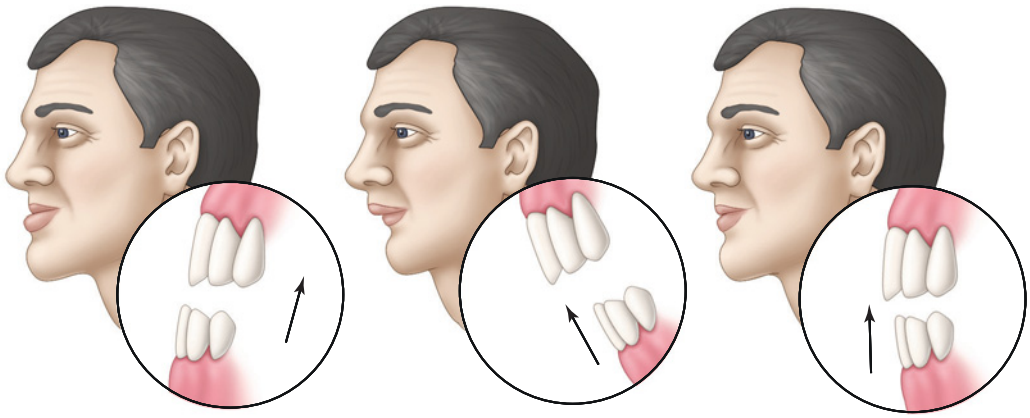


Figure 10-20 The inclination of anterior teeth often parallels the profile line of the lower third of the face. Prognathic and retrognathic profiles require different tooth setups.

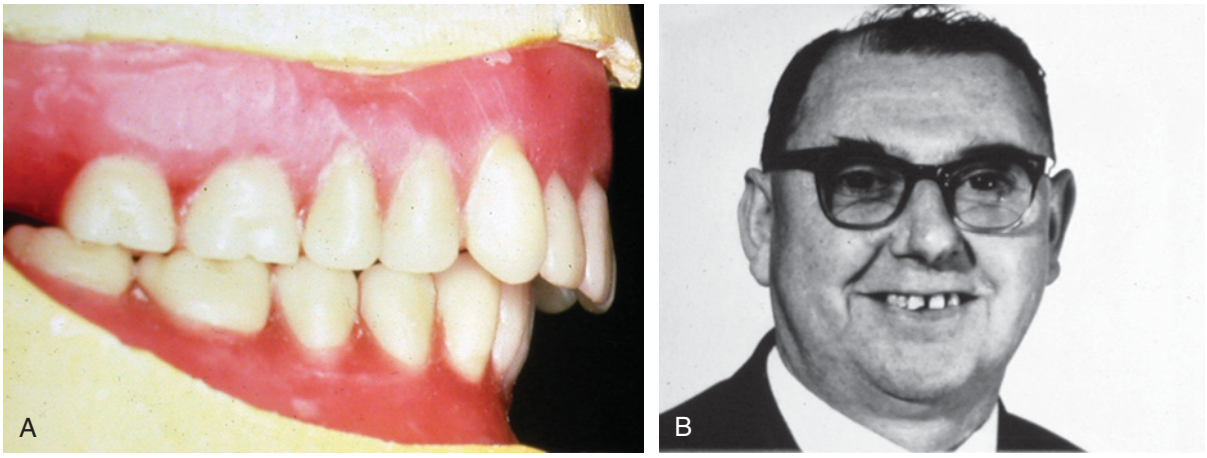


Figure 10-21 **A** and **B,** Angle class 2 division I. Male prominent midface required protrusive upper teeth with a generous overbite and overjet.

Continued

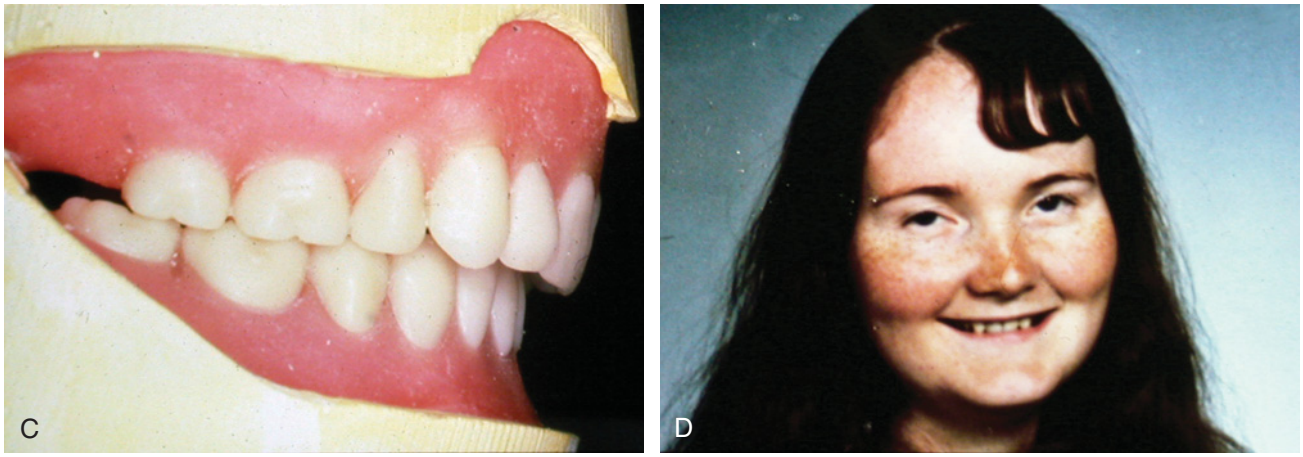


Figure 10-21, cont'd **C** and **D,** Angle class 2 division II. Female prominent midface with facial musculature required the upper teeth to be set in a retracted angle with deletion of the 4 bicuspids to recreate her previous natural dentition.

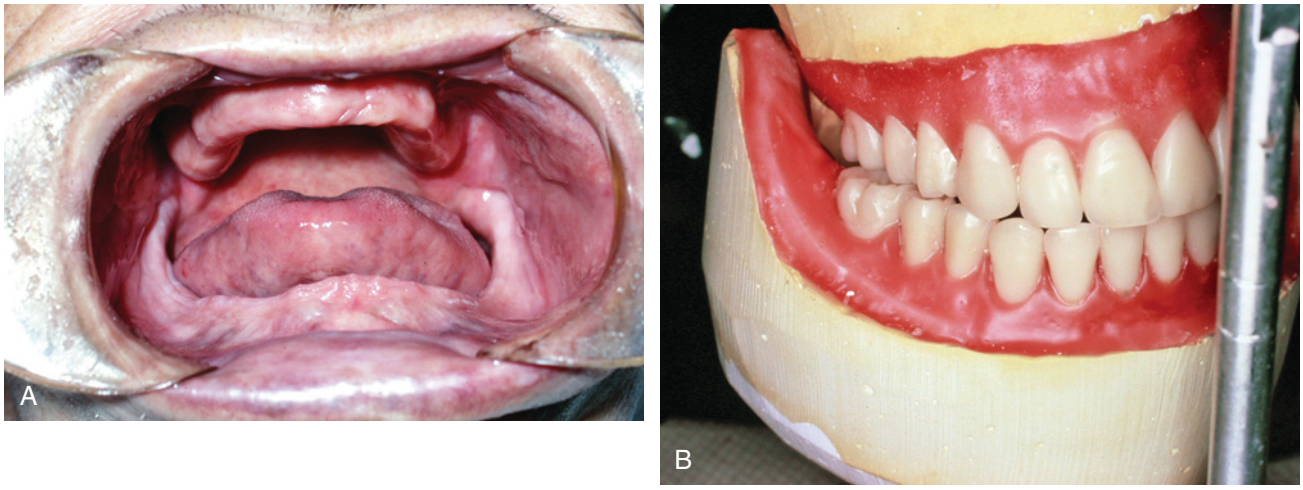


Figure 10-22 **A,** Large wide prominent mandible with small narrow retruded maxilla. **B,** Posterior crossbite setup with upper teeth lingual to lowers for best stability of both.

incisors, and the posterior teeth delete the bicuspids similar to the orthodontic therapy of serial extraction.

Prognathic patients (Angle class 3) are those with a combination of a prominent long mandible with small retruded maxillae. The setup is entirely different. Mandibular teeth are inclined lingually and distally back from the larger mandible to meet upper teeth, which incline outward from the both small and retruded upper arch. Upper anterior teeth are set "end-to-end" with no overbite/overjet and only light incisal contact. With more prognathism, the incisors may not contact at all. In order to meet the mandibular teeth, the maxillary incisors put too much tension on the upper lip musculature. Anterior teeth are set in a crossbite or "underbite." The posteriors are often set in a "crossbite" relationship with the maxillary buccal cusps positioned lingual to the mandibular teeth and an enhanced lateral occlusal curvature (curve of Wilson) to best accommodate the small maxillary/large mandibular arches (Fig. 10-22).

THE LINGUAL LOOK TEST (FIG. 10-23)

For all of the above occlusal plans, the test to check is whether or not the teeth fully touch in the lingual/palatal area. They can look fine from the buccal, but have no lingual contact. Look in the back of the articulator. Check that palatal cusps are in contact as planned. It is common to have to lift the mandibular lingual cusps up and pull the maxillary palatal cusps down to achieve your desired mandibular central fossa and maxillary palatal occlusal contacts.





Figure 10-22, cont'd **C,** Complete anterior and posterior crossbite for prognathic patient. **D,** Correct inclination of the teeth and incisal edges in a moderate prognathic relation.

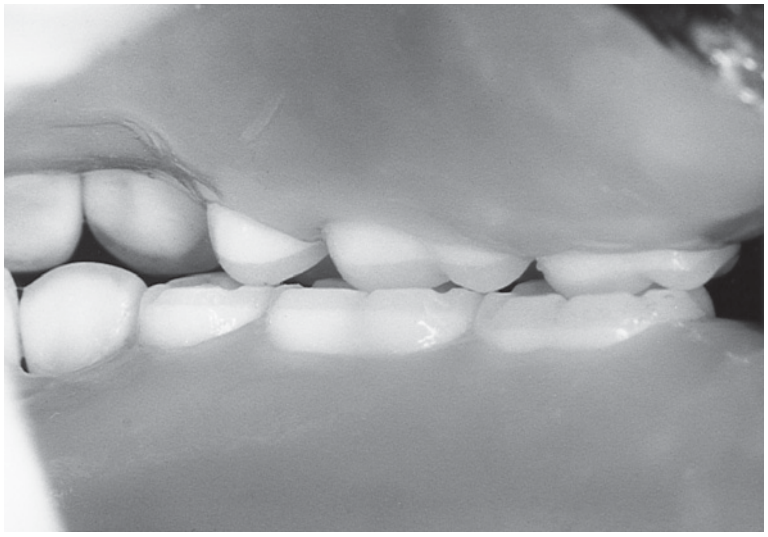


Figure 10-23 The Lingual Look test to confirm that maxillary palatal cusps are in full contact with the mandibular dentition.

COMPLETING THE WAX-UP FOR THE TRY-IN APPOINTMENT (FIG. 10-24)

Tooth setup works best with the minimum amount of wax necessary. It is easier to see tooth orientations and to move teeth when most of the denture teeth are visible. After you have set all teeth to landmarks, best esthetics, and occlusion, inspect the bases and models for wax bits and drops and remove them. Overlooked small wax droppings on the models can change the base seating on the model and then all of your occlusion. When you are satisfied that the bases are fitting fully and accurately, add the gingival contours. Flow molten wax in slight excess to build up the secondary gingival and mucosal contours, then allow the wax to cool to a firmness to allow carving. Use your favorite spatula or a set of cotton pliers to carve the wax to mimic gingival contours and papillae. Clean all wax from the tooth surfaces. The teeth above the gingiva need to be clean and free of all wax in order to be held securely and accurately during processing. Make a definite gingival finish line on the tooth

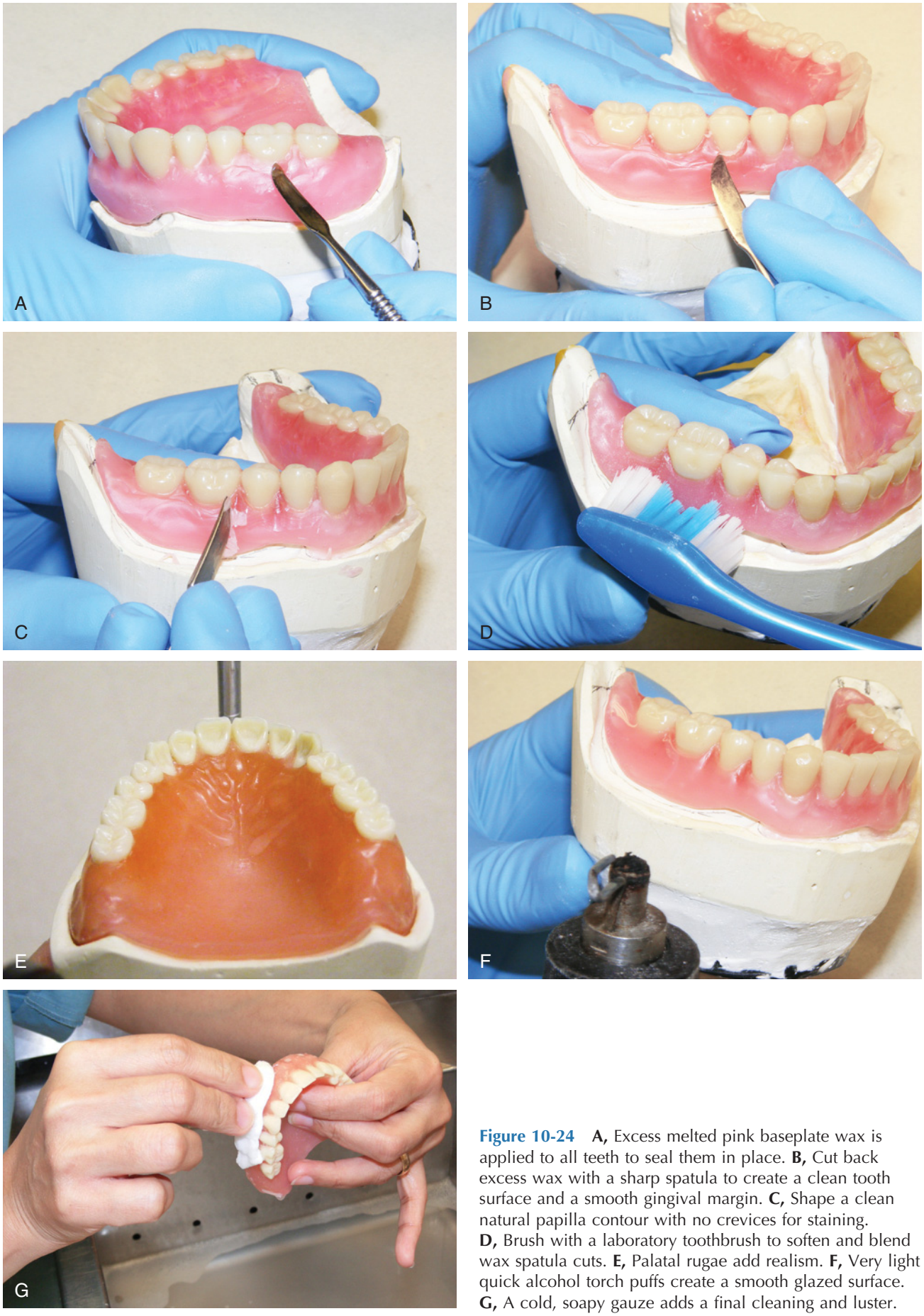


Figure 10-24 **A,** Excess melted pink baseplate wax is applied to all teeth to seal them in place. **B,** Cut back excess wax with a sharp spatula to create a clean tooth surface and a smooth gingival margin. **C,** Shape a clean natural papilla contour with no crevices for staining. **D,** Brush with a laboratory toothbrush to soften and blend wax spatula cuts. **E,** Palatal rugae add realism. **F,** Very light quick alcohol torch puffs create a smooth glazed surface. **G,** A cold, soapy gauze adds a final cleaning and luster.

but avoid grooves in the wax that will collect calculus. Finish the contours with a clean laboratory toothbrush. This will soften the spatula carvings and create a blended wax contour. A final polish with cold, soapy gauze will make this smile presentable for your patient.

SUMMARY OF TOOTH SELECTION AND ARRANGEMENT

Treatment of edentulous patients is enjoyable when one has empathy, listening skills, and an appreciation of dental esthetics. Impressions and recordings of healthy tissues need to be made and accurately transferred to an articulator. Teeth should be positioned in harmony with intraoral anatomy and circumoral muscle activity. Several different prosthetic tooth molds have been produced, and each has some purported advantages. In the absence of a clear advantage, dentists should use tooth molds that are esthetically pleasing and have a simple procedure for setup.

Bibliography

Carlsson GE, Omar R: The future of complete dentures in oral rehabilitation: a review, *J Oral Rehab* 37:143-156, 2010.

Clough HE, Knodle JM, Leeper SH, et al: A comparison of lingualized occlusion and monoplane occlusion in complete dentures, *J Prosthet Dent* 50:176-179, 1983.

Davies SJ, Gray RMJ, McCord JF: Good occlusal practice in removable prosthodontics, *Br Dent J* 191:491-502, 2001.

Hirsch B, Levin B, Tiber N: Effects of dentist authoritarianism on patient evaluation of dentures, *J Prosthet Dent* 30:745-748, 1973.

Khamis MM, Zaki HS, Rudy TE: A comparison of the effect of different occlusal forms in mandibular implant overdentures, *J Prosthet Dent* 79:422-429, 1998.

Lang BR: Complete denture occlusion, *Dent Clin North Am* 40:85-101, 1996.

Lombardi RE: The principles of visual perception and their clinical application to denture esthetics, *J Prosthet Dent* 29:358-382, 1973.

Phoenix RD, Engelmeier RL: Lingualized occlusion revisited, *J Prosthet Dent* 104:342-346, 2010.

Pound E: Utilizing speech to simplify a personalized denture service, *J Prosthet Dent* 24:586-600, 1971.

Rüdiger H, Müller F: Clinical studies on the appearance of natural anterior teeth in young and old adults, *Gerodontology* 21:10-16, 2004.

Sproull RC: Color matching in dentistry. I. The three dimensional nature of color, *J Prosthet Dent* 29:416-424, 1973.

Sproull RC: Color matching in dentistry. II. Practical applications of the organization of color, *J Prosthet Dent* 29:556-567, 1973.

Sutton AF, Glenny AM, McCord JF: *Interventions for replacing missing teeth: denture chewing surface designs in edentulous people (review)*. The Cochrane Library, Issue 4, London, 2008, J Wiley & Sons.

Van der Bilt A: Assessment of mastication with implications for oral rehabilitation: a review, *J Oral Rehab*. Published online January 17, 2011. DOI: 10.1111/j.1365-2842.2010.02197.x

CHAPTER

11

The Try-in Appointment

Aaron H. Fenton, Ting-Ling Chang

This chapter is similar to Chapter 10 in its prescriptive form of presentation as is usually employed in clinical manuals. This is done to facilitate the application of its content.

The try-in appointment is a significant one for successful edentulous patient care. It will be the first time that dentist and patient can see what has been created. The decision will then be one of acceptance, modification, or change. Mutual satisfaction with the provisional waxed-up result should be reached before the dentures are processed and become difficult to change.

By the time of a "try-in" appointment, you and your patient will have had several sessions together. At each of these appointments, you will have made various dental records: tooth selection, impressions, jaw relation records, and so on. These are those dental "things" for which your professional education prepares you and for which patients come to you. These records will help you make a smile similar to what the patient has—a conformative approach—or to intentionally change the new dentures to create something different and better—a reorganized approach. At the same time you will also have been making mental notes as to how to best communicate. Some patients are reserved and reticent; others are happy to talk more than anticipated. All of these factors come together to be resolved in the 30 to 60 minutes of "the try-in." It is really important to have you and your patient understanding and satisfied as to what results to expect before the irreversible act of processing a wax denture pattern into polymerized acrylic. A checklist (Table 11-1) is included for the many steps that are verified at the try-in appointment.

At the try-in, you will want to find out the following information in the following order of priority:

- Are the teeth acceptable in color and mold? If not, reorder and reappoint for another try-in.
- Is the articulator mounting of the models an accurate record of the patient's jaw position? If not, make new records in order to remount the models. Then reset teeth for another try-in.
- If both the teeth and mounting are acceptable, are the teeth in the best position? If not, change the midline, vertical dimension, occlusal plane, and/or arch form to be more appropriate.
- Are there any small improvements that will make the try-in fully acceptable to your patient and you (e.g., moving teeth to create a subtle rotation or diastema)?
- Should the wax contour be changed to improve tongue space or lip support?

The try-in appointment will have one of three conclusions:

1. Your patient and you are completely satisfied that the teeth are "okay" just as they are. You agree to have the wax-up processed into complete dentures. Each of you is already anticipating a happy insertion appointment. There may be some small points that will be improved in the processed dentures. For example, the dentures will be more retentive because they are made on the exact model. Registration bases formed on models with wax relief for irregular and undercut areas are less retentive.
2. You and your patient identify a significant change that is needed (e.g., the wrong color or position of the teeth). You make the records necessary for this change and arrange another try-in to verify the improvement.
3. For a very few and memorable people in your practice, you may not be able to make a wax-up that is satisfactory, even after two or three appointments. If this ever happens, the try-in may be the time to "call it quits." With tact, advise the patient that you cannot make the teeth as they want, and make arrangements for them to see someone else who may be more successful. Your patient will be better served. You will be happier, and your family will notice the difference.

BEFORE THE TRY-IN APPOINTMENT

Find out who decides. For many patients, teeth are personal and private, and they will make their own decisions and live with them. Others will have a spouse or friend whose dental opinion they value. Ask at the previous registration appointment and find out. Insist that your patient bring that

Dr. Fenton would like to offer his appreciation to Ms. Andrea Cormier for her original illustrations and the staff of dentistry in the audiovisual department at the University of Toronto for their management of images.

TABLE 11-1 TWENTY-SEVEN POINT CHECKLIST FOR THE WAX TRY-IN APPOINTMENT

Action to Check	What to Check	Response and Action
Telephone before appointment	Wax-ups ready on time?	Confirm with lab 48 hours before the appointment
	Spouse or others coming to appointment?	Yes, or agree to accept decisions
Chairside		
Existing dentures in place	In occlusion: record VDO at two skin points	Record to compare with wax-up
	Smiling: visibility, interarch space, and lip support	
Dentures out to compare to wax-up	Conformative—should be similar	Reorder teeth if color, size not correct
	Reorganized appt should be different as planned	Similar/different as planned
	Upper central to incisive papilla intaglio millimeters and angle	
	Lower central to ridge intaglio millimeters and angle	
Wax-up in mouth		
Lips apart mouth breathing	Midline in center of face and lip vermilion	Okay or move
	Anterior plane parallel eye pupils	Okay or reset tilt up/down
	Upper teeth correct length	Okay, move up/down
	Upper teeth adequate lip support	Okay, move in/out
	Adequate lip support	Add or remove labial wax for desired lip support
	Lower teeth just visible as appropriate	Okay or move; too much/little display needs occlusal plane or VDO change
Gagging	Correct PPS position: Fovea palatinae through hamular notches	Reduce wax base if excess palatal extension; counsel; can reduce denture palate but retention may drop; try first; assess for reduction; counsel.
	VDO: Excess VDO can create gagging sensation	
VDO	Occlusion: compare to previous VDO at two skin points	Assess need to change VDO
	Upper/lower teeth and gingival visibility	Subjective: All look/feel okay
	Facial profile and proportions mid/lower face	Reset VDO as needed
	Relaxed facial posture	
	Interarch space with breathing, swallowing, speaking	
	Patient perception of jaw position	
Guided jaw closure	THE TESTS	Okay or remount
	Do teeth touch in mouth the same as on articulator?	
	Are wax-ups stable between first touch and all closed?	
Smile!	Check midline again	Okay or move
	Anteriors and bicuspids pleasing visibility	Okay or change VDO up or down
	Posteriors at same level on both sides	Okay or move sides up/down to match
	Appropriate negative space between upper and lower teeth	Okay or reassess VDO and overbite/overjet
	Gingival display	Okay or carve back wax gingiva
		Excess gingiva may mean excess VDO
Speaking 50s	Upper teeth lower lip	Okay or uppers too short or long
Speaking 60s	Overbite/overjet and tongue posture	Okay or increase minimal overbite
		Decrease excess overjet
Swallowing	Patient subjective comfort and stability	Okay or reduce lingual flanges
	Wax-up intact? If teeth moved from secure wax-up, VDO and/or jaw relation may need change	Reduce excess VDO
Relaxed jaw posture	Protrusive posturing	Okay or increase overjet
Query	Tooth characterization—wear, chips, restorations?	Okay or create
Query	Gingival color okay?	Confirm gingival shade tabs
Query	Anything else?	Address questions
Query	Spouse and others satisfied?	Offer take home if absent
Query	All satisfied? Politely ask again	Confirm satisfaction, agreement to proceed, and fee to be paid next appointment
		Celebrate successful treatment to date

PPS, Posterior palatal seal; *VDO,* vertical dimension of occlusion.

"significant other" to this appointment. The last thing you want is to have dentures that are ideal in all respects, except for the important opinion of someone who was not consulted. In addition, by seeing and understanding what is involved in making a new smile, the significant other can be extremely helpful in supporting your patient during his or her adaptation and acceptance of that new smile.

There are a lot of expectations attached to this appointment. You want everything to run smoothly. Allow enough time to check and confirm the correctness of your dental result, and if necessary make improvements. Your patient will need time to make a decision. If your try-in goes faster than you anticipate, enjoy it. You will have the double pleasure of a successful try-in and happy patient, and your office will have the precious spare time for a coffee break and/or catching up on the waiting mail and phone calls.

Have all of the specific equipment that you need for a try-in available, clean, filled, and in ready-to-work order. The patient needs to see what they have, and you need to measure, and possibly move teeth in wax, or make new jaw records. In addition to your exam kit, this requires:

- A patient hand mirror and wall mirrors with good lighting to allow patients to see clearly and judge when they are satisfied.
- Two Boley gauges and a millimeter ruler will allow you to compare and verify tooth positions correctly for yourself and to show your patient.
- A Bunsen burner, or at least an alcohol torch, to melt wax so that waxes and teeth will stick together.
- A warm water bath to soften wax for quick and easy tooth movement.
- A cold water bath to quickly stabilize the new wax shape.
- Your favorite wax spatula and a sickle scaler to move teeth within wax and seal them in that position.
- An inexpensive disposable toothbrush to smooth the gingival wax.

Many patients will receive complete denture treatment as a replacement for existing prostheses, and several points in this chapter refer to previous dentures. If your patient does not have existing prostheses then these points would not apply.

Confirm that the wax-up will be ready. When you are doing your own lab work, this is not a problem, but many general dentists use independent dental laboratories to assist them. Phone ahead to verify that the wax-up (waxed models of the dentures with the denture teeth) will be delivered and ready several hours before the patient's appointment. Medical emergencies and car accidents can interrupt deliveries. Patients are not impressed with your office if they take time off work, drive sometimes hours to see you, and then are told things are not ready.

Does it look good? Perceptions count. The articulator-mounted models and the waxed-up dentition need to look neat and accurate for the patient to be reassured that they are receiving the best of care.

Will it be comfortable? Inspect all of the wax-up for any thin, sharp, or rough areas. Smooth them. You do not want to be on the defensive when you are seeking your patient's acceptance.

AT THE TRY-IN APPOINTMENT

For both your patient and you, this appointment has a lot of nervous anticipation. It is the revelation of the unknown. Your patient has probably made a financial deposit, endured several sessions of funny tasting things in their mouth, and no dentures have yet appeared. They will be wondering what to expect. What will their new smile look and feel like?

You, as the dentist, are more experienced, and with the progress of your practice, you will know more of what to expect. Despite your efforts to make the most accurate dental records, today is the first time for each of you to see the result. It is like opening a present at a party. It should be just as much fun.

EXPLANATION

At the start, explain what to expect in simple nondental terms:

- These are not the dentures. The teeth are the actual teeth, but all the rest is a wax pattern to hold the teeth so that we can check to see if everything is "okay."
- They are only for looking, not for chewing. The wax will bend and the teeth will fall out if you bite too hard on them. Because it is soft wax, it may be a little thicker in some places for strength. This also allows us room to polish the final result.
- The pattern may not be as retentive as the final dentures because they were made on models that have been relieved to protect them. The dentures will be made exactly to the models.
- The gingival color is a pink-tinted wax. The actual gingival acrylic color will be (more/less) pink as desired. For some patients, gingival acrylic shade tabs will help resolve any color concerns.
- We want to check everything and see if anything needs to be improved.
- The actual teeth will only start to be made after we are both satisfied with this wax model.

CHAIRSIDE COMPARISON

At chairside, compare the wax-ups to your study models of the patient's existing teeth. Point out how you have succeeded in either making the teeth look similar in size and position (the conformative approach [Fig. 11-1]) or making



Figure 11-1 A conformative approach. The right side waxed-up dentures are similar to the patient's existing prostheses on the left.



Figure 11-2 A reorganized approach. The new denture on the right is purposely different from the previous denture on the left.

the teeth look different as requested (the reorganized approach [Fig. 11-2]).

Note points where you and your patient are in agreement, and the points that need to be changed.

Identify a notable fold or skin pore on the left of both the nose and chin. Ask your patient to "*bite together and hold*" while you measure the distance between these points with a Boley gauge (Fig. 11-3).

This gives you an extraoral measurement of the existing vertical dimension of occlusion (VDO). Remeasure this dimension when the wax-ups are in place and determine if you have what is needed.

DENTURE COMPARISON

When ready, ask your patient to remove their existing teeth. Then do not expect them to talk and express opinions until they have teeth in again. An Alma gauge is an excellent



Figure 11-3 Record the existing VDO by measuring two skin points.

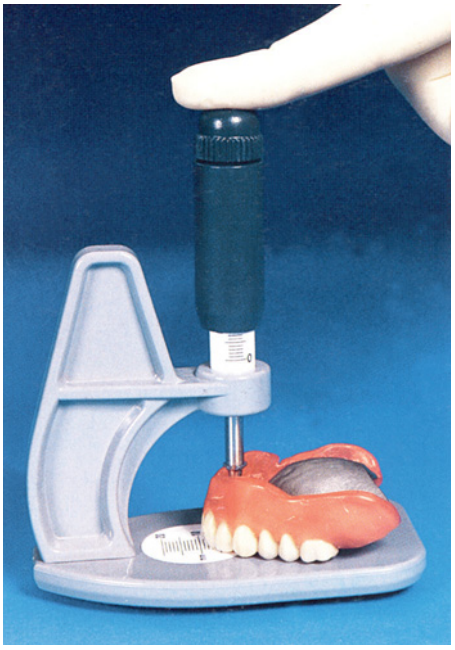


Figure 11-4 An Alma gauge records the vertical and horizontal distance between an incisal edge and the incisive papilla intaglio.

method of recording the vertical and lateral distance between the incisor edge and the incisive papilla in a denture (Fig. 11-4). These measurements between dentures allow for comparison and confirmation of tooth positions.

Alternately, a Boley gauge can measure the dimensions of the upper teeth from incisive papilla to incisal edge, and the lower teeth from the ridge crest to incisal edge. Does the wax-up have teeth in the position that you have planned relative to the current dentures? These dentures were planned to conform in appearance, but they have a restoration of the VDO to accommodate the alveolar resorption that had occurred over the 22 years of wearing the previous

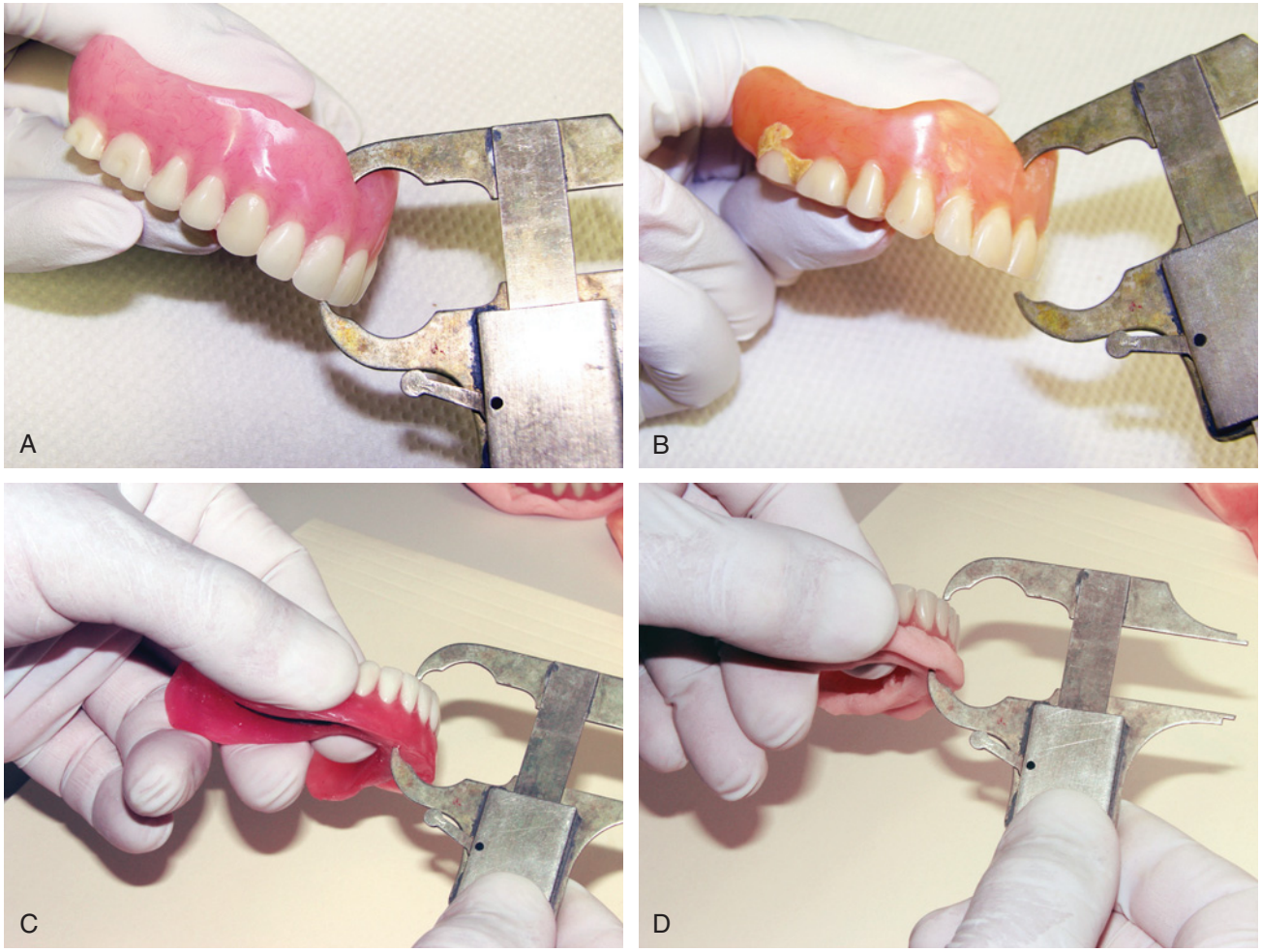


Figure 11-5 **A,** Wax-up measurement of papilla to incisal edge in millimeters. **B,** Wax-up measurement compared with existing denture. It is slightly greater as planned. **C,** Mandibular wax-up incisor to ridge measurement. **D,** Wax-up measurement compared with existing denture plus the soft liner. It is increased as planned.

prostheses. The previous lower denture was raised and reoriented 4 mm with soft liners that the patient wore for a month to assess her tolerance. The patient and her family immediately appreciated the improved facial support, speech, and tooth appearance, and they were positively anticipating the wax-ups that had even more improvement of VDO and tooth visibility in both of the upper and lower wax-ups. Now is the time to assess if the change is just right, too much, or too little. Comparison at chairside with the patient will allow you and him or her to see and understand the improvements that have been created. If the changes are more or less than desired, these measurements are the basis on which corrections can be made (Fig. 11-5).

THE REAL TRY-IN

In reality the results in the mouth are what count. Will the teeth, as framed by the lips, look like what the patient wants? This is more important than whether the teeth match the old dentures. Now you will go through a checklist of items, first with the patient, and then with yourself. The following items will serve as a guide as to what to check and what to do about it. In order of priority, confirm the following:

- Are the bases comfortable and retentive enough to allow the patient to concentrate on the appearance of teeth? A sharp flange that hurts, or a dropping down upper denture base may distract your patient from the try-in decisions that are important.
- Are the teeth the right color and size?
- Are the articulator-mounted models an accurate record of the centric jaw relation?
- Are the teeth in the correct position?
- Are the base contours supporting the lips properly?
- Are wax-ups acceptable as they are?
- Anything else? Now is the time for changes.

If you and the patient agree on the answers to these questions, then the dentures are ready to process.



Figure 11-6 The moment of truth when your patient first sees her smile!

Depending on the answers to the above questions and the steps needed to correct things, a try-in appointment may range from lasting 10 minutes and reaching a happy mutual agreement to scheduling another appointment to reach that agreement.

Insert the waxed-up dentures. Ask your patient to "*breathe through your mouth*", and then "*smile.*"

Look, make a mental image, and confirm for yourself: how are the midline, plane of occlusion, and tooth appearance? Is everything okay, or do you see a problem? You should have this mental image ready so that you can respond to your patient's reaction.

Now give your patient a hand mirror and ask what they think (Fig. 11-6).

This is the moment they have been waiting for, and it is their time. Listen before responding. Do not get upset if your hours of work are not perceived as ideal. Your patient may be only exploring what to expect. Identify the good points that you agree on, and work forward to "iron out the wrinkles." The maxillary anteriors are usually the most visible part of a smile. Start there and expand your investigation to the rest of the smile. Find out if the teeth are "okay" by seeking answers to your polite questions:

- How is the color, and how is the size of the teeth?
- How is the midline? Does it look right in the center?
- Do the teeth show enough, or not enough?
- Does the smile appear level, or is it tilted a little?
- If tilted, should we move it up on one side, or down on the other, or both?
- Are the lower teeth showing enough?
- Is there adequate space between the teeth with lips apart/mouth breathing?

Note the agreements: check, check, check, and changes needed 1…, 2…, 3… with notes, or a diagram of what to improve.

Restate your patient's comments to ensure you understood what he or she said. Every dentist can remember a time when a patient said something like "*it's too gummy.*" Does that mean carving gingival wax from the teeth to show less gum and more tooth, or do all the teeth need to be reset to reduce the gummy appearance? Such clarifications are vital to good dental management.

What you are now assessing is whether or not the waxed-up teeth are pleasingly positioned relative to your patient's face. Think of their smiling lips as the frame around a picture. The teeth should be positioned such that the central incisors are the most obvious object, located in the center of the picture, with an appropriate ratio of dental sizes and positions of teeth moving away from that center, left and right, up and down, and front to back. It should all blend in proportion as outlined by Lombardi (Fig. 11-7).

Apply these principles to what you see in the smile. Note and approve, or agree to correct the midline, tooth visibility, and occlusal plane (Figs. 11-8 and 11-9).

SPEAKING AND PHONETIC ASSESSMENT

Please refer to Chapter 15 for the theory supporting these sections. A phonetic functional assessment has four goals. Your patient gets used to the feeling of the new teeth, and starts to adapt and develop confidence and acceptance. Each of you can assess both the appearance of the teeth, and just as valuably, the space between them while speaking. Speech provides a functional assessment of an acceptable interocclusal dimension between the "rest" and "occlusal" positions of the mandible.

Everyone can count, so use numbers to assess your patient's ability to form clear and correct consonants with this wax-up.

Ask your patient to count through the 50s: "50, 51, 52, etc…." This labial/dental-formed sound will assess the visibility and position of the upper anterior teeth relative to the lower lip. Decide if the upper teeth appear pleasing in their position or if they should be moved up/down or forward/back (Fig. 11-10).

Then have your patient count through the 60s, "60, 61, 62, etc…." This lingual/dental-formed sound will assess the position of the upper anteriors to the residual alveolus, the appropriate height of the upper and lower anterior teeth, and the interocclusal airway space. The sibilant "s" sounds should be clear and crisp. If the speech is muffled, the upper anteriors may be too short and/or set too high in front of the residual alveolus. Reset them into a position where your patient can channel the airflow above the tongue and against the palatal surface of the upper anteriors (Fig. 11-11).

The upper and lower teeth should each appear to be visible with the sibilant sounds. If either the upper or lower are excessively visible compared with the other, consider

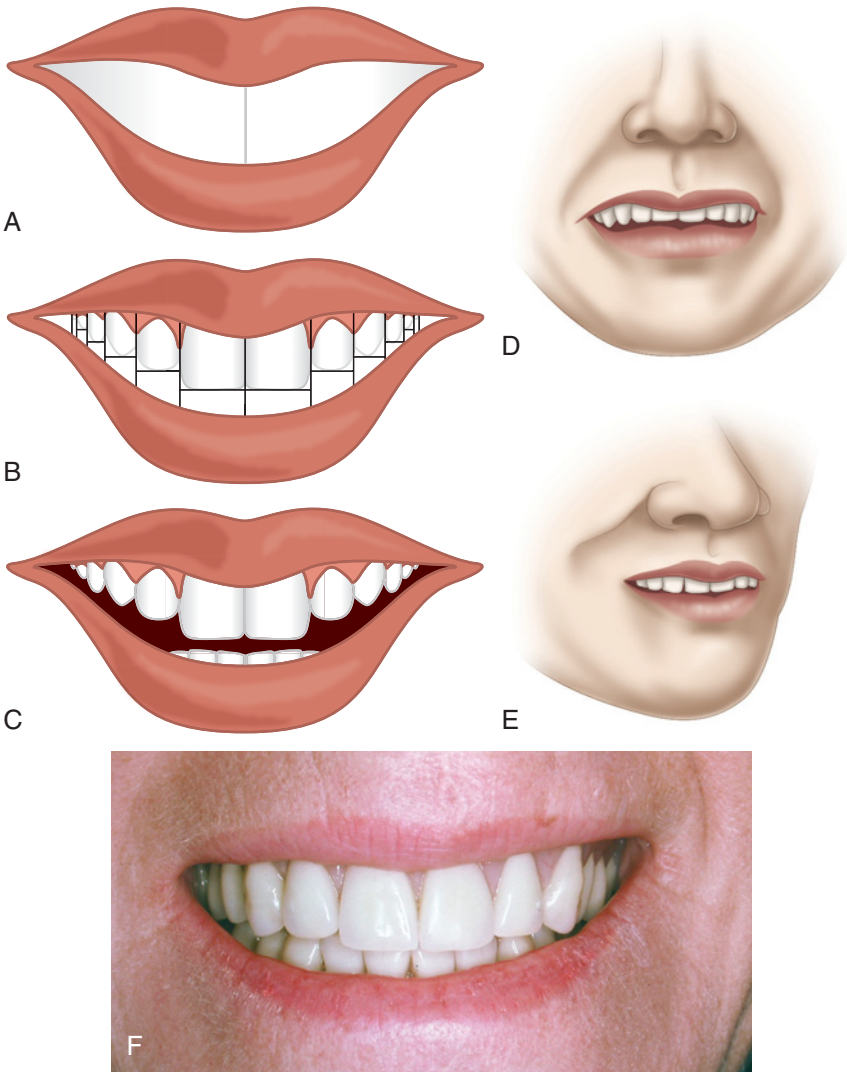


Figure 11-7 **A,** The smiling lips frame an image with the midline in the center. **B,** Perspective and dental proportion. The laterals, cuspids, and bicuspids blend posteriorly and follow the lower lip line. **C,** Subject and background. Upper front teeth are the subject. Gingiva, the interarch space, and lower teeth are background. **D,** Negative smile line not in harmony with soft tissues. **E,** Positive smile line follows lower lip contour. **F,** Complete upper and lower dentures have a pleasing appearance created by proportion between upper/lower and anterior/posterior teeth, subtle interarch space, gingiva in background, positive smile line, and facial support.

changing the occlusal plane for a better balance at the same vertical dimension. Warm the entire wax rim in a hot water bath and then move the teeth to modify the occlusal plane.

VERTICAL DIMENSION OF OCCLUSION

With the wax-ups in slight occlusion, remeasure the extraoral Boley gauge distance between your previously identified landmarks. If as a result of your assessment of ridge resorption and occlusal wear of existing dentures, you planned a slight improvement of the VDO, this measurement should be slightly greater with the wax-up compared with the old dentures. Everything is a judgment now. It may surprise you to find that the wax-up vertical dimension is more or less than anticipated, and yet it may be more or less acceptable to you and/or your patient. Whatever the perceptions, measurements are valuable to assist the decision making of your patient and yourself for the rest of this appointment. You need to know where you are in order to plan where you might go.

The speech assessments just previously finished are also a help to provide a functional assessment of the mandibular occlusal position. There should appear to be a slight but obvious negative space (the closest speaking space) between the upper and lower teeth during speech. If this dark background appears more obvious than the teeth, perhaps the entire vertical dimension is inadequate. Open the

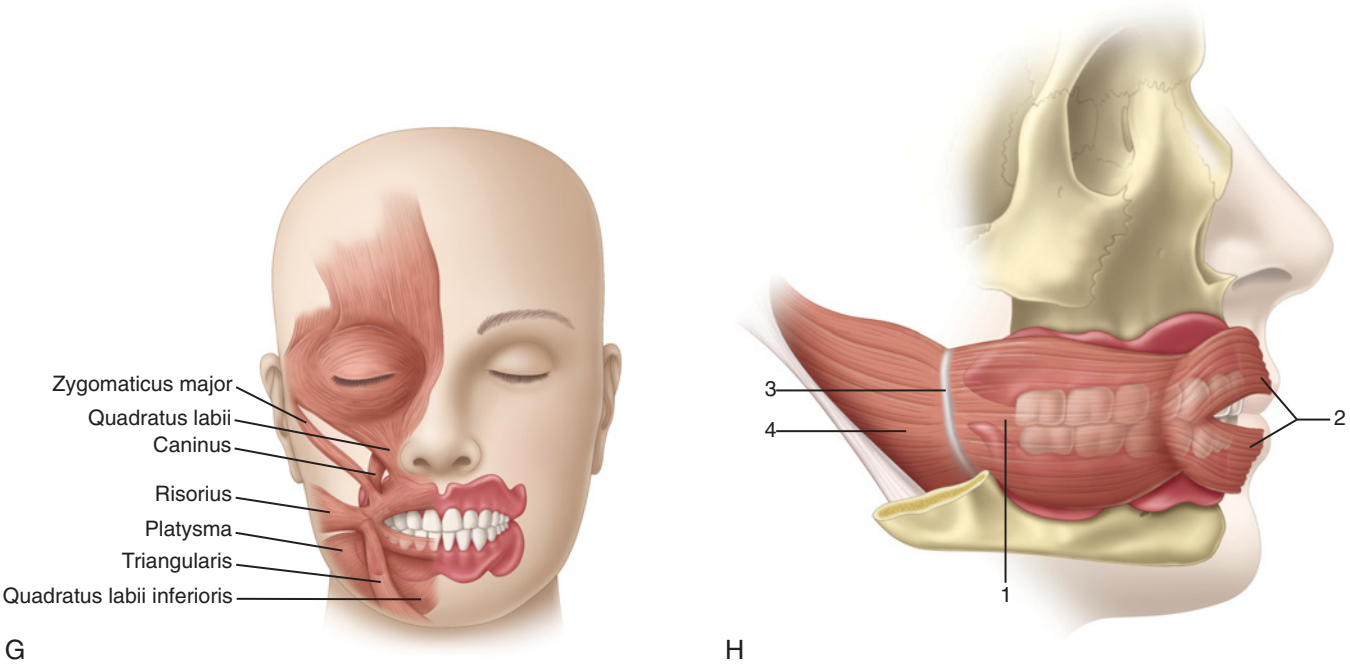


Figure 11-7, cont'd **G,** Muscles that maintain facial support. When artificial teeth and the denture base material restore the lips to their correct contour, the facial muscles will be at their physiological length, and contraction will create the normal facial expression of the patient. **H,** Functional unit of the buccinator. This muscle *(1)* and the orbicularis oris muscle *(2)* depend on the position of the upper denture for their proper action. The pterygomandibular raphe *(3)* and the superior constrictor of the pharynx *(4)* also are shown.

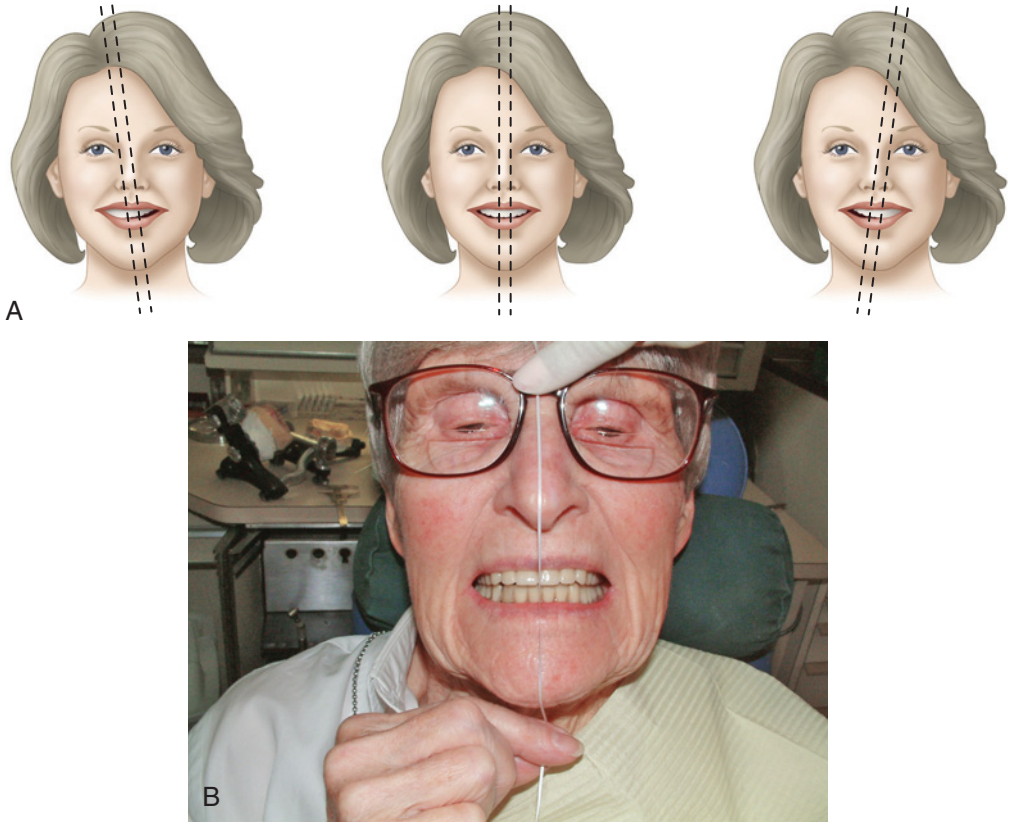


Figure 11-8 **A,** Identify facial landmarks and lines to which the smile will blend. The middle drawing shows that such parallelism provides a necessary harmony of lines. Notice the disharmony of the left and right. **B,** Using dental floss to confirm the dental midline to the facial contours.

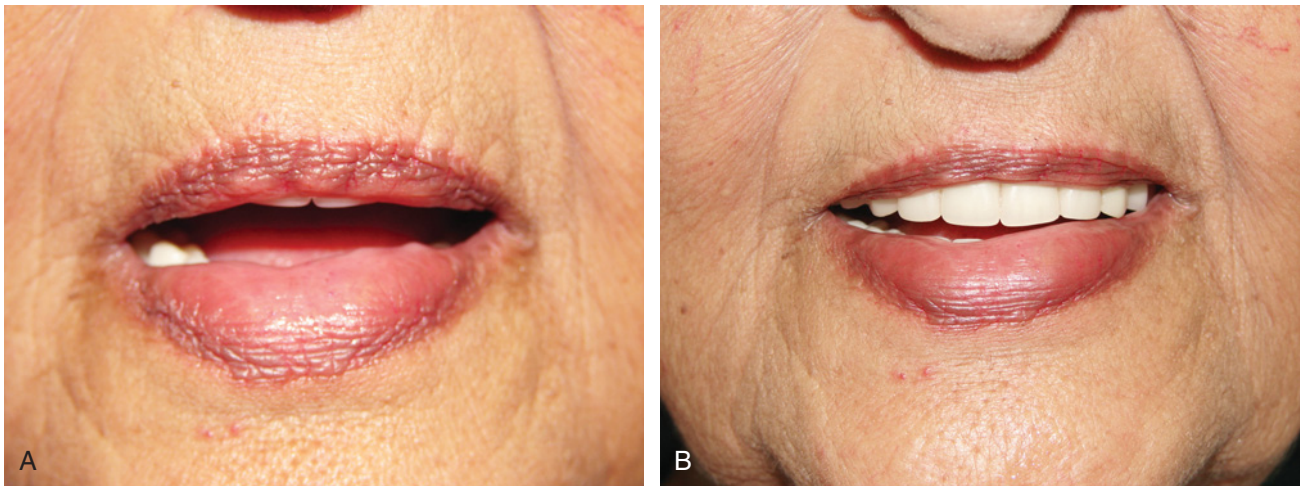


Figure 11-9 **A,** Existing dentures lack visibility because of bone resorption and tooth wear. **B,** Wax-up better visibility, but occlusal plane needs adjustment: down on left and up on right.

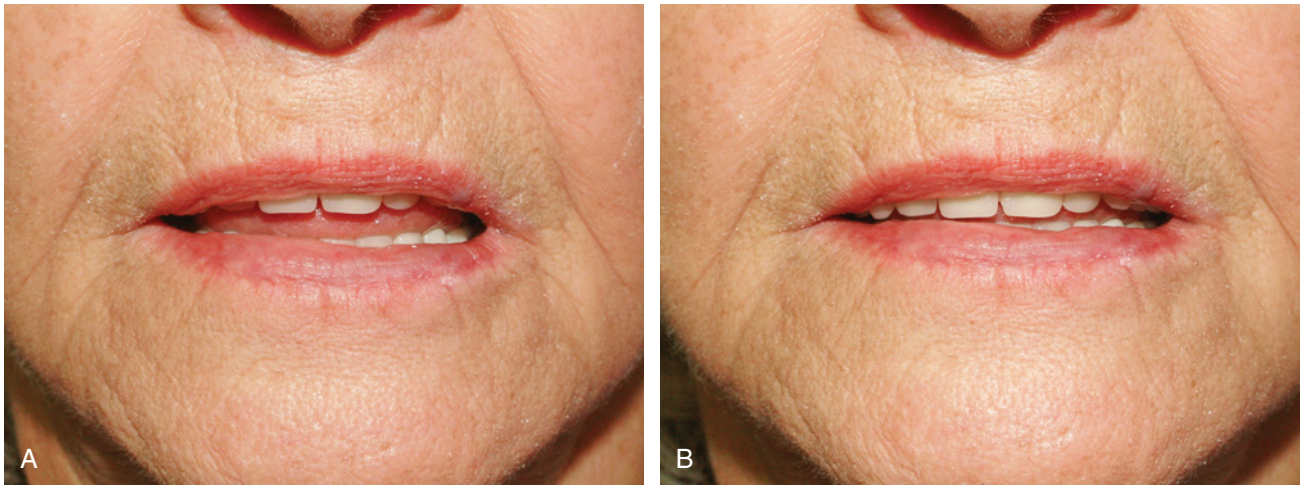


Figure 11-10 **A,** Teeth did not show during speaking the "50s." **B,** VDO increased by resetting upper and lower teeth for speech.



Figure 11-11 Patient counting through the "60s" to assess anterior tooth positions.

articulator pin, warm the wax rims, and move the entire arches to create an improved VDO. Remember that on average for every 1 mm of vertical dimension change, the anteroposterior relation also changes at 0.75 mm.

The opposite also may exist. If your patient can only speak with the teeth clenched together without any space between them, you may have been too generous in restoring the VDO. Use your Boley gauge to compare the vertical dimensions of the existing dentures and the new wax-ups. Measure the upper from the incisive papilla to the incisal edge, and the lower ridge crest to incisive papilla. Also measure the anterior-posterior dimension of the teeth relative to the incisive papilla and lower ridge crest. Raise the articulator pin from the table, warm the wax rims thoroughly, and press all the teeth in the wax-up to reduce the articulator vertical dimension. Also correct any long axis irregularities that you may have created by intruding

the teeth, cool the wax to stabilize it, and then repeat the intraoral visual and phonetic assessment.

When finished, assess the facial posture, profile, and ratios of the face. The upper, middle, and lower face should be in "thirds" for average patients. With resorption and tooth wear, patients can lose considerable facial support. They compensate with a subtly changing class III prognathic profile and excessive interocclusal dimension. Complete dentures do much to restore the facial contours and facial height to normal ranges (Fig. 11-12).

CHECK THE DENTAL OCCLUSION

Now move to intraorally assess the occlusion and articulation at your selected jaw relationship. This is where the clinical art of combining psychology, physiology, anatomy, and materials comes together. In essence, you want to make sure that the teeth fit together in the mouth the same as they just did on the articulator. If they do, you are happy that your jaw recording and articulator mountings were accurate, and you can proceed to processing the dentures with this articulator mounting. If they do not fit the same way, then you will be relieved to find this out before the dentures are processed. A new corrected registration, tooth setup, and try-in can be made to confirm your records as accurate before processing. Almost everything has some range of tolerance, and the resultant changes can accumulate to become an error: the oral mucosa can be deformed from old dentures, impressions can vary in accuracy, mounting plaster expands, trial bases have varying degrees of accuracy, wax expands and contracts with temperature, patients can shift in their mandibular posture, mucosa can be deformed under load, and dentists can unknowingly shift bases on mucosa. It is a wonder that we are able to make complete denture prostheses as well as we can. The try-in is the time to confirm that our clinical steps are satisfactory before processing.

One of the most interesting and unique skills that you will develop in all of your dental practice will be the ability to make accurate intraoral edentulous jaw relation registrations and verifications. This involves two people doing eight things simultaneously and accurately. You have to develop your skill at feeling what a patient's relaxed jaw closure feels like as you and the patient allow the jaw to arc closed along the posterior border of the Posselt's diagram. Meanwhile you have taught the patient and he or she has learned three things: (1) what it feels like to allow the jaw to close passively, (2) what it feels like to stop at a certain point, and (3) how to hold that position so that you can check the occlusion of your prostheses. This action is repeated several times until the patient is comfortable, the movement is consistent and repeatable, and you are satisfied with its accuracy. At the same time, you are doing three things: (1) holding the upper base up and secure against the maxillary mucosa; (2) holding the lower base down and secure on the mandibular residual ridge; and (3) positioning your dental light, yourself, and the patient's lips so that you can clearly see the teeth.

You need to see the teeth at three different positions as your patient closes:

1. When the teeth are just apart (close but not touching)
2. When a first contact is made, and where it is
3. When all teeth are in occlusion

The following descriptions of hand/finger position assume a right hand dominant operator. If left-handed, please reverse the description.

RELAXING AND REHEARSAL OF A RELAXED JAW CLOSURE

All of us have strong protective jaw muscle reflexes to prevent hurting ourselves. Patients will instinctively learn and adapt to altered closing patterns and jaw positions to avoid uncomfortable prostheses. If jaw recordings are made to such an altered position, then as soon as you make better, more comfortable dentures, patients will be able to use a relaxed normal closing. Now your brand new teeth will not fit! They were made to the old adapted position that the patient had to develop to survive with their old teeth.

The successful dentist has learned what a patient's relaxed jaw closing arc feels like, and learned how to work with patients to let them relax and achieve this comfortable closure. It is easier for some than others. The edentulous patient presents the unique challenge of making this recording while simultaneously holding two movable bases in their correct positions. If a patient has any teeth, overlaid roots, or implants present, the security and stability of denture bases is dramatically improved.

Ask your staff for quiet. You need to avoid all distractions and things that might startle your patient. Now is not the time for the interruptions of ringing telephones, staff questions, or the rattling of trays and instruments behind your patient. Your patient has to be allowed to relax, and stay relaxed, while you concentrate on what you are doing and observing.

Ask the patient to remember and resume the relaxed jaw posture that they learned from your registration appointment. Be patient while they adjust. Gently place your thumb just over the patient's chin and your first finger underneath so that you can feel the chin through the overlying soft tissues. Rehearse a relaxed open and closing cycle and wait until you can feel a relaxed gently guided arc of closure of the mandible. Sometimes rehearsing an active protrusive and relaxed retrusive movement helps, *"Stick your chin out, then let it relax and fall all the way back."* Other times asking your patient to *"Stick your tongue way up in the back of your mouth,"* will help them to overcome a protrusive jaw habit. A stable registration requires that the patient allow the jaw muscles to relax so much that the jaw closing

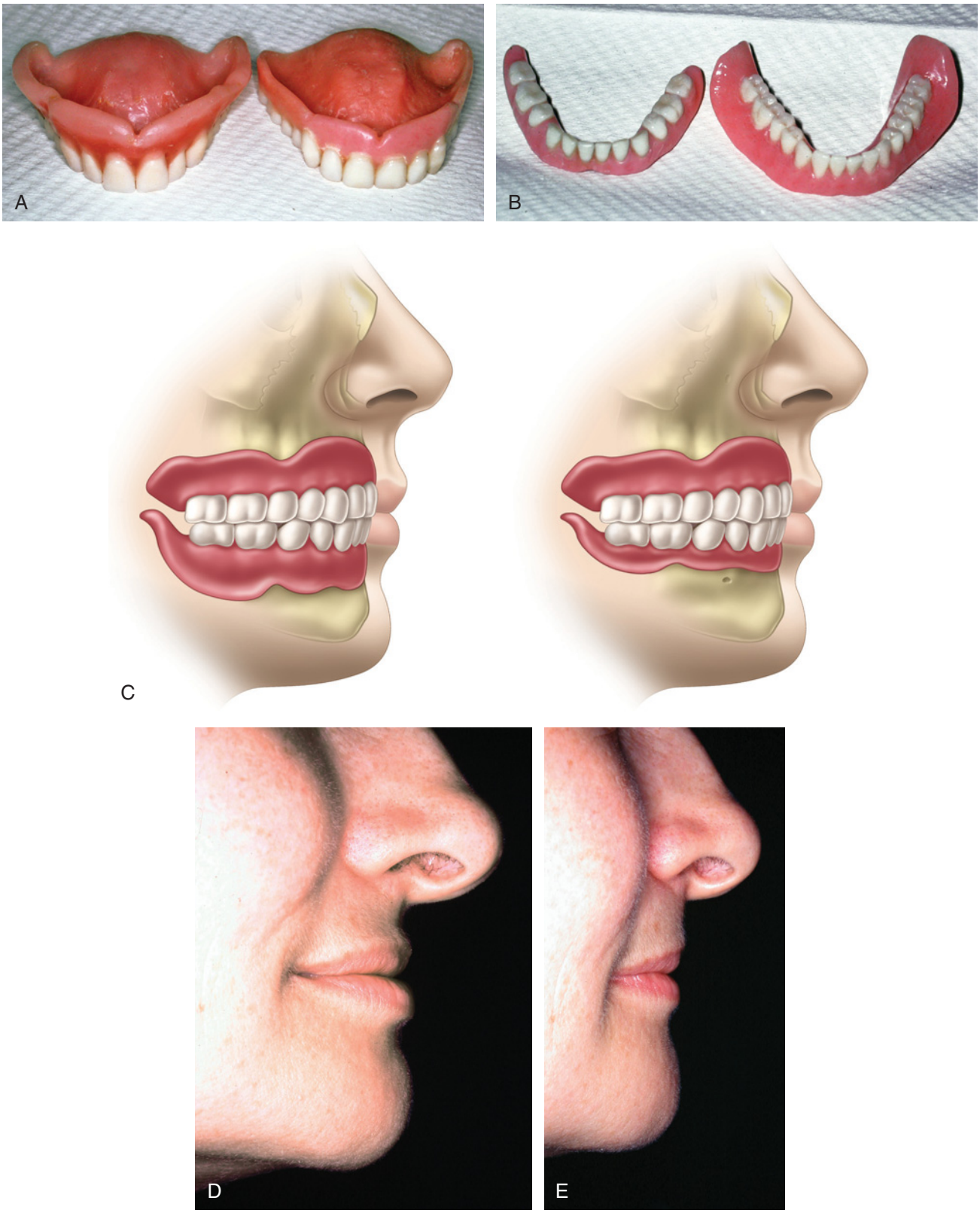


Figure 11-12 **A,** Reorganized upper wax-up on left has changed arch and increased vertical height. **B,** Reorganized lower wax-up on right has appropriate increase in tissue coverage and vertical restoration. **C,** *Left,* New upper and lower prostheses in proportion. *Right,* Previous prostheses were inadequate. **D,** Old dentures can only create a collapsed class III profile with redundant lips. **E,** New wax-ups restore facial profile and pleasing appearance.

is guided by the temporomandibular joint ligaments in harmony with your gentle chin guidance. Your patient's muscles should have minimal influence on the opening or closing movements of the mandible.

There are many methods of making jaw relationships and which one you use will be determined by the relative stability and retention of the trial bases. If the upper base is retentive and stable, then concentrate on holding the lower base secure on the mandible while guiding the patient in a relaxed closure.

SINGLE-BASE STABILIZATION FOR TRY-IN ASSESSMENT (FIG. 11-13)

A single-base stabilization may be an option when the upper base is definitely secure and retentive. You can then double your attention to the lower wax-up, the less secure of the two bases. Place the index finger of each hand on the buccal flange of the lower base. Press down firmly and verify that this is comfortable for your patient. Gently place your thumbs on the patient's chin. Then press down again on the bases and try to shift it forward and back. Find out how secure the base is against the mucosa and feel what it is like when the base shifts. That is what you want to avoid. It is too easy to inadvertently shift the base distally on the oral mucosa as you are checking a retruded jaw position for the denture occlusion. The goal is to just hold the base down without shifting on the tissues. Use your fingers intraorally on the base, and your thumbs extraorally under the chin, as a clamp to hold the lower base comfortably and securely down on the mandible. The denture base and mandible need to move together as one unit, while you guide the patient to relax, open, and gently close to assess the occlusion.

DOUBLE-BASE STABILIZATION FOR TRY-IN ASSESSMENT (FIG. 11-14)

Alternately, if both bases have limited retention/stability, then both must be stabilized by the dentist at the same time as the mandible is guided in closure. This is a more complex maneuver. This is the overall best test because it allows you to feel with your fingers what happens to both of the denture bases as the patient's teeth come into contact.

With the wax-ups in the mouth and the patient relaxed, position the patient and your dental light so that it shines, and you can see, along the maxillary occlusal plane. The mandibular teeth will move up to this point despite the almost universal dental student request to *"bite down."*

With your left arm from above, place the middle to proximal portion of your thumb and first finger at a midpoint on the buccal flanges of the upper denture, so that your thumb and fingertips extend past the upper denture teeth. Tighten your grasp to engage the upper denture, and then lift your arm to hold the upper denture securely against the maxillae.

When this is secure, then direct your attention to guiding the mandible. Place your right thumb in the anterior chin, being careful not to interfere with either the labial flange or teeth of the lower denture wax-up. Then place your curved first finger under the chin so that you can feel the position of the mandible between your thumb and finger. Ask your patient to *"Let your jaw relax all the way, so it can move by itself."* Rehearse and wait until you can feel that the patient can relax the elevator and depressor muscles and you can move their jaw gently up and down with your thumb and finger. As they allow relaxation, feel with your right arm that a smooth curved arc of opening and closure



Figure 11-13 Stabilize the lower base. Use your two fingers and thumbs to clamp the lower wax-up on the mucosa while gently allowing the patient to close.



Figure 11-14 Stabilize both bases. The left finger and thumb hold the upper up and the lower down, while the right thumb and finger gently guide on the chin.



Figure 11-15 "Stop when you feel the teeth first touch." Look to see where and how the teeth are touching.



Figure 11-16 Feel how the bases move when teeth close from "first touch" to "all the way."

is occurring along the posterior border of a sagittal Posselt's diagram.

When that is achieved, guide the patient to close "*slowly, close slowly … not too fast …*" without biting pressure. Many patients will move faster and with more strength than appropriate. Relax and slow down. As the mandible arcs toward the maxillae, release your left hand thumb and first finger body from the upper denture base just enough so that the finger and thumb tips gradually engage the approaching lower denture base. Hold it down against the lower ridge. Meanwhile your right hand thumb and curved first finger are stabilizing and guiding the mandible in small repetitive arcs of small opening and larger closures as the patient gradually closes his or her jaw. As the teeth come close to contact, reengage the upper base flange with the middle of your thumb and first finger to hold the upper base securely against the maxillary mucosa. By now you should have gentle and comfortable, but firm and consistent, pressure with both of your hands on the patient: The left hand is holding the lower and then the upper bases against the mucosa, and the right hand is guiding the chin with posterior pressure in small repetitive opening/gradually closing arcs. Look to see the space remaining between the teeth as they approach contact. The space should appear equal on each side. If not, you have a good early indication of where to look for an occlusal interference. Ask your patient to "*Close gently, and stop as soon as you feel something touching,*" (Fig. 11-15).

Repeat these small 5- to10-mm opening and closing arcs to first contact several times. Verify the relaxed mandibular closure using your judgment, as well as the patient's judgment, to determine where the teeth first touch. Check that your holding of the bases is still accurate. It is too easy to inadvertently allow the bases to shift on resorbed ridges as you check the occlusion. The tilting of a lower denture base hitting at a posterior tooth and then shifting up at the front is so close to the normal arc of jaw closure that it is easy to miss.

You have to manually carefully and securely stabilize the bases on the mucosa. Be really critical at the try-in. If there are interferences, find them now. Correct the articulator mounting and the tooth arrangement at the wax try-in. You and your patients will both be happier.

Later on at the insertion appointment, the dentures then have their final more accurate fitting of the processed bases on the mucosa and the teeth secure in poly(methyl methacrylate) (PMMA). It is so demoralizing to then find a big posterior interference. You will have to do a remount, a lot of adjustment by grinding, or even removing, resetting, and reprocessing the teeth. In either case, these are compromises that you can avoid by careful assessment and correction at the wax try-in.

Now is the test. If the teeth appear to your eyes as if they are all touching at the same time, then ask your patient to continue to "*gently close all the way until the teeth stop, and hold them together*" (Fig. 11-16).

Look with your eyes and feel with your fingers. What happens between the first light contact and full occlusal contact? The correct occlusion should not shift or move the denture bases. Depending on the resiliency of the supporting mucosa, the entire denture bases may move slightly toward the tissue, but this mucosal compression should be felt and seen as only the slightest of equal movements of the denture bases without any occlusal change. If this happens, then you can have confidence that the try-in is accurate and that dentures made to this position should be well fitting after processing and adjustment. With your experience, this will be the happy norm for your practice.

WHEN IS A REMOUNT NEEDED?

Remounts are the means whereby you can correct the positions of dentures to be accurate between your patient and the articulator analogue. In an ideal world, remounts would

TABLE 11-2 REMOUNTS FOR COMPLETE PROSTHESES IN DENTISTRY

Remount	When	Why
#1—Wax-up	If needed, at wax-up try-in appointment	Models on the articulator have to be in same relation as the patient's mouth. If the wax-up is different in the mouth compared with on the articulator, then make a record to correctly remount the models. Then reset the teeth. It is best to find this out now, before processing.
#2—Processed	In laboratory while processed dentures are deflasked, but still on models	Processing changes should raise the teeth only slightly. When dentures are remounted, the articulator pin is lifted off the table 1 to 3 mm. This slight VDO increase allows refinement of occlusion/articulation with teeth secure in final acrylic rather than flexible wax. The preprocessed VDO is recreated during this adjustment.
#3—Delivery	If needed, at delivery appointment, after bases have had PIP adjustment.	Despite all efforts for accuracy, small errors of all steps are now accumulated. Occlusion/articulation can be precisely refined because dentures are now completely processed. Large errors may need teeth to be cut off and reset.

PIP, Pressure-indicating paste; *VDO,* vertical dimension of occlusion.

not be necessary, but complete denture prosthetics have many variables. Remounts allow you to adjust for variables that have occurred despite your efforts. With developing skill, the need to remount will become less and less, but it never goes away. Generally they are needed at three different occasions for different reasons (Table 11-2).

When your patient stops closing at first contact and you see that several teeth are not touching, yet they all were on the articulator, then despite your efforts, your registration and mounting are inaccurate. You need to have the models on the articulator hold the teeth in the same relations as in the mouth. Early in your career, it will be tempting to just correct a wax-up in the mouth and proceed without remounting models correctly. However, dental laboratories will process and adjust denture occlusions to the models they receive. If you do not remount the models, your patient will end up with the denture occlusion that existed before you reset it "in the mouth."

If at the wax-up try-in, the teeth are not properly occluding, find out where the teeth are touching first, and then make a new interocclusal record. This will allow you to remount the wax-up on the articulator and reset the teeth to the more correct position. Another try-in appointment is usually in order. Most patients can feel where the teeth touch first: right or left, front or back. Repeat that "*close until the first touch*" movement, and ask your patient to point with a finger to where they feel the teeth touching. They can't see because your left hand is in front of their face. You may not be able to see it because your fingers are in the way while stabilizing the bases, but they can feel with the pressure receptors in oral mucosa, and then point with a finger. If after several checks, a consistent jaw closing pattern leading to an initial contact and shift to final occlusion is detected, then decide how to best make a new record.

Remount at Increased Vertical Dimension (Fig. 11-17)

If the discrepancy results in a vertical dimension change of 2 mm or less, then it is tempting to make a new interocclusal record between the existing teeth as they are. The problem is that a single tooth contact on one side can shift the registration bases on the mucosa and produce an inaccurate recording. The solution is to make the remount recording at a slightly increased vertical dimension in order to avoid any tooth contact (i.e., 2 mm error + 1 to 2 mm space for recording = 3 to 4 mm or more increased vertical dimension). After making a new mounting on the articulator, then it becomes an art to use the anterior teeth positions as the reference to reduce the vertical dimension 3 to 4 mm on the articulator back to what is needed. It is also a presumption that the arc of closure on the articulator is insignificantly different from the arc of mandibular closure of the patient over this changed vertical dimension.

Remount at Correct Vertical Dimension (Fig. 11-18)

The more accurate and appropriate method of correcting occlusal errors detected at the wax-up try-in appointment is to remove interfering teeth from the wax-up so that an occlusal record can be made at the correct vertical dimension as planned for the completed result. The vertical dimension on the articulator does not change so you have no concerns about differing arcs of closure creating small errors. The teeth will be set in the articulator in the same position and vertical dimension as planned for your patient. This is a more accurate and physiologically appropriate method. If the mandibular occlusal plane has been accurately positioned, remove all the upper posterior teeth

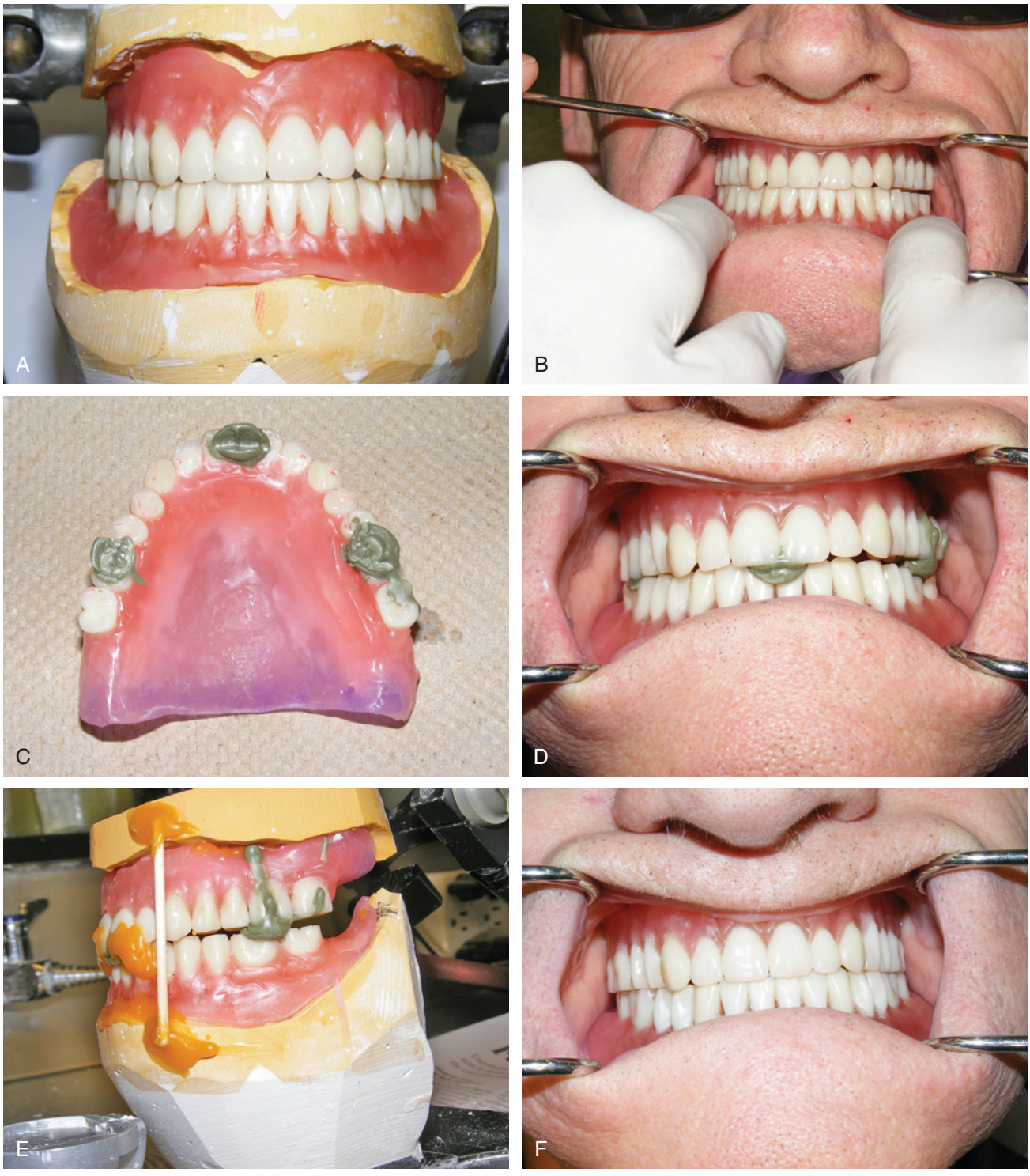


Figure 11-17 **A,** Wax-up ready for try-in. **B,** Relaxed jaw closure and stable bases, but not all teeth are touching. **C,** Tripod of Aluwax contacts to record jaw position just open from any tooth contact. **D,** Each Aluwax record is slightly different in thickness. **E,** Use sticky wax and Q-tip to make sure the teeth do not move during remounting. **F,** After reset, the second wax try-in looks better.



Figure 11-18 **A,** Wax-up try-in has anterior open bite and excess overjet with relaxed closure to a posterior-only contact. Wax registration must have been made to a protruded position. **B,** On relaxed closure along arc *(C),* the single posterior interference at *B* produces the anterior open bite. To achieve occlusion *(A),* patient must learn to shift jaw with muscles, or slide denture bases on mucosa. Neither is acceptable! **C,** Interfering posteriors are removed to allow corrected VDO. Anterior right central is set for best position and visibility. **D,** Remount at correct VDO. All anterior and posterior teeth will be reset. **E,** Situation recovered. The second try-in confirms pleasing smile of midline, occlusal plane, proportion, and stable occlusion. **F,** Balanced opposing lines. Dissimilarities in the inclination, rotation, and position of the teeth on each side of the midline provide what is called asymmetrical symmetry, which is essential for natural-appearing teeth.

except the first bicuspids. Set them aside in order in a wax card so that they will not be lost or mixed up. Leaving the first bicuspids in place allows for a visual and tactile check on the desired vertical dimension. Use what recording material works best for you. Classic dental impression plaster, and recently fast-setting silicone "bite registration" materials also can work well, but a new mix has to be made and loaded every time. They are more stable than waxes, but they have a finite window of useful time. It is sometimes a challenge to have an edentulous patient relaxed and then closed to the desired correct vertical dimension before the material has set. Conversely some patients have difficulty holding a jaw relation position while you wait for a material to set.

Our preference is for wax. It can be easily and quickly heat softened and can be refined and remade several times if necessary until a suitably satisfactory reproducible record is created. Properly softened wax has just the slightest resistance, which can assist in holding bases in place. The actual contact time needed for the record is only seconds.

The caveat is that wax records have to be handled carefully to avoid distortion. Laboratory models may need bracing with sticky wax and dental burrs to stabilize against the inadvertent pressures that occur when mounting models with a mix of plaster. Afterwards waxes also are easy to clean up and continue with tooth setup.

Try in trial denture bases and guide your patient to close to the best vertical dimension position. Now that the interfering teeth have been removed, check that you and the patient can now make a relaxed accurate closure without shifting of the bases. If other teeth still create an interference, remove them also. If the anterior teeth have been set with a slight space of overbite/overjet, use dry heat to add a small anterior palatal wax stop into which the lower anterior teeth can indent.

Lubricate the opposing teeth with a little petroleum jelly (Vaseline) so that they will not stick and distort a wax record. Check to see the space now available in the posterior so that you can plan a section of wax rim to be added that will be slightly higher in dimension. Use dry heat with a Bunsen burner or torch to add on and seal a softened wax rim. Shape it to the anticipated best fit. Soften the surface with a Hanau torch, and then temper the wax rim in a water bath so that it has even viscosity for a wax recording. Reseat and repeat your secure manual stabilization of the trial bases and guide your patient in a relaxed closure to your correct VDO. Open and close and repeat this recording several times until you are satisfied with its accuracy.

Check how the anterior teeth are now positioned. The more accurate posterior wax remount jaw relationship also may mean that the upper and lower midlines and overbite/overjet relations of the anterior teeth have changed. Make note of what corrections are needed and confirm as necessary with your patient. Arrange for the next try-in appointment to verify the appearance of the teeth and the corrected occlusion.

The Interappointment Laboratory Procedure for the Wax Try-in Remount (Fig. 11-19)

Removable prostheses have teeth set and adjusted after processing on the articulator-mounted models. These models have to be accurately positioned on the articulator so that the wax-up occlusion is the same as in the patient's mouth. A remounting is just as critical as the intraoral remaking of a jaw registration. Each contributes equally, and both have to be accurate.

If the jaw relation for remounting has been made at the correct vertical dimension, then the remounting is simplified. This actual record is far more critical than the orientation of the occlusal plane of the models on the articulator. Another facebow record is not required. Remove the upper model and its plaster mounting from the articulator. Cut a groove in the plaster/stone junction, and with a

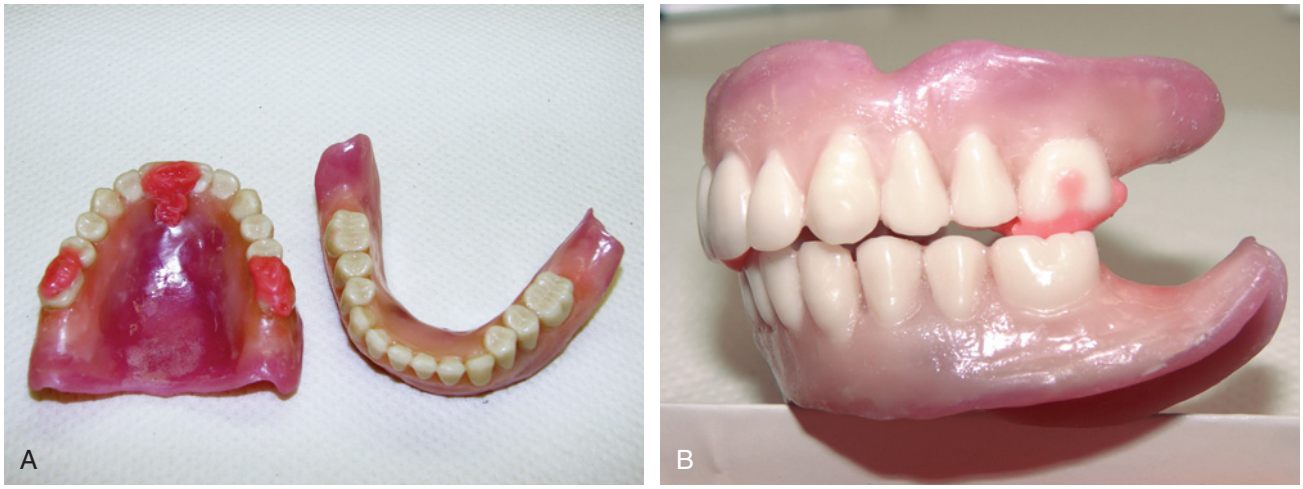


Figure 11-19 **A,** Wax tripod makes a new interocclusal record for remounting. **B,** The wax tripod must create a stable unmistakable position out of the mouth. If not, improve.



Figure 11-19, cont'd **C,** Notch the plaster and tap to separate the master model from the mounting. **D,** Trim 1 cm from the upper plaster to create the space for a thin plaster remounting. **E,** Gouge and wet the trimmed plaster to hold a new plaster mix. **F,** Sticky wax the newly registered wax-ups and models together. Replace the trimmed plaster mount. Everything must be secure. **G,** Hold the models so that they do not move. Close the upper arm into soft plaster mixed with slurry water. **H,** Hold the pin down with an elastic band, and let the plaster mount harden before resetting the wax-up.

tap on your lab knife, separate the upper model from its plaster mount. Check the little details. Does the upper model have clear indexing grooves without undercuts? Remove any molten wax drops that may have inadvertently landed on the models, or in the bases. Do the bases fit accurately and fully on the models? If not, find out why and improve. Are the articulator condyles fully closed and locked? Seat the ascending column of the lower mounting ring, mounting plaster, lower model, lower base, interocclusal record, upper base and upper model in the articulator. Is it stable and is there enough space above the upper model to make a plaster mount? If not, trim the plaster mount and/or model base. Does the anterior occlusal plane appear reasonably centered and level left to right in the articulator? Because your mounting is now more accurate, it should be better. Use sticky wax and lab burrs/Q-tip shafts to secure the stone models/bases/wax record so that this column is secure. Are the mounting rings tight? You do not want anything to shift during the remount. Find an elastic band to hold the articulator arms together after it has been closed. Wet the base of the upper model, close the upper articulator arm and estimate the amount of plaster needed to remount. Make a soft mix of mounting plaster, fill the undercuts in the upper mounting ring, and add a slight excess of plaster to the top of the upper model.

Now is the critical step! Hold the upper model with one hand so you can feel and hold it securely. It must not move as you fully close the upper articulator arm into the mounting plaster until the articulator pin is fully seated on the anterior table. Place the elastic band over the articulator to hold it securely together while you trim and smooth the mounting plaster. Again, the recording must not move before the plaster is set, or else the jaw relation record accuracy will be lost. Set the articulator aside until the plaster is fully set. This time will vary depending on the plaster. If slurry water is used, the mounting will be hard and ready to use in 10 minutes.

Resetting the Dentition for Try-in

After the plaster has set, clean up the mounting and remaining setup.

Assess, and if the anterior teeth need any reseating, position them first to satisfy the esthetic needs of your patient. The midline and anterior occlusal plane needs to be correct.

Assess and improve if needed the position of the mandibular teeth in the occlusal plane. For the best comfort, bolus, and tongue control of a mandibular denture, the teeth should be set within a triangle of the width of the retromolar pad and the distal corner of the mandibular cuspid and at the height of the middle of the retromolar pad.

Reset the mandibular and maxillary posterior teeth. Chapter 10 has outlined several of the concepts and philosophies of posterior tooth setup, and manufacturers provide teeth in several different molds. Reestablish the desired occlusal anatomy as first created for the try-in.

TRY-IN FOR ESTHETICS

When the waxed-up prostheses are ready and in the mouth, check and confirm that the midlines, anterior and posterior occlusal planes, vertical dimension, and the occlusion all appear adequate and accurate and your patient is in agreement. This will allow you to make a good set of complete dentures that will appear and function to the limitations of the patient's anatomy.

Your re-creation of the smile will vary depending on your patient's skeletal anatomy as described in Chapter 10 on tooth selection and arrangement. The best result for many of your patients may be a standard setup with a minimum overbite/overjet.

Many times you, or your patient, will want you to do better. Now you can add the individual improvements that will make your prostheses unique and personal for your patient. Find out what your patient wants to have to make their smile their own. Check on information from a variety of sources. Do they have old photographs showing what their smile looked like before? Do they have a brother, sister, or child whose teeth are similar to what they remember and want to re-create? Ask them to bring a picture, or take a picture of that person. Perhaps they have a picture of some famous person whose smile they admire. Ask if they remember any spaces or teeth that were crooked that are unique and they want reproduced. Your patient will appreciate your efforts even if they have no specific requests. Take a few minutes right at chairside where your patient can see that you are personally creating something unique for them. Use your hot spatula and/or sickle scaler to move teeth to create the subtle and desired irregularities of nature. In the absence of any clear indications, a theory to create individualized smiles based on age, gender, and personality can be applied. Young feminine patients would likely have teeth with little wear, whereas with age and chewing teeth will appear more natural with definite incisal wear (Fig. 11-20, *B*). This worn-appearing dentition was appropriate and appreciated by the patient who provided the images in Fig. 10-2.

Others with the prominent maxilla of Angle class II division 1 or 2 will need their front teeth set with more anterior overbite or overjet than normal (as seen in Fig. 10-21). Conversely, prognathic patients with an Angle class III skeletal relationship will need an "end-to-end" anterior occlusion and a posterior crossbite occlusion to best match their large anterior-positioned mandible relative to their small retruded maxillae (as seen in Fig. 10-22).

The Next Level: Characterization of Individual Tooth Colors and Position

Now is your chance to really make a smile. Anterior tooth characterization can produce strikingly realistic effects that make the patient's smile look as if it is their enamel, dentin, and gingiva. Teeth can be modified to create a personal smile in a number of ways and combinations. Color changes







Figure 11-20 **A,** Minimum wear standard arrangement restores smile. **B,** A simple sketch by the dentist of the outline form of artificial teeth will be helpful in planning the incisal wear to be incorporated for a particular patient. *Dotted line* shows the original appearance of the incisal edges of artificial teeth; *solid line* shows the incisal wear anticipated. **C,** Incisal wear for a realistic appearance relative to age. See patient records in Fig. 10-2.

can emphasize a tooth position and make teeth appear more visible and unique for your patient. This patient was able to provide a preextraction study model and a smiling photograph, which gave much valuable information to create a unique smile. The right maxillary central was selected with a lighter shade to simulate the previous prominent and light-colored porcelain crown.

When records exist, they provide valuable guidance (Fig. 11-21). Photographs, study models, and extracted teeth give unique clues for the re-creation of a smile. Individual grinding and placement of teeth can re-create a smile that is realistic for a patient where average value tooth setup principles would not provide the result desired. The patient shown in Fig. 11-22 had preextraction images and models that showed the Angle class II dental occlusion and the unique wear patterns of the anterior teeth.

The incorporation of previous dentistry can make a smile appear so real for a patient. They know that others have been used to seeing them with their dentistry for years. If their new smile has some of these visible features built in, the dimension of realism and patient acceptance is greatly increased. Your patient will feel that that their prostheses are so real that they are undetectable. These restorations in teeth are usually planned at this time, but actually created and placed in teeth during and after the final processing (Fig. 11-23).

ESTABLISHMENT OF THE POSTERIOR PALATAL SEAL (PPS)

If the palatal seal area has not been defined at the impression appointment, it needs to be done now. All of the periphery of a maxillary complete denture has a curtain of lip or cheek musculature to create an atmospheric seal, except for the posterior border across the palate. This area is modified by scraping a groove 2 mm wide and deep into the final stone model before denture processing. This creates a processed denture that purposely indents into the soft tissue. This alteration provides four functions: (1) it compensates for the slight shrinkage of processed acrylic across the arch of the palate, (2) the peripheral seal is maintained during the slight movements of the denture on mucosa, and (3) the posterior border of the denture can maintain

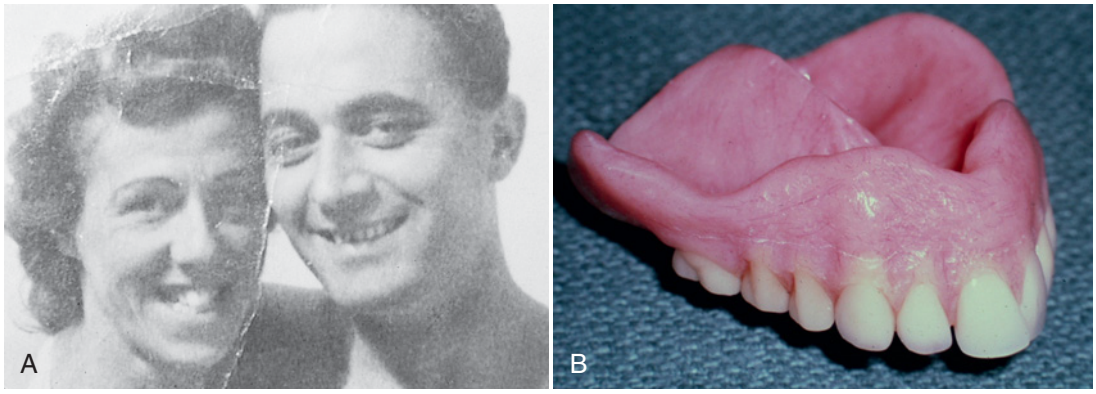


Figure 11-21 Characterization with colors: use different tooth colors to create the best effect. **A,** The prominent position and color of this patient's maxillary right central were identified from a photograph. **B,** The maxillary central incisors were Dentsply shade 102; the rest of the smile was Dentsply shade 114. This emphasized the tapered arch form and created the illusion of more prominence for the upper right central incisor than was prosthetically possible. The smile appears real to this patient.

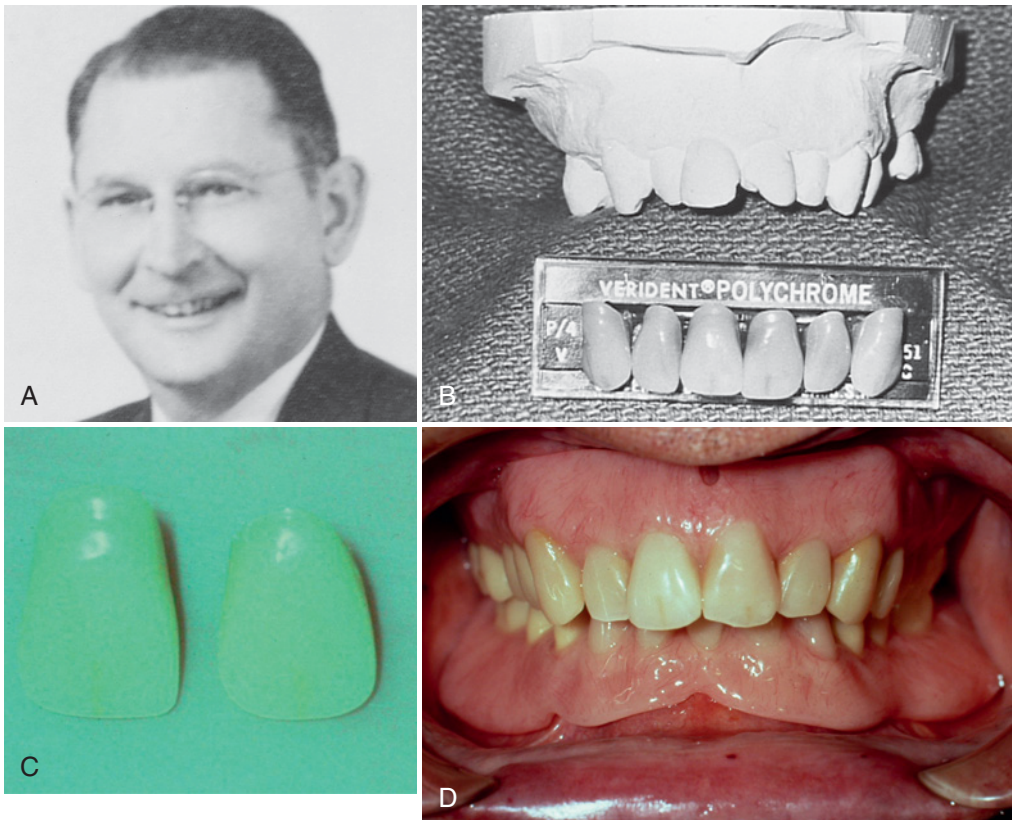


Figure 11-22 Characterization by grinding: immediate dentures allows for realistic tooth selection and shaping. **A,** A previous photograph hints at the prominence of the maxillary central incisors, their overlap of the lateral incisors, and the Angle class II relationship. **B,** A study model allows selection of the best available mold. **C,** The acrylic teeth are trimmed to re-create the actual tooth shape. It could not be found in any mold guide. **D,** The completed prosthesis faithfully replicates the irregularity of tooth color, size, mold, and Angle class II position. This patient's smile looks real.

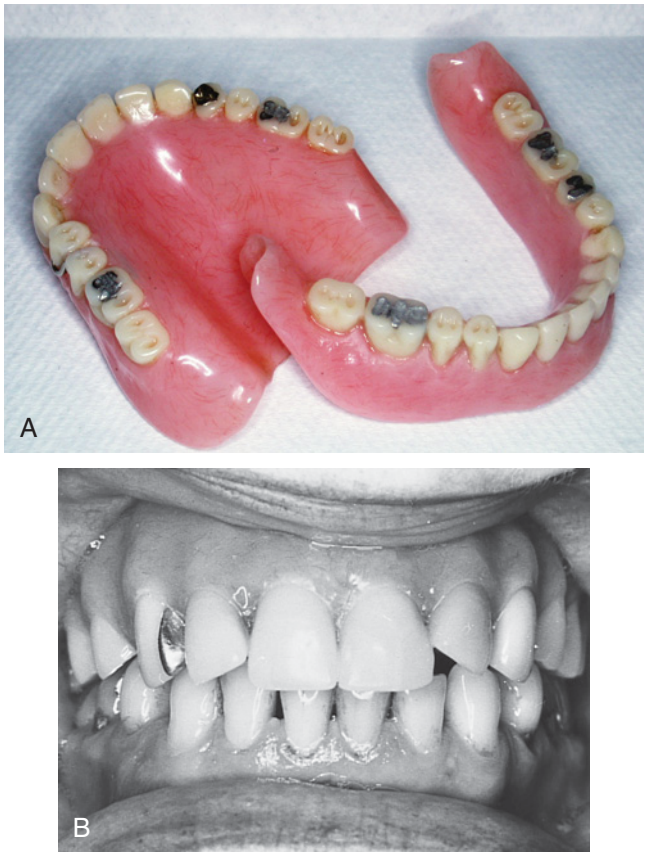


Figure 11-23 **A,** Realism. Small spaces, a gold inlay, a clasp, and five silver amalgam restorations added for a smile. **B,** Realistic prosthetic smile created with a bicuspid gold inlay, irregular teeth arrangement, and chipped anterior teeth.

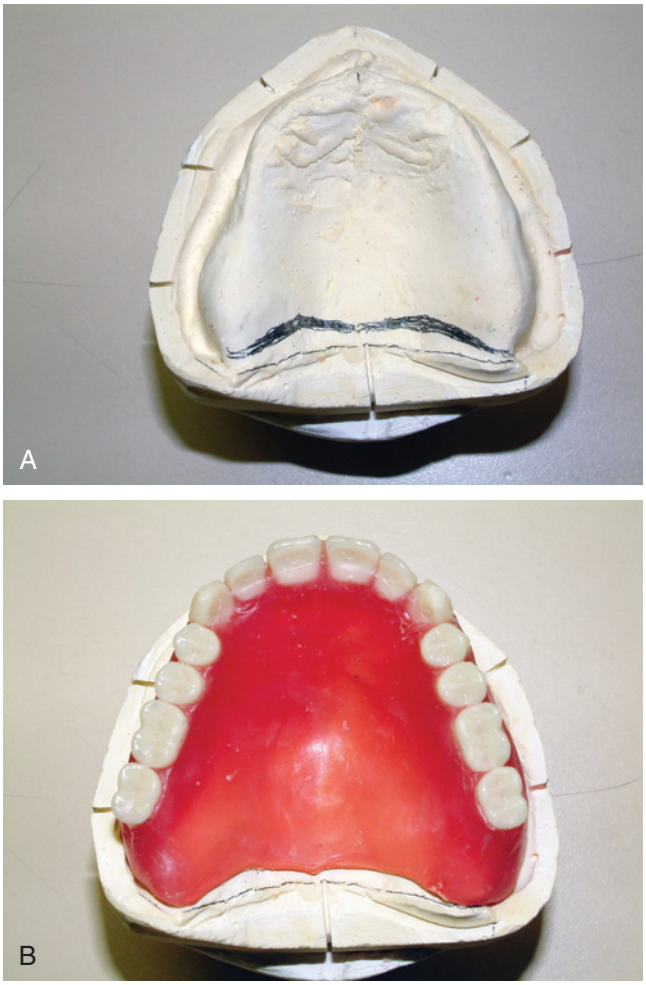


Figure 11-24 **A,** Palatal seal identified on model. **B,** Wax-up extension confirmed in palatal seal area.

adequate thickness for strength and yet (4) become less noticeable to the patient's tongue as it blends into the mucosal contour.

The PPS is located and confirmed by five methods: locating anatomy on the model, observing tissue color difference, mirror probing to assess tissue resilience and patient tolerance, and observing soft palate movement. The PPS is created as a groove in the stone model where the hard palate ends and the soft palate starts. Look for two small dots in the posterior midline of your stone model. These are the fovea palatinae, which identify where soft palate musculature inserts on the hard palate. Locate the hamular or pterygomaxillary notch at the posterior of each residual alveolus. With more resorption, these may be less distinct on the model, but they can be located and confirmed by intraoral palpation. Join these three landmarks with a pencil line on the model, and you have the start of your PPS (Fig. 11-24).

The depth and extent of the PPS can be best confirmed by assessing the color, resiliency of the tissue, and contact tolerance directly in your patient's mouth. Position your patient and the dental light so that you can clearly see the soft palate. The hard palate has keratinized mucosa, which is displaceable but relatively well attached to withstand the pressures of mastication. This keratinization gives the hard palate mucosa a pale appearance compared with the pink nonkeratinized mucosa on the mobile soft palate. Look for this color change as a guide to the border between the hard and soft palates. Look to find the fovea palatinae. Use the dental mirror as a probe to gently confirm the superior indentation of each hamular notch. Then assess the resiliency of the mucosa across the posterior border of the hard palate and your patient's tolerance of mucosal contact in that area. People vary in the activity of their gag reflex (Fig. 11-25).

To judge the range of movement of the soft palate, ask your patient to say "Ah, Ah" forcefully several times. This requires your patient to seal and release their epiglottis and soft palate quickly so that you can see a "vibrating line" where the soft palate tissue starts to move dorsal to the immobile hard palate mucosa. Soft palate form and mobility have been classified because this will influence the patient's tolerance to the posterior extension of the denture base. Note the anatomy, and transfer that data to the stone model. On the basis of these five investigations, you can

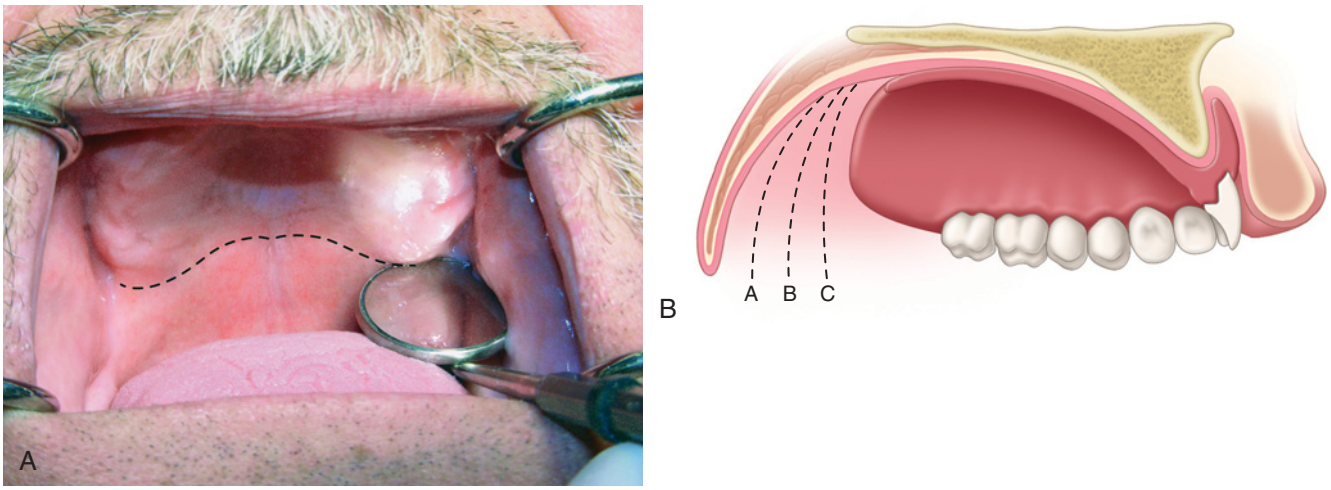


Figure 11-25 PPS verification. **A,** Use a mirror to assess the depth of the hamular notch and palatal tolerance. Visualize a line from notch to notch through the fovea palatinae. **B,** The vibrating line and width of the posterior palatal seal depend on the soft palate form (*A, B,* or *C*). Form *C* allows only a narrow posterior palatal seal; *A* allows the widest seal.

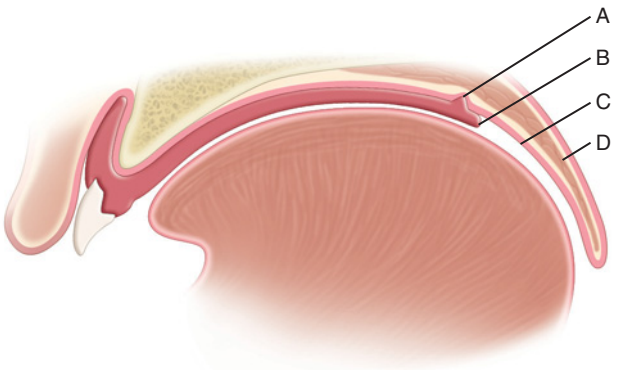


Figure 11-26 Sagittal diagrammatic view of denture in place in the mouth. A bead on the posterior extent *(A)* is 1 to 1.5 mm high and 1.5 mm broad at the base, and 2 mm anterior to the end of the denture *(B). C,* Movable soft palate. *D,* Muscles of the soft palate.

verify the location and depth of the groove to be carved into the master model before processing (Fig. 11-26).

Your PPS is placed just anterior to the vibrating line at a depth that is tolerable to the resiliency and mobility of the tissue. After processing, the upper denture posterior palatal border will have a narrow sharp groove that will indent into the palatal tissues. This maintains the peripheral seal during the normal functional denture movement. If the groove is too deep so as to irritate the palate, it can be adjusted at the first recall appointment (Fig. 11-27).

When all is satisfactory, the wax-ups will be the pattern that will be used to create dentures. Check and confirm with your patient if any specific gingival color is better for them. Some patients will have differences in skin tones such that more or less gingival color may appear better for them (Fig. 11-28).

FINAL DECISION MAKING AND CLOSURE

A dental office can be a stressful environment. Because your patient is edentulous, he or she may have accumulated horrible associations with sitting in a dental chair. They may just want to get out of there. Nervousness can impair a patient's ability to make a satisfactory decision. Tell your patient you want to be sure that they and anyone else is satisfied before you make the irrevocable act of processing dental acrylic to make their smile. Use your judgment. Only for some patients, offer them the option of taking the wax-ups home to assess in the comfort of their own home. Caution them that the dentures are only wax. "*They are for looking, and NO BITING. The teeth can be loosened with any biting and there is a risk of swallowing or aspirating a denture tooth. Also wear them only 5 minutes at a time as the wax will soften. Otherwise keep them cold in the refrigerator. If any teeth come loose, do not try the teeth in again. Bring all of the teeth back, or I will have to buy more to replace them for you. If you lose a tooth in your mouth that cannot be found, you may have to go and get a chest x-ray for your own safety.*"

This is an option if their spouse or significant other has a definite opinion about the teeth, but has not or cannot attend the try-in. With all of these caveats, most patients decline this offer, or make sure that their spouse does come in. Some may accept, but make sure they understand the risk. We have no control over what patients do outside of our offices.

When your patient, their significant others, and you have agreed that the waxed model of a new smile is acceptable, remind your patient what processing the dentures really means. The actual teeth will be used. The shape will be the same as it is now, and the wax is changed into the

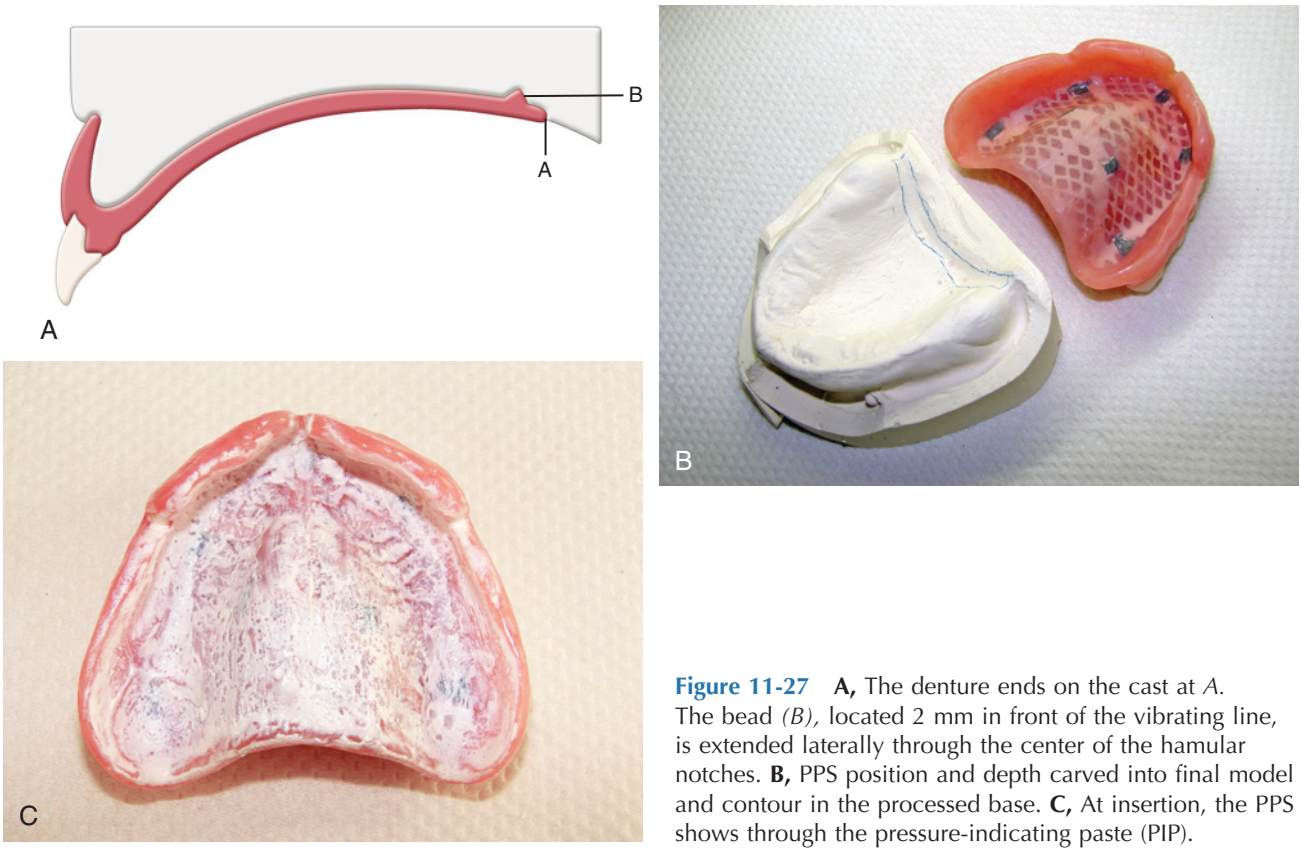


Figure 11-27 **A,** The denture ends on the cast at *A*. The bead *(B),* located 2 mm in front of the vibrating line, is extended laterally through the center of the hamular notches. **B,** PPS position and depth carved into final model and contour in the processed base. **C,** At insertion, the PPS shows through the pressure-indicating paste (PIP).



Figure 11-28 Confirm a preferred shade of gingival acrylic.

gingival acrylic to make their unique and personalized completed dentures. The dentures cannot be changed after that without additional costs to reorder teeth and cut apart and reprocess the dentures, if that is even possible.

At this point, your patient needs to assume responsibility for their decision to accept the appearance of the dentures that you will be processing for them. It is common practice to request a financial deposit of at least the total laboratory costs that will be accrued. It is amazing how finances clarify a decision whether or not to accept something. You may want to clarify this by having your patient sign an acceptance agreement (Fig. 11-29).

Occasionally this document will become valuable if a patient later contends they did not see the teeth or understand that this is the way they would be made.

THE LABORATORY PRESCRIPTION

If teeth have been moved or reset, the final wax contours need to be created to best assist your patient to manage their prostheses. As discussed in previous chapters, gingival wax is shaped to allow a patient's musculature to stabilize and retain dentures while simultaneously talking, chewing, swallowing, or engaging in amorous activities (Fig. 11-30).

Confirm these shapes at chairside, and/or direct the laboratory to rewax as needed. The following chapter discusses the reasons and steps involved in creating the best wax pattern. While processing poly methyl(methyl) methacrylate is a simple technology that dental offices can accomplish, many dentists delegate this procedure to a commercial dental laboratory in order to achieve predictable good quality at an economical cost for their patient. The dentist is still responsible for the results that are created for his or her patient's care. A laboratory prescription is a legal document authorizing the delegation of the procedure by the dentist to a commercial laboratory. Most jurisdictions have criteria that have to be met in this communication (i.e., identification of the patient, dentist, and laboratory;

I, (insert patient's name), have been given the opportunity to look at the final arrangement of the artificial teeth (while positioned in wax). Any necessary changes have been made, and I am happy with the general appearance of the dentures.

Signature Date

Figure 11-29 Patient's statement of satisfaction with the arrangement of artificial teeth.

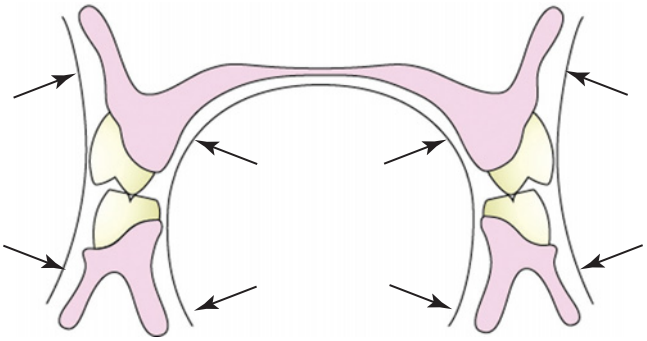


Figure 11-30 "The Neutral Zone." Make gingival contours so a patient can use muscles to stabilize their teeth. *(Copyright 2011, University of Toronto.)*

date; date of delivery; and procedure to be done). Beyond that, the dentist needs to specify what is requested, both generally and specifically.

- Are the teeth and gingival wax to be changed at all, or kept as is?
- Where is the posterior palatal seal to be placed in the master model?
- What shade of gingival acrylic is needed?
- Are the dentures to be returned on the stone models for occlusal adjustment? If not, the laboratory will adjust occlusion as they see best, and the dentist must accept the result.
- If "finish for insertion" is requested, is a remount index needed?

SUMMARY

The try-in appointment is the most significant one of those involved in edentulous patient care.

For the first time, the patient and dentist have the opportunity to see what the future holds. The dentist does his or her best to create an environment and a result that are pleasing and satisfactory. The dentist has multiple assessments to confirm with the patient. Then they both must decide if what is presented is acceptable. Anyone else who might have a significant opinion should be included. When all are agreed, then the wax try-in will be processed to become the patient's new smile. This is an irreversible procedure. The dentist will also have assessments and agreements to be made with a prescription to a commercial dental laboratory for treatment steps to follow (e.g., palatal seal location and processing method). All of the interests of the patient, the dentist, and the commercial laboratory come together to be resolved at the try-in appointment. The dentist is responsible for the overall result, and if a change is needed, the dentist needs the skills and a protocol to implement them. Sometimes more than one appointment is needed to obtain the best result.

Bibliography

Carlsson GE, Omar R: The future of complete dentures in oral rehabilitation: a review, *J Oral Rehab* 37:143-156, 2010.

Clough HE, Knodle JM, Leeper SH, et al: A comparison of lingualized occlusion and monoplane occlusion in complete dentures, *J Prosthet Dent* 50:176-179, 1983.

Davies SJ, Gray RMJ, McCord JF: Good occlusal practice in removable prosthodontics, *Br Dent J* 191:491-502, 2001.

Hirsch B, Levin B, Tiber N: Effects of dentist authoritarianism on patient evaluation of dentures, *J Prosthet Dent* 30:745-748, 1973.

Khamis MM, Zaki HS, Rudy TE: A comparison of the effect of different occlusal forms in mandibular implant overdentures, *J Prosthet Dent* 79:422-429, 1998.

Lang BR: Complete denture occlusion, *Dent Clin North Am* 40:85-101, 1996.

Lombardi RE: The principles of visual perception and their clinical application to denture esthetics, *J Prosthet Dent* 29:358-382, 1973.

Phoenix RD, Engelmeier RL: Lingualized occlusion revisited, *J Prosthet Dent* 104:342-346, 2010.

Pound E: Utilizing speech to simplify a personalized denture service, *J Prosthet Dent* 24:586-600, 1971.

Rüdiger H, Müller F: Clinical studies on the appearance of natural anterior teeth in young and old adults, *Gerodontology* 21:10-16, 2004.

Sproull RC: Color matching in dentistry. I. The three dimensional nature of color, *J Prosthet Dent* 29:416-424, 1973.

Sproull RC: Color matching in dentistry. II. Practical applications of the organization of color, *J Prosthet Dent* 29: 556-567, 1973.

Sutton AF, Glenny AM, McCord JF: *Interventions for replacing missing teeth: denture chewing surface designs in edentulous people (review)*. The Cochrane Library, Issue 4, London, 2008, J Wiley & Sons.

Van der Bilt A: Assessment of mastication with implications for oral rehabilitation: a review, *J Oral Rehab*. Published online January 17, 2011, DOI: 10.1111/j.1365-2842.2010.02197.x

CHAPTER 12

Prosthesis Insertion and Follow-up Appointments

Ting-Ling Chang, Aaron H. Fenton

WAXING AND PROCESSING THE DENTURES

DEVELOPMENT OF THE PROPER FORMS OF THE POLISHED SURFACES

Three principal surfaces are involved in the functional stability of dentures: the basal or impression surface (often called the intaglio surface), the occlusal surface of the teeth, and the polished surfaces (Fig. 12-1). The form of the polished surfaces of a denture influences stability, retentive quality, and denture esthetics. In addition to evaluation of appropriate position of the prosthetic teeth, the polished surface contours and border thickness should be determined at the try-in appointment to ensure optimal phonetics, enhance stability and retention, and avoid lip and cheek biting. The denture bases between the teeth and the border should be shaped in such a manner as to aid retention by the mechanical directional forces of the muscles and tissues. Generally speaking the contours are full on the buccal aspect of the denture but are quite concave on the palatal and lingual surfaces because of the functional and "at rest" space requirements of the tongue. When the lingual and buccal borders of a mandibular denture are being shaped, they can be made concave to conform to the tongue and cheek so the muscles will grip and tend to seat the denture (Fig. 12-2). On the contrary if the lingual and buccal surfaces are made convex beyond the confines of the border, the inclined plane forces resulting from pressures of the tongue and cheeks will tend to unseat the denture.

The development of the proper forms of the polished surfaces must be based on accurate impressions of the tissues that limit the extent of the dentures, and the prosthetic teeth must be arranged in proper relation to the ridges so the slopes of the polished surface can have a favorable angle with the cheeks, lips, and tongue (Fig. 12-3). The correct buccolingual position of the teeth is important because lateral forces also are exerted on the dentition during function. Teeth positioned too buccally or too lingually allow the musculature of the cheek or tongue to create unfavorable forces on the inclined plane of the surface of the teeth and the polished denture. These forces will tend to unseat the denture. A buccal position of the teeth would likely not allow an adequate concavity of the denture base between the gingival collar and denture border; the muscle action of the cheeks would tend to unseat the mandibular denture.

The buccal surface of mandibular dentures in the first premolar region should be vertical to concave in shape so as not to interfere with the action of the modiolus, connecting the facial muscles with the orbicularis oris muscle. This connecting point of muscles can displace the mandibular denture if the polished surface inclines toward the cheek or if the dental arch in the premolar region is too wide. The lingual flange of the mandibular denture should have the least possible amount of bulk, except at the border, which must be quite thick. This thickness is under the narrower portion of the tongue, and it greatly enhances the seal by contacting the mucolingual fold.

In the maxillary denture, the patient's speech will be impaired unless a proper palatal contour is developed. Additional care should be taken with the contours of the palatal alveolar surface in the area of the premolars and canines. Airflow for speech sounds is greatly affected by the contact or approximation of the lateral tongue in these areas. There should be a gentle concave contour of the denture base extending from the palatal surface of these teeth to the horizontal shelf of the palate. If this contour is a deep concavity or a near right angle between the vertical alveolar process and the horizontal shelf, the lateral border of the tongue will not control air during speech. Particularly, the "s" sound will be distorted, sounding more like a "sh." Fricative sounds of "f" and "v" also may be distorted. Wax should be flowed along the junction of the alveolar ridge and the horizontal shelves to create a gentle concave curve. Patients also can be given water during the try-in of the dentures. With a slightly wet mouth, they can be asked to speak. If water escapes from the lips, wax should be added in the area

Gratitude is expressed to Dr. John Beumer III, Dr. Eleni Roumanas, and Dr. Michael Hamada for their work on UCLA School of Dentistry Complete Denture Educational Curriculum (supported by Ivoclar Vivadent and the American College of Prosthodontics) and the photos shown throughout the chapter.

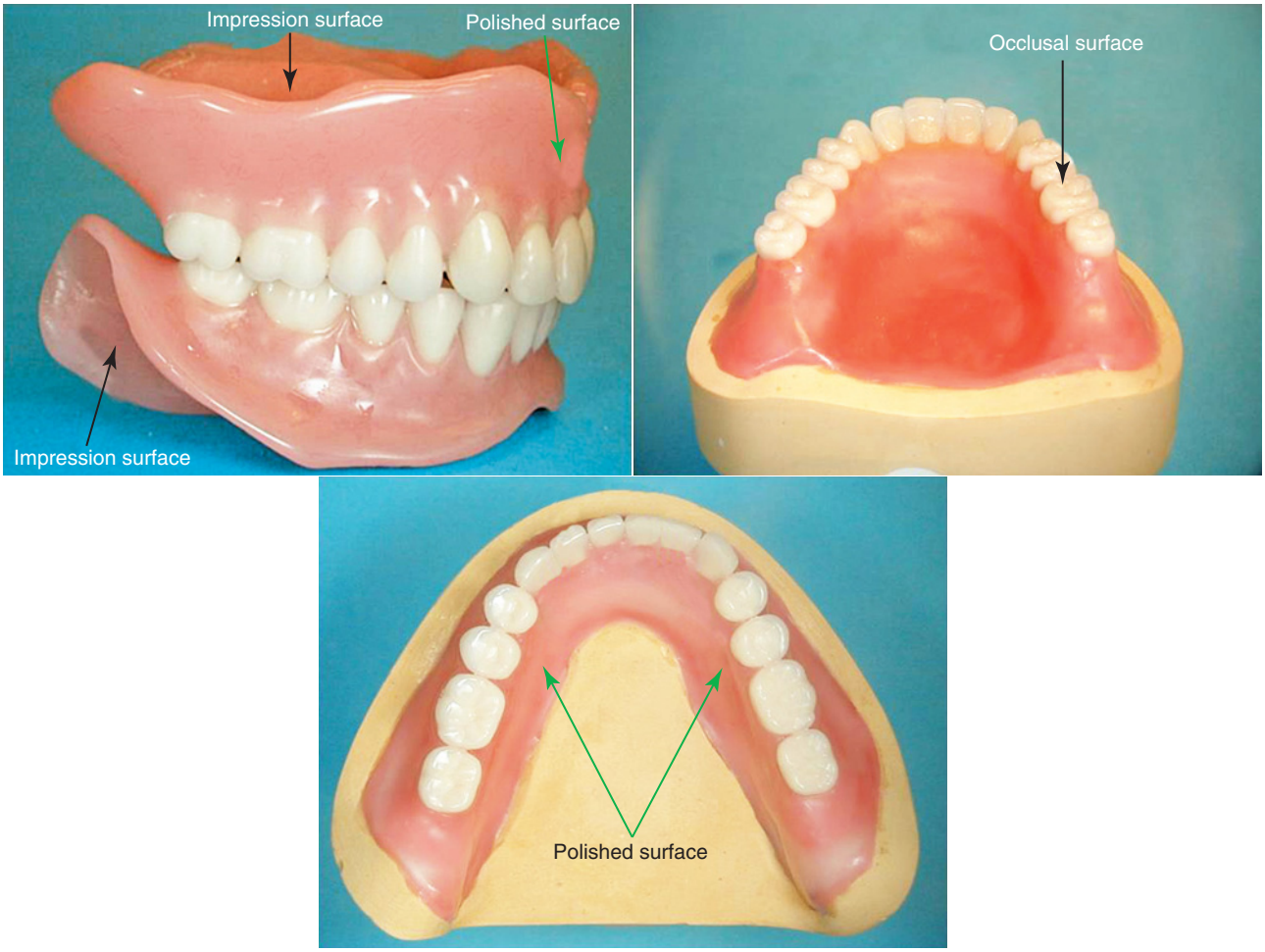


Figure 12-1 Three surfaces—impression, occlusal, and polished surfaces—involve the functional stability of the complete dentures.

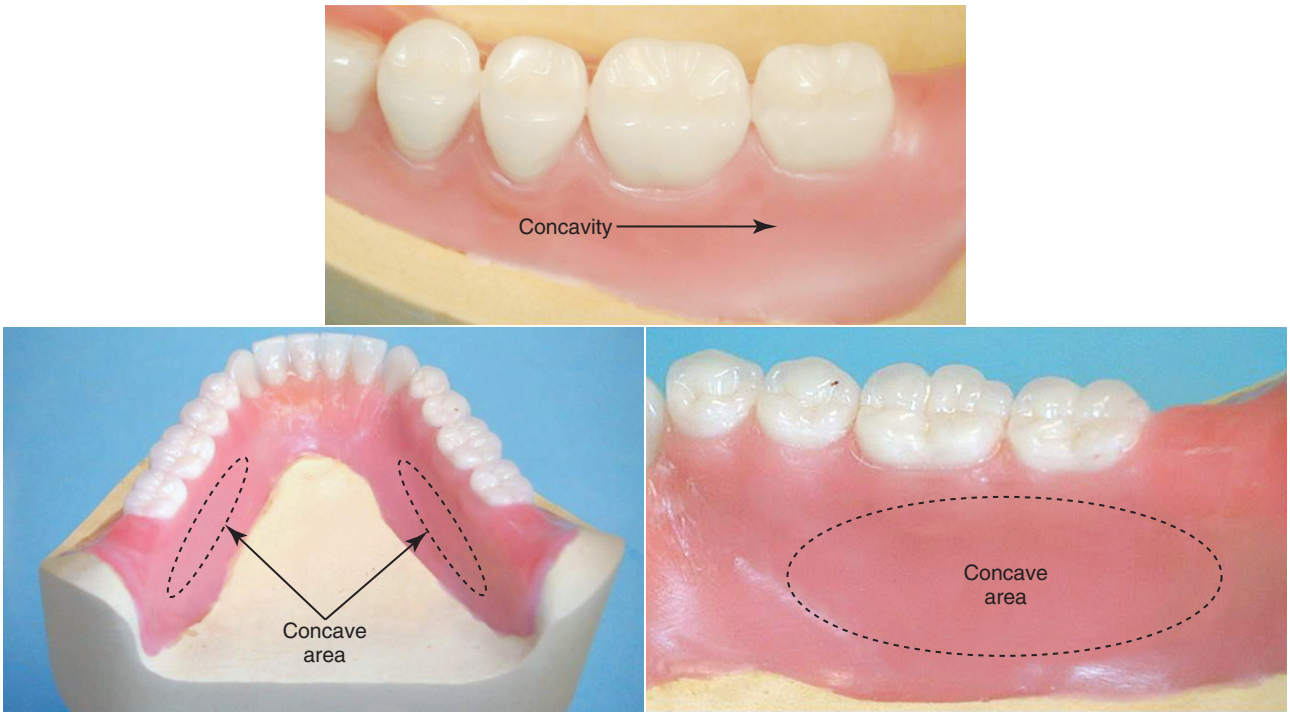


Figure 12-2 The lingual and buccal polished surfaces of a mandibular denture are concave to conform to the tongue and cheek so the muscles will grip and tend to seat the denture.

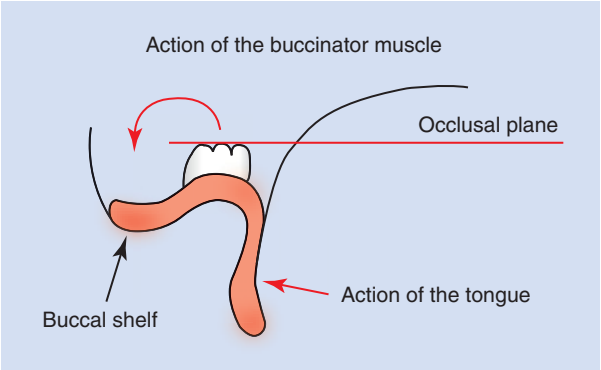


Figure 12-3 The tongue seats the mandibular denture against the concave lingual polished surface while transporting the food bolus onto the occlusal table. The action of buccinator muscle prevents lateral displacement of the denture.

of the premolars and canines on the offending side. When these ideal contours are created, the technician must be advised not to alter these contours during the final wax-up or finishing of the denture.

Once the speech-related palatal contour is properly developed, the rest of palatal surface of the maxillary denture should be waxed to a uniform thickness of 2.5 mm. Thus when the processed resin is smoothed and polished, the palate will be as thin as possible and yet sufficiently thick to provide adequate strength.

COMPLETION OF WAX-UP AND FESTOONING

Before the addition of wax to finalize the wax-up, it is important to evaluate the prosthetic occlusion. Wax shrinks when it loses temperature; therefore it is not uncommon for teeth to move slightly out of occlusion. This is particularly visible when viewing from the posterior of the articulator into the lingual aspect of the dentition. Often the lingual aspect of the teeth needs to be lifted to meet the occlusal plane. Use of the metal occlusal plane is useful to evaluate that the teeth are set in harmony with each other and the metal occlusal plane.

The wax surfaces around the teeth are known as the art portion of the polished surface and should, for esthetic reasons, imitate the form of the tissues around the natural teeth. Attentions to carving, stippling, cervical exposure of teeth, and thickness of the palate and borders are the final touches before processing of the dentures. After the proper occlusion is established and finalized, additional baseplate wax is added on the buccal and labial surfaces of the mandibular and maxillary trial dentures and along the cervical collars of the teeth. The excessive wax is removed first so the land area of the master cast is exposed, and then the small end of a knife is held at a 45-degree angle to the tooth surface to form the wax gingival margin (Fig. 12-4, *A* to *C*). Gingival outline form and contours must be reproduced. This is particularly useful in patients with a high smile line who display significant amounts of gingiva (Fig. 12-4, *D*). Maxillary and mandibular canine eminences are reproduced to properly support the lips and the corners of the mouth for esthetics and avoidance of lip biting (Fig. 12-4, *E*).

Slight projection of the root to follow the individual tooth can be made by adding some wax at the root areas and scraping out some wax at the interradicular areas. Creating gingiva rolls helps with deflecting the buccal mucosa away from the biting surfaces. The interdental papilla must be flat or slightly concave so as to provide a more natural appearance and to avoid food impaction. These festooning details are subtle and necessary to achieve a natural look, but they should not be overemphasized so as to create a food trap problem. Care should be taken to expose the complete clinical crown of the anterior teeth. This adds to the esthetics because most adult natural dentition reveals the teeth to the cementoenamel junction (CEJ). Also, the less acrylic resin that is visible around the teeth, the more natural the appearance is.

The lingual surface of the mandibular denture may be made slightly concave without extending the depth of the concavity under the lingual surface of the teeth. A projection of the tooth beyond the polished surface acts as an undercut into which the patient's tongue will slip, thereby causing the denture to be unseated and also allowing food to accumulate (Fig. 12-5).

In the maxillary denture, palatal festooning restores part of the palatal surface of the tooth that is not supplied in artificial teeth. Wax is added and carved on the artificial teeth to imitate the normal palatal contours of each tooth (Fig. 12-6).

After wax-up and festooning are completed, seal the periphery of the denture flange to the inner edge of the land of the cast. The wax should be flush with the land (Fig. 12-7, *A*). After soaking the master casts and mountings in water for a few minutes, gently remove the casts from the mountings (Fig. 12-7, *B* and *C*) and prepare for flasking and processing.

FORMATION AND PREPARATION OF THE MOLD

After the trial dentures have been waxed, they are prepared for flasking. An ejector-type (three-piece) flask is used to facilitate removal of the denture after processing without danger of breaking the denture. The pieces of the flask are usually referred to as the drag (bottom), the cope (middle portion that will capture the teeth of the denture), and the cap (which is the thin top of the flask). Dental plaster and stone are used to invest the dentures and create the mold within the flask. A limited number of steps are necessary to create the mold, but optional steps are often taken during



Figure 12-4 **A** and **B,** All excessive wax should be removed from the land areas of the master cast *(arrows)*. **C,** A small end waxing knife is held 45 degrees to form the wax gingival margin. **D,** Note that the length of the cuspid and the premolar is similar to the natural state, and the gingival outline gradually tapers toward the occlusal plane to mimic natural teeth display. **E,** Esthetic festooning of the anterior teeth to display the CEJ and natural-looking gingival outline form and contour. The maxillary and mandibular canine eminences are reproduced to properly support the lips and the corners of the mouth.

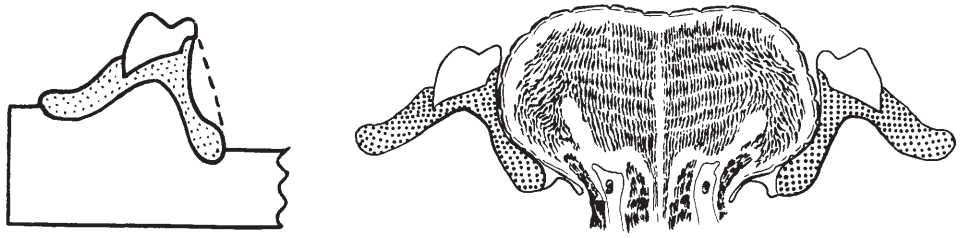


Figure 12-5 **A,** Proper form of the lingual polished surface contour. **B,** Position of the tongue relative to the lingual surface of the denture base is accommodated in the concave lingual polished surface.

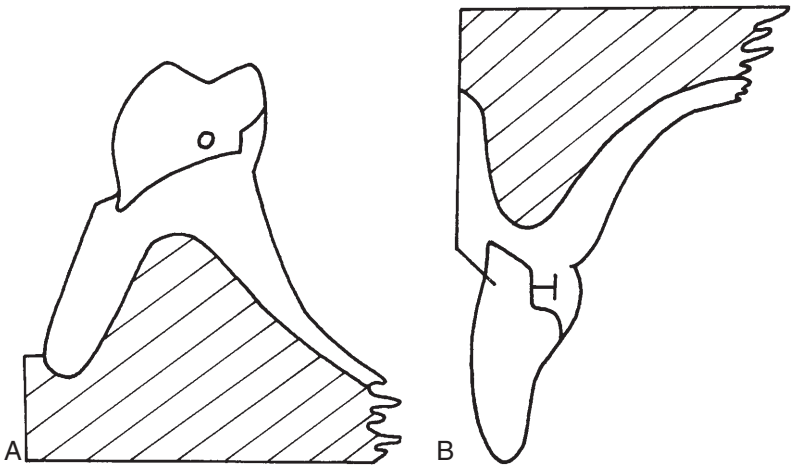


Figure 12-6 **A,** The normal lingual contour of the posterior denture teeth is established during the waxing procedure. **B,** The palate contour of the upper central incisor is reestablished to aid phonetics.







Figure 12-7 **A,** After completion of festooning, seal periphery of the denture flange to inner edge of the land of the cast. The wax should be flush with the land. **B** and **C,** After soaking the master casts and mountings in water for a few minutes, gently remove the casts from the mountings. Note no damage on the master cast and the mounting. This allows cast reattachment to the mounting after processing.



Figure 12-8 Master casts and wax dentures fit easily in the bottom half of the flasks.

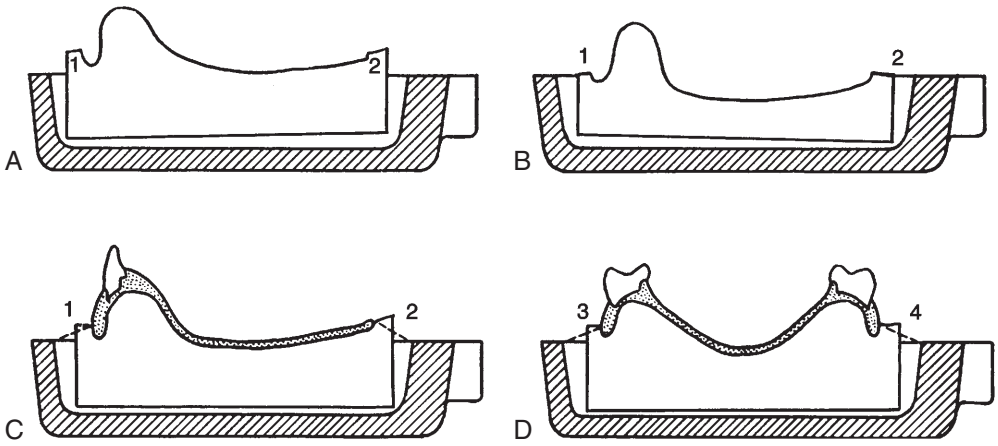


Figure 12-9 First half of flasking of the maxillary denture. **A,** Cast too high in area 1 and 2. **B,** Area 1 and 2 at a favorable level. **C,** Area 1 and 2 should be beveled. **D,** Area 3 and 4 to be beveled.

the investing procedure to allow the multiple portions of the stone mold to "fall apart" during deflasking. This offers ease in deflasking the denture and decreases the risk of fracturing the denture or teeth during removal of the denture from the flask (divesting). These optional steps are described as such.

The denture with master cast is placed in the flask to establish its height in relation to the height of the drag of the flask (Fig. 12-8). The cope of the flask is placed in position to ensure that the teeth do not project beyond the top of the flask. Ideally, approximately ⅛ to ¼ inch (3 to 6 mm) of space should be available between the occlusal surface of the teeth and the top of the flask. If the teeth are too high, the cast must be reduced in thickness. The land area of the cast should be flush with the drag of the flask to prevent possible breakage of the cast in later separation of the two halves of the flask (Fig. 12-9).

The distal ends of the lower cast may be high in relation to the remainder of the cast and extend close to the posterior edge of the flask. This condition causes the distal ends of the cast to be at an acute angle to the rim of the flask. Thus the distal ends are vulnerable to breakage when the flask is separated; care should be taken to avoid creating an undercut or too vertical a surface in this area when the cast is invested.

A mix of plaster is poured in the bottom half of the flask, and the cast, which has been painted with separating medium (Fig. 12-10, *A* and *B*), is placed down into the plaster until its rim is nearly level with the top edge of the flask. The plaster is leveled between the edge of the cast and the rim of the flask.

Separating medium is applied on the plaster, and the top half (cope) of the flask is set in position. The two flask halves must meet exactly. Then a mix of dental stone is poured up to the level of the incisal edges of the anterior teeth and the tips of the cusps of the posterior teeth. The exposed stone is painted with separating medium, the flask is completely filled with another mix of plaster, and the

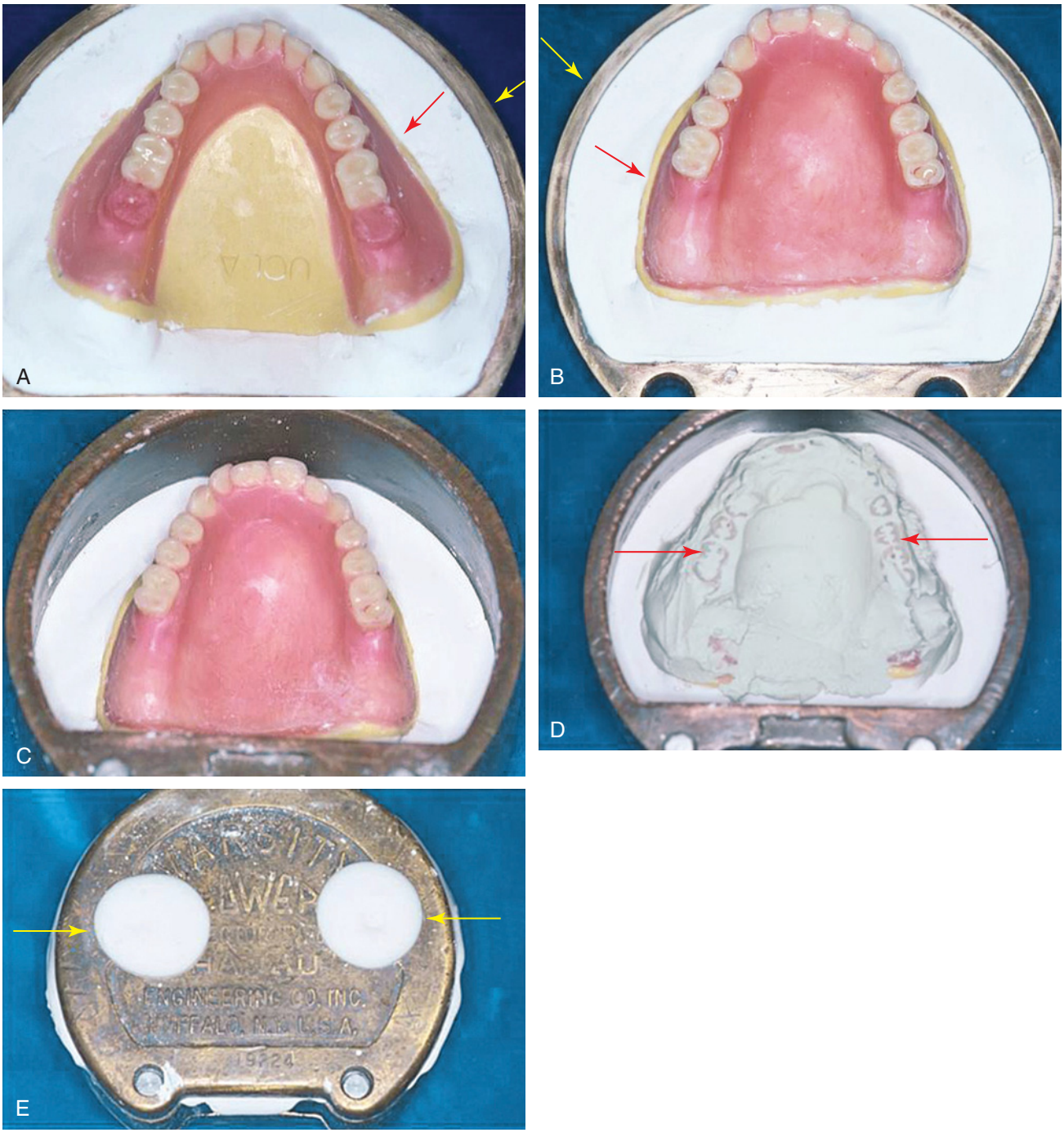


Figure 12-10 **A** and **B,** The denture flasks are partially filled with plaster and the casts are then positioned within the flask so that the land of the cast *(red arrows)* is on the same level as the edge of the flask *(yellow arrows)*. **C,** The upper portion of the flask is placed into position. Note that the denture teeth fall below the top level of the flask. **D,** A thin layer of improved dental stone is applied to the surface of the trial denture. Note that the occlusal and incisal surfaces of the denture teeth are partially exposed *(arrows)*. **E,** The flask is then filled with plaster and the top of the flask is placed into position. The excess plaster is expelled through holes on the top *(arrows)*.

Continued















Figure 12-10, cont'd **F** and **G,** The flasks are heated in very hot water and then separated. **H,** The wax is then washed away with streams of hot water. **I** and **J,** The wax and the record bases have been completely removed. The denture teeth are imbedded in one side of the flask and the master casts are imbedded in the other side. **K** and **L,** After drying the stone, both sides of the flask are covered with a tinfoil substitute. Care must be taken to avoid coating the denture teeth with the tinfoil substitute.

cap of the flask is set in position (Fig. 12-10, C to *E*). Some technicians do not expose the tooth surfaces with this pour of stone, but rather place one complete pour of stone up to the superior level of the cope and then place the cap. If the teeth are exposed and an additional thin pour of 2 to 3 mm is used, this pour will easily be separated during the divesting procedure, and the technician will be aware of the position of the teeth when using any mechanical devices to break away the stone mold. This "protective" step might be especially useful when easily breakable porcelain teeth are used on the denture. The flask is placed in boiling water and allowed to remain 4 to 6 minutes to soften the wax. Then it is removed from the water, and the drag and cope portion are "opened" from the side opposite the greatest undercut. The wax is removed, and the residual wax is washed out with a stream of boiling water (Fig. 12-10, *F* to *H*). After the stone is dry, but while still hot (Fig. 12-10, *I* and *J*), the inside of the mold and the cast are painted with tinfoil substitute (Fig. 12-10, *K* and *L*). The tinfoil substitute must not come in contact with the teeth or pool in the mold around the teeth. It is allowed to dry, and a second coat is painted on the inside of the mold. The flask is allowed to cool to room temperature. When acrylic resin teeth are used, the exposed surfaces of the teeth must be free of wax and tinfoil substitute and any other debris. Residue on the teeth is the main cause for adhesive failure.

PACKING THE MOLD

An acrylic resin dough is made by mixing the powder (polymer) and liquid (monomer) in accordance with the manufacturer's directions. Monomer is a sensitizer that can cause an allergic contact eczematous reaction on the skin or mucous membrane. Consequently, it is advisable to wear rubber gloves and work under proper ventilation. When the monomer is completely polymerized, it rarely elicits an allergic reaction. When the mixture has reached a doughy consistency, it is placed between two plastic sheets and formed into a roll that is flattened to about ¼ inch (6 mm) thick, and pieces are cut and systematically placed over the teeth in the flask. If there are severe undercuts in the anatomical portion of the edentulous ridge (in the drag of the flask), a small portion of resin also may be placed in these undercut areas. The flask is closed in a press with a sheet of separating plastic between the two halves until they are almost in approximation. Then the flask is opened, the excess flash resin is cut away precisely at the denture border, and additional resin is added at any places where no flash was evident (Fig. 12-11). This trial packing procedure is repeated until the mold is filled and no flash is formed. It is usually not necessary to continue to add resin after the first trial pack; however, repeated packs reveal a need to continually remove the flash. Then the flask is closed completely without the separating sheet. The slightest discrepancy in closure of the two halves of the flask will cause an error in the occlusion.

The flask is transferred to a spring clamp for processing. The clamp is closed tightly but not fully compressed. This will allow the resin to expand upon processing and then finally contract while still under pressure. Most methylmethacrylate denture resins are processed for 9 hours in a cooling bath of water held at a constant temperature of 165° F (73.5° C). However, acrylic resins can be processed at temperatures of 135° F to 180° F. Distortion is reduced when the resin is processed at or below the manufacturer's recommended temperature. However, the amount of monomer remaining in the cured resin clearly affects the degree of cytotoxicity of the denture base material. Potentially more monomer will be present at the processing temperatures. The flask must cool to room temperature before deflasking begins. It is crucial that sufficient time be allowed for cooling inside the flask. If this precaution is not taken, increased distortion of the resin will occur.

FABRICATION OF FACEBOW TRANSFER JIG

Deflasking is usually carefully completed with an air chisel, and the processed dentures are left on the casts. The casts and dentures are returned to the mountings on the articulator, and the processing changes are observed. Usually the change is noted by observing the occlusal pin on the anterior guidance platform and is often in the realm of 1 to 2 mm. Minor processing changes are usually corrected at this time. However, new interocclusal records and final adjustment of the dentition will be done at insertion time. It should be noted that adjusting the occlusion after processing and at delivery could sacrifice too much tooth stock.

The upper cast is attached to the upper mounting, and a record of its relationship to the articulator is made in plaster on the lower mounting ring. Fast-setting plaster is added on the lower mounting ring, and the teeth of the upper denture are pressed into the plaster while the cast is in its keyed position on the articulator (Fig. 12-12). Only the occlusal and incisal surfaces of the denture teeth engage the plaster. This facebow transfer jig also can be made after the final wax-up, just before investing the maxillary denture.

LABORATORY REMOUNT AND EQUILIBRATION (AS # 2 REMOUNT IN TABLE 11-2)

The expansion after denture processing may create a slightly increased vertical dimension of occlusion (VDO). When the master casts with the processed dentures still on them are returned in their original mountings in the articulator, this slightly increased VDO can be noticed because the

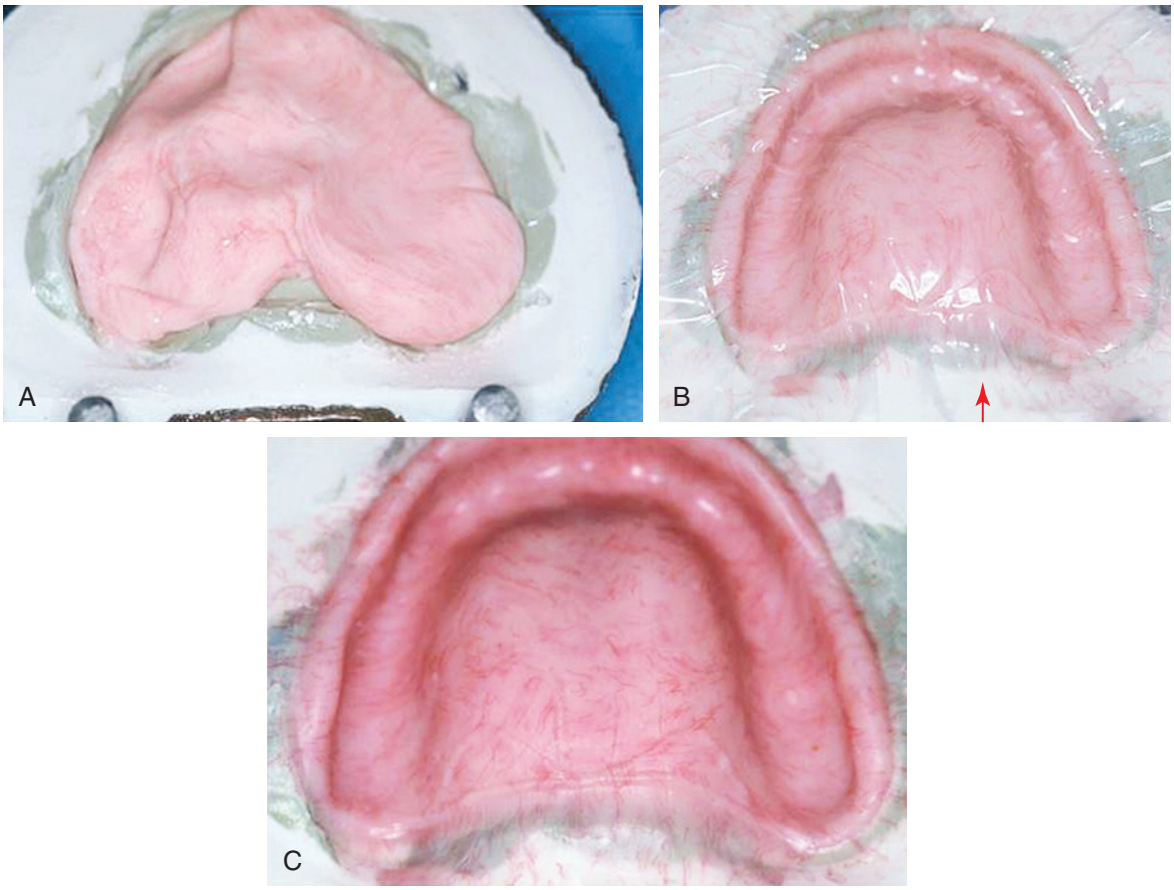


Figure 12-11 **A,** An acrylic resin dough is made by adding polymer to monomer in the proper amounts. **B,** The flask is closed in a press with a sheet of plastic (*arrow*) placed in between the two halves. **C,** After several closures and when the resin has been suitably compressed, the plastic sheet is removed, and the flask is closed and placed in a press and then placed in a curing tank.

incisal pin is slightly away from the incisal table on the articulator during the laboratory remount. The processing changes may create initial occlusal contacts in the posterior teeth first (Fig. 12-13). This slightly increased VDO is really a benefit because it allows more occlusal refinement than can be created during the wax-up stage. The goal of the laboratory remount and occlusal reequilibration is to bring back the preprocessing VDO, and the incisal pin contacts the incisal table again on the articulator.

Modifying the occlusal surfaces of the teeth by selective grinding will eliminate most of the errors caused by processing changes. However, it will not eliminate errors produced by the impressions or jaw relation records, nor will it eliminate errors that develop when the dentures are removed from the casts or are polished. Therefore new interocclusal records should be made at the time new dentures are first inserted in the patient's mouth. To avoid dimensional and occlusal changes, patients should be advised to store dentures in water.

Once the preprocessed VDO is regained by adjusting all initial occlusal contacts at centric position, then special care is required to keep it. Avoid further adjustment on functional cusps during the excursive movement. Use red articulating paper to mark these "supporting occlusal" contacts and avoid adjusting them further. Use blue articulating paper and make protrusive and lateral excursions. Adjust these blue contacts using the acronyms of "BU-LL," buccal upper and lingual lower, and "MU-DL," mesial upper and distal lower to remove interferences on excursions without damaging the red occlusal support contacts. This selective occlusal adjustment by grinding can create a balanced articulation to the limits of excursions to the cusp tips and incisal edges.

REMOVING PROCESSED DENTURES FROM THE MASTER CASTS

Make cuts into the base of each cast almost to the resin. Insert the plaster knife into the cuts and carefully separate the sections of stone. Remove all stone from the dentures. The Kingsley scraper is particularly useful in removing tenacious elements.



Figure 12-12 Fabrication of facebow transfer jig: Attach processed upper denture with its mounting and a record of its relationship to the articulator is made in fast-setting plaster on the lower mounting ring. Only the incisal and occlusal surfaces of the denture teeth engage the plaster.



Figure 12-13 Laboratory remount: processed dentures on the casts are reattached to the plaster mountings of the articulator. The changes that occurred in the processing of the acrylic resin have caused errors in the occlusion.

FINISHING AND POLISHING DENTURES

The feather edges of the denture base material are removed with files, scrapers, and burs. Finish borders with an acrylic bur. Be careful to remove excess resin beyond the land. Be careful to preserve the border width and contour. The feather edges around the gingival line of the teeth are cut down by means of chisels and knives to conform with the desired contour; care is taken not to cut acrylic resin teeth. With burs, stones, chisels, and sharp scrapers, the surface is shaped until it is smooth and clean. No plaster and no deep scratches should remain before polishing. Any difficulty during polishing of the dentures is due to their not being properly prepared for polishing.

Use a very wet rag wheel with liberal amounts of wet pumice to polish the palatal, lingual, labial, and buccal areas. The periphery of the denture also must be carefully polished. Use the edge of the wheel as shown during polishing to avoid burning the acrylic resin. Do not overpolish and thereby lose the contours that were developed during festooning. A final high polish is given to all the surfaces with a rag wheel and polishing material (tripoli, tin oxide, and water). Examine the tissue side of the dentures and carefully remove any bubbles present with a Kingsley scraper or other sharp instrument.

FABRICATION OF CLINICAL REMOUNT CASTS

Remounting casts serves as an accurate, convenient, and time-saving method of reorienting the completed dentures on the articulator for occlusal corrections. All undercuts on the tissue surface of the dentures are filled with wet tissue paper, clay, or wet pumice (Fig. 12-14, *A* and *B*). Blockout should be only at the undercuts. Most internal denture anatomy should remain to support the dentures during occlusal adjustments. Remount casts that only duplicate the flanges often allow the dentures to rock or shift during the occlusal adjustments.

Fast-setting plaster or artificial stone is poured into the denture. After the plaster has set, the excess is trimmed down to the border (Fig. 12-14, *C* and *D*), and the dentures are removed from the casts. The casts are examined to ensure that the grooves formed by the border of the dentures are not deeper than 1 mm to allow accurate seating of the dentures (Fig. 12-14, *E*).

With the remounting jig and index positioned on the mandibular member of the articulator, the maxillary denture and remounting cast are placed in the plaster facebow transfer jig. The maxillary remount cast is attached to the maxillary member of the articulator by means of fast-setting plaster (Fig. 12-14, *F*).

HYDRATE THE DENTURES

Before delivery, the dentures must be soaked in water for 72 hours for proper dimensional hydration recovery. This hydration time can be reduced to 2 hours by using low pressure water containers.

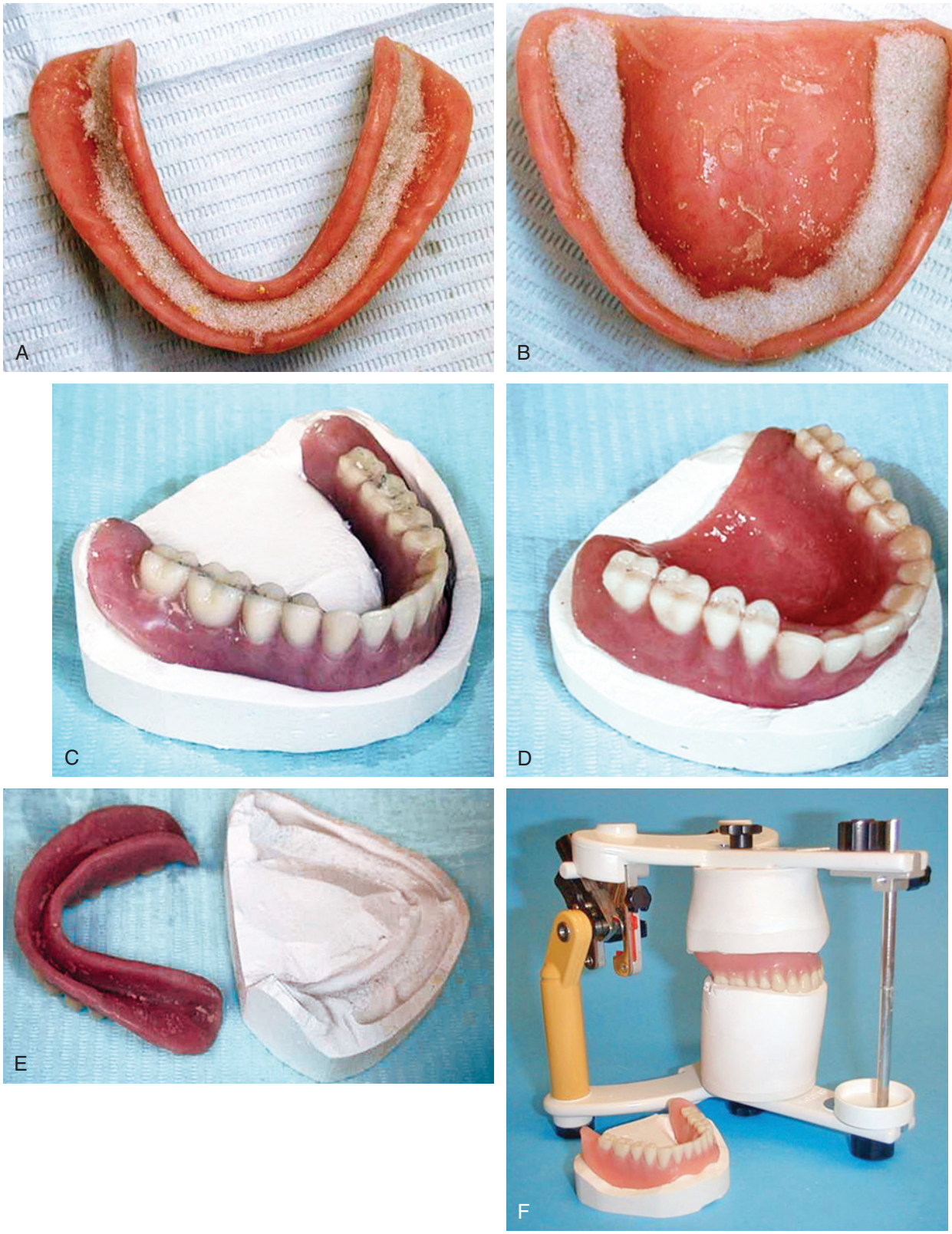


Figure 12-14 **A** and **B,** Fabrication of remount casts. Begin by blocking out the undercuts associated with the tissue-bearing surface of the dentures with moistened pumice. **C** and **D,** Mix a small amount of plaster, place it on the lab bench, and imbed the denture into it as shown. **E,** Lower denture removed from the remount cast. All the blockout material should be removed, and the denture should fit accurately on the cast. **F,** The maxillary remount cast is attached to the maxillary member of the articulator using the facebow transfer jig.

DELIVERY OF THE COMPLETED DENTURES

Certain technical procedures must be carried out to ensure a successful prosthodontic service. Inaccuracies in the materials and methods used to get the dentures to this stage must be recognized and eliminated before the patient wears the dentures. The inaccuracies may be the result of (1) technical errors or errors in judgment made by the dentist, (2) technical errors developed in the laboratory, or (3) inherent deficiencies of the materials used in the fabrication of the dentures. Ideally the patient should be instructed to keep any previous dentures out of the mouth for 12 to 24 hours immediately before the insertion appointment. This is essential if the new dentures are to be seated on healthy and undistorted tissues. If the tissues are being distorted by old dentures, the new dentures will not seat perfectly, even if they fit perfectly. Improper seating of dentures at this time can cause the appearance of errors in occlusion or fit that would not exist if the tissues were undistorted. Adjustments of any type to correct such apparent errors, if made at this time, may be unnecessary and can cause irreparable damage to the dentures. This caution is predicated on the requirement that the patient be without any dentures for 24 hours (sometimes longer) to get the tissues healthy before the final impressions are made. Many patients will find leaving the dentures out of their mouth for 12 to 24 hours an unreasonable request. An acceptable alternative is to have the existing dentures relined with a soft temporary material to minimize tissue distortion problems.

ELIMINATION OF BASAL SURFACE ERRORS

Before the placing of dentures in the patient's mouth, the dentures should be inspected digitally and by magnifying loupes to be sure that the tissue surface has no imperfections, the polished surface is smooth, the denture flanges have no sharp angles and are not too thick, and the denture borders are round and smooth with no obvious overextension. If carefully border-molded impressions have been made, the flanges and borders should require little if any alteration. The dentist's objective should be to make the final impressions and master casts so perfectly that there is no doubt in the mind of the technician as to the form and extent of borders and flanges when the dentures are trimmed and polished.

ADJUSTMENT OF DENTURE BASE

The use of pressure-indicating paste (PIP) is essential to evaluate and improve the adaptation of the denture to the tissue. Denture-supporting mucosa varies in its compressibility under load, so that despite accurate impressions and models, some adjustments over thin areas of mucosa or undercuts will make patients more comfortable. PIP helps for the following reasons:

- Pressure spots may have been present in the final impression, which was otherwise acceptable and used.
- Processing changes can create a slight contraction of the maxillary denture base, and it is common to relieve the lateral surfaces in the tuberosity area to compensate for processing changes.
- Bilateral undercuts on the residual ridge can interfere with the initial placement of dentures and relief may be needed to allow comfortable insertion and removal.
- It is common to provide relief for the thin mucosa over the lingual bony prominence of the mylohyoid muscle insertion.
- With advanced resorption, the mentalis and incisive canal nerves may have so little tissue over them that they require relief to avoid discomfort.

Dry the denture first and then run the brush with the same direction and apply a thin even layer of PIP onto the surface of the denture (Fig. 12-15). The painted surface may be sprayed with a silicone liquid or wetted with water. Carefully seat the denture with firm finger pressure on the first molar areas. Extreme pressures are not desirable because this will distort the tissue. Do not have your patient bite when using PIP at this point because the uncorrected occlusal errors may shift the denture and create an erroneous PIP pattern. Remove the denture immediately and inspect the pressure spots. There are four possible patterns to observe when reading PIP:

1. A clean wipe on the periphery results from cheek rubbing during insertion. Do not adjust clean wipe areas.

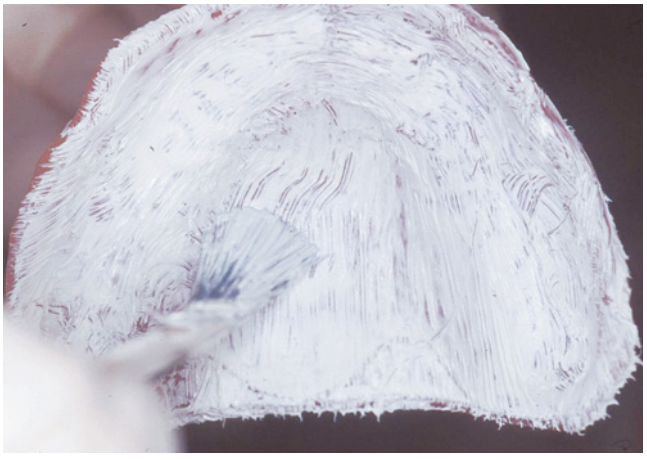


Figure 12-15 Dry the denture first and then run the brush with the same direction and apply a thin even layer of pressure-indicating paste (PIP) onto the surface of the denture.

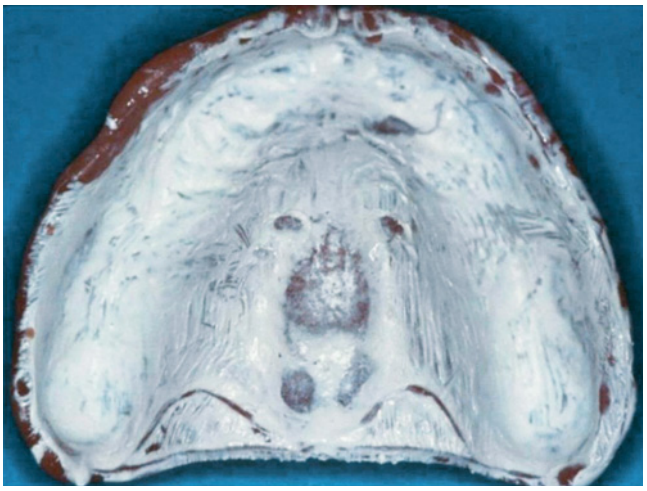


Figure 12-16 The PIP pattern indicates severe pressure on the portion of the denture that overlies the torus.

2. Disturbed brush lines indicate the desirable tissue contact.
3. Undisturbed brush lines indicate no tissue contact yet.
4. Pink acrylic show-through spots indicate excessive tissue contact and pressure. These pink marks in the paste indicate where the denture base should be adjusted to relieve the interference (Fig. 12-16).

The goal is to create the best of #2 (complete comfortable contact), with the least of #3 (spaces) by relieving #4 (pressure spots). Remove the grindings and moisture with a gauze pad and apply PIP, repeating the above procedure until pressure areas are eliminated.

ADJUSTMENT OF DENTURE BORDERS

Apply disclosing wax on an incremental dried denture border and warm up the wax in the water bath for 5 seconds. Seat the denture firmly with even finger pressure. Instruct the patient to go through the necessary border-molding movement. Carefully remove the denture without smearing the wax. Adjust any visible pressure area or overextension. Repeat the procedure until no more overextended border is indicated.

ERRORS IN OCCLUSION

Errors in occlusion can result from a number of factors. These include a change in the state of the temporomandibular joints (TMJs), inaccurate maxillomandibular relation records by the dentist, errors in the transfer of maxillomandibular relation records to the articulator, ill-fitting temporary record bases, change of the VDO on the articulator, incorrect arrangement of the posterior teeth, failure to close the flasks completely during processing, use of too much pressure in closing the flasks, and unavoidable processing changes in the denture base material during polymerization. Acrylic resins shrink when they change from a moldable to a solid form. They have a high coefficient of thermal expansion and in cooling after polymerization, they shrink, causing dimensional changes. The greatest amount of change occurs when the dentures are removed from the casts. Further change may occur if too much heat is generated in polishing the dentures. Denture base acrylic resins also absorb water and saliva. This absorption causes a 1% to 3% expansion and can alter the relationships of the cusps' inclined planes. After finishing of the dentures, the prostheses should be maintained in water so this dimensional change occurs before the final occlusal refinement that is accomplished at the insertion appointment. All errors in occlusion should be corrected and equilibrated by laboratory remount (refer to laboratory remount and occlusal equilibration on pages 263-265) and clinical remount. Failure to correct occlusion before the patient wears the dentures can cause destruction of the residual alveolar ridges.

CLINICAL REMOUNT AND OCCLUSAL EQUILIBRATION (AS #3 REMOUNT IN TABLE 11-2)

Laboratory remount and adjustment is to correct the processing changes and re-establish the preprocessing VDO. There are different types of errors that require clinical remount and occlusal equilibration for further correction of these errors. The purpose of the clinical remount is to correct for the fact that adjusted denture bases seat more accurately than record bases and to accommodate for errors made during the making of centric relation (CR) records. The maxillary denture already should be mounted on the articulator with the plaster remount cast and the facebow transfer jig as previously described. The mandibular denture on the remount cast will be mounted to the maxillary denture by means of using a CR record. Before obtaining the CR record, place two cotton rolls on the first molar denture teeth and have the patient close down for 5 minutes. This preparation procedure allows optimal denture adaptation and seating the post–palatal seal area for the subsequent interocclusal records.

The dentures must be remounted on the articulator by means of accurate interocclusal records (CR and protrusions are necessary for this procedure) for the selective grinding necessary in perfecting the occlusion. When new accurate interocclusal records are made and the completed dentures are remounted on the articulator, the errors in occlusion are easily visible, easily located, and easily corrected by selective grinding. Properly made interocclusal records will not cause the denture bases to slip or rotate in relation to their bony foundations. Furthermore, on the articulator, the dentures will be firm on their remount casts. The points of

contact and errors of occlusion can be observed visually from both buccal and lingual aspects, with magnification if desired, and articulating paper marks are quite easily made on the dry teeth. There is an additional psychological benefit for better patient management because the clinical remount permits performing the selective grinding in the laboratory, not at the chairside.

CENTRIC RELATION RECORD

Rehearse with the patient a few times before obtaining the CR record. Stabilize the mandibular denture with the index fingers on the buccal flanges and the thumbs under the mandible. The patient is instructed to retrude and elevate the tongue to touch the roof of the mouth in the back during closure. Some gentle manual guidance on the patient can be applied simultaneously in a hinge movement. This will ensure the condyles are properly seated. Repeat a few times until the patient is relaxed and repeated closure pattern is observed.

Place low-fusing modeling compound (ISO) that has been softened in a water bath at 110° F on the occlusal surfaces of the mandibular denture. Place the mandibular denture in the water bath for 10 seconds (Fig. 12-17, *A* and *B*). Carry to the mouth and have the patient close in centric relation just short of tooth contact as in the previous rehearsal (Fig. 12-17, *C*). Care must be taken to prevent the patient from penetrating the record material and making tooth contact. Remove the mandibular denture with the record and inspect. If there is direct tooth contact through the compound record, there is the possibility that the bases shifted and an incorrect record was made. The record must be repeated. Chill the compound record in cold water until it is hard. Trim the record with a scalpel so that only slight indentations remain. Trim the buccal side so the seating of the maxillary denture teeth can be visually checked (Fig. 12-17, *D* and *E*).

Reinsert the mandibular denture with the thoroughly chilled and trimmed compound record for confirmation. The patient is instructed and guided to close in CR relation as previously described. The record is acceptable if there is no tilting or torquing of the dentures from initial contact to complete closure. Underlying soft-tissue displacement may cause a slight movement of the bases and must be taken into account when evaluating the contact. If the record does not satisfy these criteria, the procedure must be repeated.

REMOUNT THE MANDIBULAR DENTURE

The maxillary denture should be mounted already on the articulator by means of the facebow transfer jig (see Fig. 12-14, *C* and *D*), which will have preserved the facebow orientation of the dentures. As a result, the horizontal condylar setting recorded at the try-in appointment should be valid, and it is not necessary to repeat the facebow or protrusive record.

After the dentures and compound record are chilled and thoroughly dried, the mandibular denture is positioned on the remount cast. Next, the maxillary denture teeth are carefully positioned in the compound index and secured with a drop of sticky wax in the canine and second molar regions bilaterally. Sticky wax can be used to secure both dentures to their remount casts, if necessary. The incisal pin should be adjusted to allow for the thickness of the interocclusal wax record by raising the upper member of the articulator about a millimeter and dropping the incisal pin. The condylar controls must be locked into centric position. Plaster is used to secure the mandibular denture to the lower member of the articulator (Fig. 12-18).

VERIFYING CENTRIC RELATION

The CR record should be verified for accuracy before any tooth adjustments. The ISO compound is used, and the CR recording is repeated. After chilling and drying of the wax record, the dentures are returned to the articulator. With the articulator locked in CR, the maxillary teeth should fit precisely into the new compound record. If all the teeth drop simultaneously into the record, the mounting is correct. If the opposing teeth do not fit exactly into the indentations in the new record, either the original mounting was incorrect, or the patient gave an incorrect relation when making a second record. To evaluate this, the dentist returns the dentures with the chilled compound record to the mouth and evaluates the accuracy, as previously described. If the record still appears correct in the patient's mouth, the original CR registration or mounting was incorrect. In this situation, the mandibular cast should be separated from the mounting ring and the cast remounted according to the second CR record. The new mounting is again checked in the same manner to validate its correctness.

PROTRUSIVE RECORD (OPTIONAL)

The remount occlusal index has preserved the original facebow orientation of the dentures; thus the optimal condylar setting recorded at the try-in appointment should still be valid. A new protrusive record is only made if there is any question as to the accuracy of the original condylar setting (Fig. 12-19). As previously stated in the chapters related to articulators and lateral excursive records, precise and reproducible lateral records are difficult to record because of denture instability and tissue resiliency. Therefore most clinicians agree that average lateral condylar settings are sufficient for denture construction.



Figure 12-17 **A** and **B,** Place low-fusing modeling compound (ISO) that has been softened in a water bath at 110° F on the occlusal surfaces of the mandibular denture. Place the mandibular denture in the water bath for 10 seconds. **C,** Place the lower denture with softened ISO compound intraorally and have the patient close in CR just short of tooth contact. Instruct the patient to retrude and elevate the tongue. Some gentle manual guidance on the patient can be applied simultaneously in a hinge movement. This will ensure the condyles are properly seated while obtaining the CR record. **D,** Remove the CR record. Chill in cold water until it is hard, and trim the excess with a scalpel so that only the cusp tip indentations remain. Trim the buccal side so that the seating of the dentures can be visually checked. **E,** The dentures and trimmed CR compound record are positioned together before reinsertion to recheck the accuracy of the record intraorally.

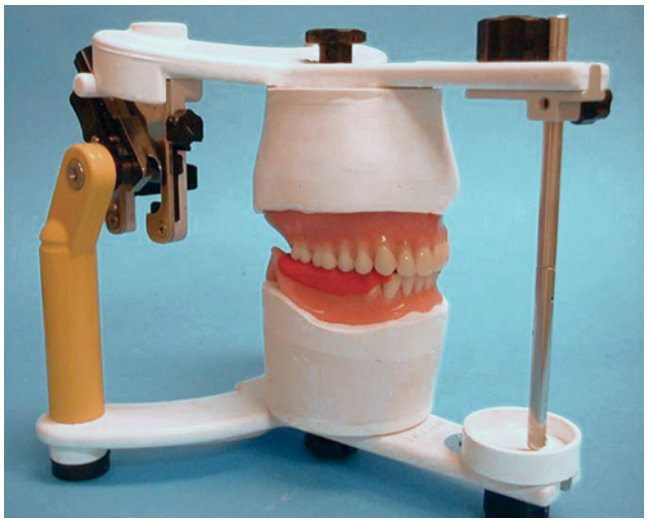


Figure 12-18 The mandibular denture on the remount cast is mounted on the articulator with locked centric control.



Figure 12-19 Protrusive record: Instruct the patient to bring their mandible forward 3 to 5 mm at about edge-to-edge position and then gently close into registration compound material.

ELIMINATING OCCLUSAL ERRORS IN ANATOMICAL TEETH

Final correction of occlusal disharmonies is made at this time by means of methodical selective grinding that will give simultaneous contact around the arch in CR occlusion and in eccentric movements and also maintain tooth form. CR occlusion should be equilibrated and established first with the condyles in their locked position on the articulator. During this CR grinding procedure, the incisal guide pin is relieved of contact on the incisal guidance table to allow for the slight reduction in vertical dimension that must necessarily take place. Articulating ribbon of minimum thickness is used for marking contacts of the teeth because thicker articulating paper gives deceptive contacts. Representative occlusal errors and adjustments are depicted in Fig. 12-20. Grinding the occlusal errors is done with small stones or a number 8 round bur. The marking process and the grinding are repeated until all *except* the anterior teeth contact in CR. Ideally all bearing cusps of the maxillary and

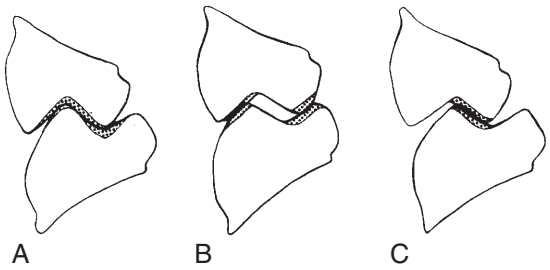


Figure 12-20 Correction of errors in CR occlusion. Grind the shaded areas. **A,** Teeth too long. **B,** Teeth too nearly end to end. **C,** Too much horizontal overlap.

mandibular posterior teeth will make simultaneous contact. However, it is not uncommon for one or two functional cusps not to make contact after establishing the final CR occlusion. It is not necessary to continue adjusting until these cusps make contact because that aggressive adjustment will sacrifice the established VDO. The final articulating marks should remain on the dentition to maintain a reminder of the CR contacts during the upcoming adjustment of lateral excursions and protrusion.

Unlike occlusal philosophies in natural dentition, balanced occlusion is desirable for working and balancing contacts to occur simultaneously. The goal is for balancing side contacts to appear across the arch and within the tooth on the working side of the arch. During evaluation of contacts and selective grinding, tooth contacts will prevent other teeth around the arch from making contact. The goal is to maintain the integrity of the functional cusp tips in both arches (maxillary lingual and mandibular buccal cusps) and allow all cusps to move through the "sluice ways of the opposing dentition" (working and balancing grooves and mesial and distal inclines). The functional cusp tips are not reduced, but rather the opposing fossae are made deeper and/or wider. Also, if the "high" contact is on the functional cusp inclines, the cuspal inclines can be reduced, thereby gradually moving the contact more toward the functional cusp tip. In lateral excursions, if a central bearing cusp is "high," creating simultaneous contacts of other teeth, the opposing fossa can be widened. Balancing cusp tips and inclines are adjusted similarly, but adjustments to the cusp tips can be accomplished if needed, without the risk of decreasing the VDO.

After the CR contacts have been established, the occlusion is examined in lateral excursions and protrusion. One of the articulator condyles can be released to allow a unilateral lateral movement. Using a different color articulating ribbon from the CR contacts is recommended so the interfering contacts during eccentric movement can be differentiated from the CR contacts. The articulating ribbon is placed over the teeth on both sides, the articulator is moved into a working lateral position, and the contacts are marked on both sides for the same lateral movement. Care is taken not to grind on working cusp tips or the opposing

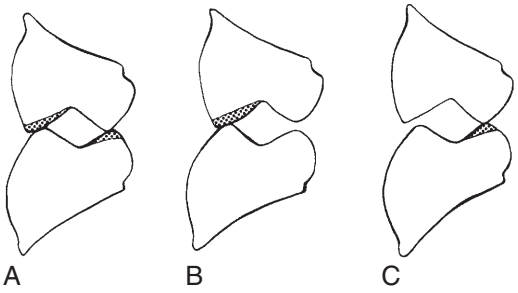


Figure 12-21 Correction of errors on the working side during lateral excursion. Shorten interfering contacts as indicated by the shaded areas. **A,** Upper buccal and lower lingual cusps too long. **B,** Upper buccal cusps too long. **C,** Lower lingual cusps too long.

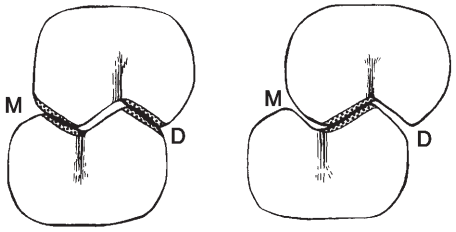


Figure 12-22 Correction of errors in the mesiodistal relationship during protrusion. Grind the shaded areas. *D,* Distal surface; *M,* mesial surface.

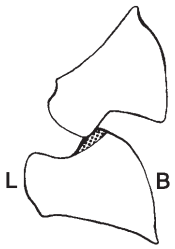


Figure 12-23 Eliminating deflective occlusal contact on the balancing side. Grind the lingual incline of the mandibular buccal cusp. *B,* Buccal surface; *L,* lingual surface.

fossae contact of the working cusp tips that were established in CR occlusion and remain marked with the original color ribbon. Grinding to correct lateral occlusion is limited to altering the lingual inclines of the maxillary buccal cusps and the buccal inclines of the mandibular lingual cusps on the working side and the lingual inclines of the mandibular buccal cusps on the balancing side. Repeat the marking and grinding on the opposite lateral excursion. The types of interceptive occlusal contacts and the necessary adjustments are depicted in Figs. 12-21 to 12-23. In most instances, the lateral movement of the incisal guide pin need not exceed 3 mm. This amount of lateral movement usually moves the posterior cusp tips in an end-to-end position and meets the functional demands of the patient.

If the grinding has been done in right and left lateral and intermediate movements, grinding in protrusion will also have been accomplished; however, a straight protrusive movement should be evaluated. Again, the dentist may wish to use a third colored ribbon to protect the central bearing contacts and to note what "new" protrusive contacts have occurred that may be severely lifting the anterior pin from the incisal guide table. Usually only few teeth reveal a heavy discluding contact and require adjustment. Testing with articulating ribbon should show uniform protrusive contact throughout the arches of the maxillary and mandibular dentures.

Carborundum paste should not be indiscriminately used to eliminate errors in the occlusion of cusped teeth. Aggressive use of the paste could decrease vertical dimension and the sharpness of the cusps. If carborundum paste is used, smoothing of minute irregularities must be limited to only a few gliding movements of the articulator.

If lingualized occlusion is selected, it is important to maintain the centric occlusal contacts on the maxillary lingual cusps and mandibular fossa during the occlusal equilibration. Adjust the maxillary buccal cusps and mandibular occlusal anatomy except the fossa to remove the interfering contacts during the excursive movements. Use of two different colors of occlusal ribbon is recommended to differentiate the centric contact and the interfering excursive contact.

ELIMINATING OCCLUSAL ERRORS IN NONANATOMICAL TEETH

If nonanatomical, flat-plane teeth have been used, maxillary posterior teeth should be corrected first for flatness by very conservative sanding on ultrafine sanding paper against a truly flat surface. Place the maxillary monoplane setup on the remount cast and mark the occlusal contacts with articulating ribbon. Selective grinding should be done only on the mandibular teeth because the occlusal plane of the maxillary denture has already been corrected by careful sanding.

If all occlusal correction steps were properly performed, the contacts achieved in the mouth should be the same as those achieved on the articulator when the dentures are inserted. The mounted casts and articulator should be maintained until the adjustment period is over. Finally the remount casts can be sent home with the patient to bring at follow-up visits.

ADVANTAGES OF BALANCED OCCLUSION IN COMPLETE DENTURES

The simultaneous and smooth gliding contacts of upper and lower teeth from CR position to any eccentric positions within the normal range of mandibular function are

developed to lessen or limit tipping or rotation of the denture bases in relation to the supporting structure. The tipping or rotation movements of the denture base are likely to create soreness and inflammation, which may lead to accelerated bone resorption. However, debates arise regarding if the advantage of balanced occlusion in dentures truly exists when a bolus of food on one side separates the teeth so that they cannot possibly be in balancing contact on the opposite side. If a bolus of food were between the teeth during most of the day, there would not be much merit in having an exactly balanced occlusion. However, teeth make contact many thousands of times a day in both eccentric nonfunctional mandibular movements and centric positions, with no food in the mouth. Even while a person chews food, the teeth cut through to contact every few fractions of a second. A balanced occlusion ensures even pressure in all parts of the arch, which maintains the stability of the dentures and is more biomechanically favorable to the denture-bearing tissue and bone.

SPECIAL INSTRUCTIONS TO THE PATIENT

Educating patients to the limitations of dentures as mechanical substitutes for living tissues must be a continuing process from the initial patient contact until adjustments are completed. However, certain difficulties that will be encountered with new dentures and the information related to the care of dentures should be reinforced at the time of initial placement of the dentures. Forewarning makes the patient more tolerant of problems and less likely to relate them incorrectly to the fit of the dentures. Explanations provided after problems develop often are interpreted as excuses by the dentist for dentures that function less than satisfactorily.

INDIVIDUALITY OF PATIENTS

Patients must be reminded that their physical, mental, and oral conditions are individual in nature. Thus they cannot compare their progress with new dentures to other persons' experiences. Denture complaints that are annoying and painful to some patients may be of secondary importance to others. Chewing and speech patterns considered successful by some persons may be interpreted as unsuccessful by others. Patients tend to forget the severity of problems with the passage of time. Many persons indicate that their dentures have always been comfortable, even though they may have had a difficult adjustment period. In addition, adaptability to new dentures is modified by age. Persons who make the adjustment to new dentures during middle age may experience considerably more difficulty with dentures 15 years later, even though the new dentures may be technically superior to the original ones. These remarks can be discouraging to patients with new dentures unless they have been advised of this possibility.

APPEARANCE WITH NEW DENTURES

Patients must understand that their appearance with new dentures will become more natural with time. Initially, the dentures may feel strange and bulky in the mouth and will cause a feeling of fullness of the lips and cheeks. The lips will not adapt immediately to the fullness of the denture borders and may initially present a distorted appearance. Muscle tension may cause an awkward appearance, which will improve after the patient becomes relaxed and more confident. Patients should be instructed to refrain from exhibiting their dentures to curious friends until they are more confident and competent at exhibiting them. When patients are not careful in following these instructions, they may likely become unfairly critical of the dentures and develop an attitude that will be difficult for the dentist to overcome. During the edentulous or partially edentulous period, gradual reduction of the interarch distance and collapsing of the lips will have occurred. These changes usually have been so gradual that family and friends were not aware that they existed. Therefore a repositioning of the orbicularis oris muscle and a restoration of the former facial dimension and contour by the new dentures may seem like too great a change in the patient's appearance. This can be overcome only with the passage of time, and patients are advised to persevere during this period.

Some dentists advise patients to change a hairstyle or change glasses along with their new dentures. This allows onlookers to notice the overall change in the face. Often the dentures are not even noticed by the observer as being responsible for the change in appearance, but rather the pleasing change in the overall face will be observed. A change in glasses or hairstyle also allows the patient to respond to the comments with a discussion about the glasses or the hair and not confide about the new dentures, unless he or she wishes.

MASTICATION WITH NEW DENTURES

The patient must be constantly reminded that eating with dentures is a developed skill. Learning to chew satisfactorily with new dentures usually requires at least 6 to 8 weeks. Patients will become discouraged unless they are aware that this learning period is to be expected. New memory patterns often must be established for both the facial muscles and the muscles of mastication. Once the habit patterns become automatic, the chewing process can take place without conscious effort. The muscles of the tongue, cheeks, and lips must be trained to maintain the dentures in position on the residual ridges during mastication. Patients can be told that "these muscles must learn what they should and should not do."

Patient comfort and mastication may be impaired because of the elicited excess flow of saliva for the first few days after placement of new dentures. However, in a relatively short time the salivary glands accommodate to the presence of the dentures, and normal production of saliva returns.

Patients should begin chewing relatively soft food that has been cut into small pieces. If the chewing can be done on both sides of the mouth at the same time, the tendency of the dentures to tip will be reduced. Patients should be told that during this early period, mastication is best attempted on simple types of food such as crackers, soft toast, or chopped meat and that no attempt should be made to masticate more tough and fibrous foods. First-time denture wearers may be advised to eat foods that require little mastication, but those that are ready for swallowing with a simple push of the tongue against the palate. This will give the patients confidence in stabilizing the dentures. Also, during the learning period, patients are advised to avoid observation by friends or members of the family because the patients will be awkward in the beginning phases of chewing and susceptible to embarrassment and discouragement. Kindly but misplaced joking remarks and comments by members of the family may readily lead a patient to become self-conscious about the dentures, and this will be reflected in the attitude toward the dentist and the dentures.

Occasionally, edentulous patients have gone without dentures for long periods and have learned to crush food between the residual ridges or perhaps between the tongue and the hard palate. These persons usually experience increased difficulty in learning to masticate with new dentures, and the time for adjustment will likely be extended.

Patients should be told that the position of the tongue plays an important role in the stability of a lower denture, particularly during mastication. Patients whose tongues normally rest in a retracted position relative to the lower anterior teeth should attempt to position the tongue farther forward so it rests on the lingual surfaces of the lower anterior teeth. This will help develop stability for the lower denture.

SPEAKING WITH NEW DENTURES

Fortunately, the problem of speaking with new dentures is not as difficult as might be expected. The adaptability of the tongue to compensate for changes is so great that most patients master speech with new dentures within a few weeks. If correct speech required exact replacement of tissues and teeth in relation to tongue movement, no patient would ever learn to talk with dentures. If it were not for the extreme adaptability of the tongue, the necessity of additional bulk over the palate would cause a lasting speech impediment. Even a 0.5-mm change at the linguogingival border of the anterior teeth would cause a speech defect, especially in the production of "s" sounds. Therefore tooth positions that restore appearance and masticatory function usually do not produce phonetic changes that are too great to be readily compensated.

Speaking normally with dentures requires practice. Patients should be advised to read aloud and repeat words or phrases that are difficult to pronounce. Patients usually are much more conscious of small irregularities in their speech sounds than those to whom they are speaking. It should be noted that elderly patients with dentures often have hearing impairments and will have a greater difficulty in changing speech patterns without auditory feedback. An understanding of tongue positions during speech is valuable. Dentists should have an appreciation of tooth position, palatal contours, and lingual contours of the mandibular denture, and these should be technically addressed at try-in and insertion, rather than complete reliance on patient adaptation.

ORAL HYGIENE WITH DENTURES

Patients must be convinced of the importance of maintaining good oral hygiene for the health of the oral cavity. Plaque, stains, and calculus accrue on dentures and oral mucosa of edentulous patients in a similar fashion as in the mouths of dentate patients. Dental plaque is an etiological factor in denture stomatitis, inflammatory papillary hyperplasia, chronic candidiasis, and offensive odors, and it must be removed.

Patients should be instructed to rinse their dentures and their mouths after meals whenever possible. Once a day, it is essential that the dentures be removed and placed in a soaking type of cleanser for a minimum of 30 minutes. This time is required for effective killing of microorganisms on the dentures, as well as removal of all stains. Commercial cleaners are quite effective, and leaving the dentures in the cleanser overnight is even better. Before the dentures are placed in the cleanser, they should be brushed gently with a soft brush and a nonabrasive detergent on all surfaces. Patients need to be instructed that the brushing is required to remove plaque because the soaking will not do so. The dentures should be brushed over a basin partially filled with water or covered with a wet washcloth to prevent breakage in case they are dropped. Patients should be discouraged from using toothpastes because most contain an abrasive material that will wear away the surface of acrylic resin. An inexpensive alternative soaking cleanser is one that can be made up with 1 teaspoon of household bleach and 2 teaspoons of water softener (Calgon) in 8 oz of water. This alternative soaking cleanser should only be used for complete dentures containing no metals because the sodium hypochlorite may pit or corrode the metals. The mucosal surfaces of the residual ridges and the dorsal surface of the tongue also should be brushed daily with a soft brush. This will increase the circulation and remove plaque and debris that can cause irritation of the mucous membrane or offensive odors.

PRESERVING THE RESIDUAL RIDGES

The residual ridges were not intended to bear the stresses of mastication created by complete dentures. Therefore patients, especially when their general health is somewhat impaired, may expect some irritation and discomfort of the oral tissues. No two patients' mouths will react alike because some tissues tolerate stress better than others. Therefore it is impossible to predict exactly what to expect. Patients must be aware of these varying and unpredictable conditions.

If some irritation of the tissues is experienced, patients are advised to remove their dentures and rest the mouth for a time. It may be harmful to the patients' tissues and their psyche to tell patients that they must keep their dentures in the mouth constantly during this initial adjustment period. They may become highly nervous and fatigued and be unnecessarily discouraged. However, patients are advised to wear the dentures one day before an adjustment appointment so any sore spots will be visible and accurate corrections of the dentures can be made. Patients must be cautioned concerning the critical nature of adjustments to the dentures. They must be convinced that the dentist is the only person qualified to undertake this most important aspect of denture service. Obviously, patients should never attempt to adjust the dentures themselves.

Patients should be informed that dentures must be left out of the mouth at night to provide needed rest from the stresses they create on the residual ridges. Failure to allow the tissues of the basal seat to rest may be a contributing factor in the development of serious oral lesions, such as inflammatory papillary hyperplasia, or it may increase the opportunity for microbial infections, such as candidiasis. When dentures are left out of the mouth, they should be placed in a container filled with water to prevent drying and possible dimensional changes of the denture base material. Residual ridges can be damaged by the use of denture adhesives and particularly home reliners, to compensate for ill-fitting dentures. Patients should therefore be cautioned about this. If these materials are used, patients soon feel insecure without them. Adhesives, and especially home reliners, can modify the position of the denture on the residual ridge that can result in a change of both vertical relations and CRs or a change in occlusal contacts, which may cause irreparable damage to the residual ridges in a short time. The special instructions must include directions for continued periodic oral examinations for all edentulous patients. The tissues supporting dentures change with time, and the rate of change depends on both local and general factors. Good dentures eventually become ill fitting and can damage the mouth without the patient's being aware that anything is wrong. Pathosis, which may or may not be associated with the dentures, can develop in the edentulous oral cavity. All edentulous patients should be examined by a dentist at least once a year, and their names should be placed on a recall list for that purpose.

EDUCATIONAL MATERIAL FOR PATIENTS

Because the education of patients is so critical to the success of new dentures, many dentists provide written instructions or other formal educational material that has been developed. In studying the material, patients become aware that dentures are not permanent, that the mouth changes, and most important, that the care they provide themselves may be a deciding factor in the success they experience with dentures. People remember less of what they hear than of what they see. For this reason, it is highly recommended to provide denture-wearing patients with printed information about their new teeth, about the care and cleaning of the teeth, about their use, and most important, about the periodic inspections that will be necessary.

FOLLOW-UP APPOINTMENTS

The complete denture service cannot be adequate unless patients are cared for after the dentures are placed in the mouth. In many instances, the most crucial time in the patient's perception of success or failure of dentures is the adjustment period. The dentist is responsible for the care of the patient throughout this period, and this occasionally requires a number of follow-up appointments. The complete cooperation of the patient during the adjustment period is essential. In educating patients, the dentist must explain to them the problems that they are likely to face during the adjustment phase and the procedures that both the patient and the dentist must follow to alleviate these problems. It is important that the dentist and the patient have a clear understanding as to the financial implications of the adjustment period, which reflects the dentist practice management protocol.

TWENTY-FOUR-HOUR ORAL EXAMINATION AND TREATMENT

An appointment for a 1- to 3-day adjustment should be made routinely. Patients who do not receive this attention have more trouble than those who are cared for the first several days after the insertion of the new dentures. This is the critical period in the denture-wearing experience of the patient. When the patient returns for the first adjustment, the dentist can ask, "How are you getting along with the sore mouth?" This invites patients to describe their experiences and soreness, if any. The dentist must listen carefully to the patient and on the basis of these comments can learn approximately where to look for trouble. The statements also may furnish valuable information about esthetic, functional, and mental attitude problems that may be developing.

EXAMINATION PROCEDURES

The occlusion should be observed before the dentures are removed from the mouth. To do this, the mandible is guided into CR by stabilizing the mandibular denture with the index fingers on the buccal flanges and the thumbs under the mandible. The patient is instructed to retrude and elevate the tongue to touch the roof of the mouth in the back during closure. Some gentle manual guidance on the patient can be applied simultaneously in a hinge movement. Direct the patient to *"open and close your 'lower jaw' until you feel the first feather touch of your back teeth."* At the first contact, the patient is directed to open and repeat this closure, *"only this time stop the instant you feel a tooth touch and then close tight."* If the teeth touch and slide, there is an error in centric occlusion (CO). When such an error is detected, the dentures are placed on their remount casts on the articulator, and the occlusion is rechecked there. If the same error is found on the articulator, it requires occlusal adjustment. If there is an error in the mouth and none is found on the articulator, new interocclusal records must be made. The mandibular remount cast is removed from the articulator and remounted with the new CR record to correct the occlusion error.

After the occlusion has been tested and corrected (if necessary), ask the patient where the worst soreness is and a thorough visual and digital examination of the oral cavity follows so the location of sore spots can be determined. The examination begins with the mucosa of the maxillary buccal vestibule and proceeds around through the labial and the buccal vestibules on the other side of the mouth, with careful observation of the frena. The hamular notches and the hard and soft palates are examined for signs of abrasion. The area of the coronoid process is palpated, and the patient is asked if there is any tenderness in this region.

The mandibular dental arch and associated dental structures are systematically examined both visually and digitally. The tissues lining the vestibular spaces and the alveololingual sulci, particularly the mylohyoid ridges and the retromylohyoid spaces, are observed carefully. The sides of the tongue and the mucosal lining of the cheeks also must be inspected.

ADJUSTMENTS RELATED TO THE OCCLUSION

A number of problems can result from errors in the occlusion. Soreness may develop on the crest of the residual ridge from pressures created by heavy contacts of opposing teeth in the same region. Soreness also may be seen on the slopes of the residual ridge as a result of shifting of the denture bases from deflective occlusal contacts. Before unnecessarily shortening or excessively relieving the denture base, the dentist must observe the occlusion carefully in the mouth and on the articulator, giving particular attention to the possibility of heavy balancing-side contacts that could cause rotation of the mandibular denture base. Such occlusion errors are almost impossible to locate in the mouth because of movement of the denture bases on the supporting soft tissues. Clinical remount and occlusal equilibration may be needed to correct such occlusal errors during the follow-up visits.

Small lesions on the buccal mucosa of the cheek in line with the occlusal plane indicate that the patient is biting the cheek during mastication. This problem usually can be corrected by reducing the buccal surface of the offending mandibular tooth to create additional horizontal overlap, thus providing an escape for the buccal mucosa.

A patient may complain, "My dentures are tight when I first put them in my mouth, but they seem to loosen after several hours." This symptom usually is an indication of errors in the occlusion that can be corrected after new interocclusal records are made, the dentures are remounted, and the occlusion is adjusted on the articulator. The dentures become loose because the deflective occlusal contacts cause a continual shifting of the denture base, which in turn causes distortion of the tissues in the basal seat. Although this problem may develop by the time of the 1- to 3-day adjustment, it is more likely to be seen a little later on.

ADJUSTMENTS RELATED TO THE DENTURE BASES

A number of problems with new dentures are related to the denture bases themselves. Irritation to the vestibular mucosa is most often caused by denture borders that are too sharp or denture flanges that are overextended. This is often seen at the hamular notch area, along the mandibular retromylohyoid area, mandibular buccal area, and prominent anterior frena. Before any adjustments are made, a heavy coating of PIP or disclosing wax in the offending area, with border molding, will determine if the problem is overextension or contact pressure along the bone at the flange extension. Lesions in the region of the hamular notch must be considered carefully. If the irritated tissue is posterior to the notch, the denture base is too long and must be shortened. However, if the soreness is in the notch itself, the posterior palatal seal is likely creating too much pressure, and the inside of the tissue surface of the denture base will need to be relieved very cautiously so as not to loosen the border seal. Use the following three steps to evaluate this area with PIP: (1) one notch with adjustment, (2) the other notch with adjustment, and then (3) the posterior border length and posterior palatal seal on the denture surface with adjustment. The use of these steps will minimize making an error in reading the PIP and overreducing the seal (Fig. 12-24). The remainder of denture borders are shortened and rechecked with paste again. Finally they can be polished with pumice and a rag wheel. Irritated frena and disclosing wax showing pressure in the notches will require that the notches be deepened slightly (Fig. 12-25). Widening of the notch may not be necessary and, if done to excess, could reduce denture

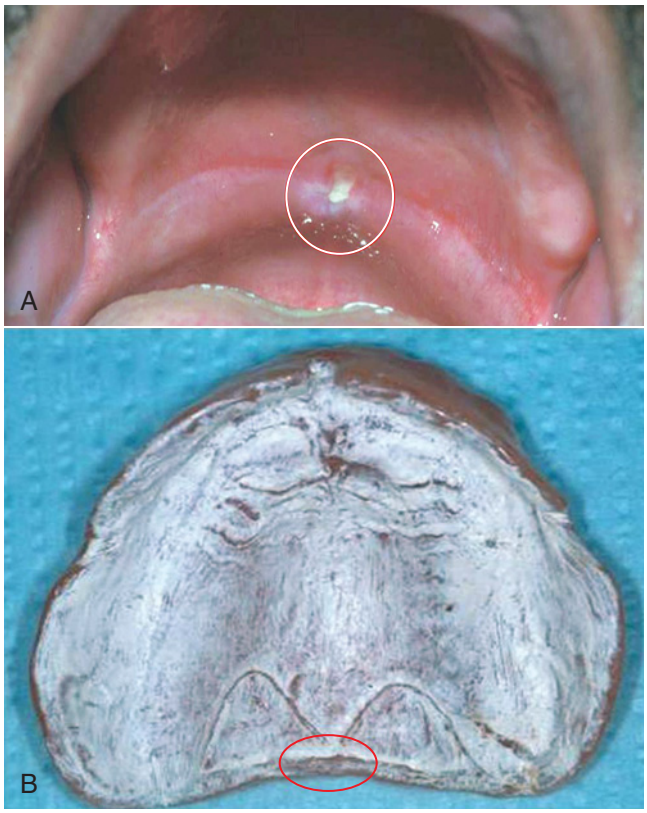


Figure 12-24 **A,** Note the ulceration at the midline of the posterior palatal seal area. **B,** The PIP pattern reveals the bead is too deep and too sharp.

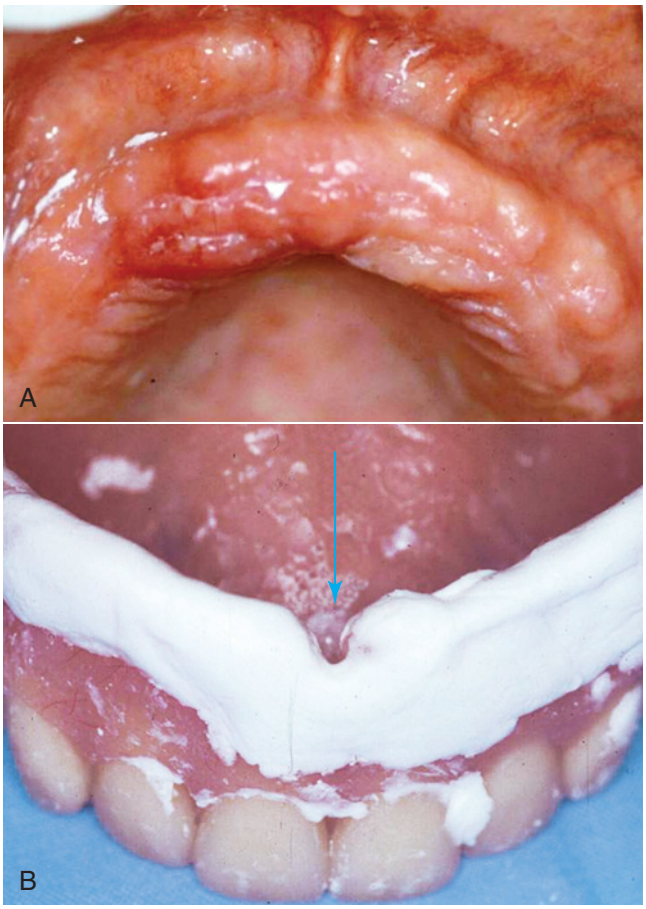


Figure 12-25 **A,** The anterior maxillary frenum is the most common frenum to become irritated from overextended denture. **B,** The disclosing wax pattern reveals the overextension area.

retention. The notch is deepened with a fissure bur and polished with a stone or small wheel. PIP should be used to evaluate pressure areas on the basal surface, regardless of whether sores or ulcerations are evident. It should be applied and read in the same way as described during the insertion phase. When pressure areas are found, they need to be adjusted and the entire denture disclosed again. It will be common that additional pressure areas will present and need relieving. Finally the contact will be uniform throughout the denture. An indelible marking pencil placed on the ulcerative tissue as a pressure transfer should never be used as the only means of tissue recall evaluation. Only focusing on the acute problem will likely move the pressure to another area of the denture, causing another acute ulcer to be dealt with a few days later. Skilled practitioners may use a combination of paste and markers, but the student who watches the faculty use the indelible pencil may incorrectly assume it is the faster and easier diagnostic tool of choice. Students should be encouraged to learn to "read" the subtle but very diagnostic signs derived from correctly manipulated pressure paste (Fig. 12-26).

Excessive pressure from the mandibular buccal flange in the region of the mental foramen may cause a tingling or numbing sensation at the corner of the mouth or in the lower lip. This results from impingement on the mental nerve and occurs particularly when excess resorption has caused the mental foramen to be located near the crest of the mandibular residual ridge (Fig. 12-27). A similar situation can occur in the maxillae from pressure on the incisive papilla transmitted to the nasopalatine nerve. The patient may complain of burning or numbness in the anterior part of the maxillae. Relief may be required in the maxillary denture base in this region.

Patients may return for the initial adjustment appointment complaining that their dentures cause them to gag. This problem may actually be related to the dentures themselves, or there may be a psychological component. When the problem is denture related, usually the maxillary denture is the culprit, although on occasion the mandibular denture or both will be involved. Most often, the gagging relates to the posterior border of the maxillary denture. The border may be improperly extended, or the posterior border seal may be inadequate. Gagging often occurs when the posterior border seal is disrupted as the tissue distal to the vibrating line moves upward and downward during function. When the vibrating line has been properly located, it is not necessary (and usually not desirable) to extend the posterior border of the maxillary denture more than 2 mm beyond

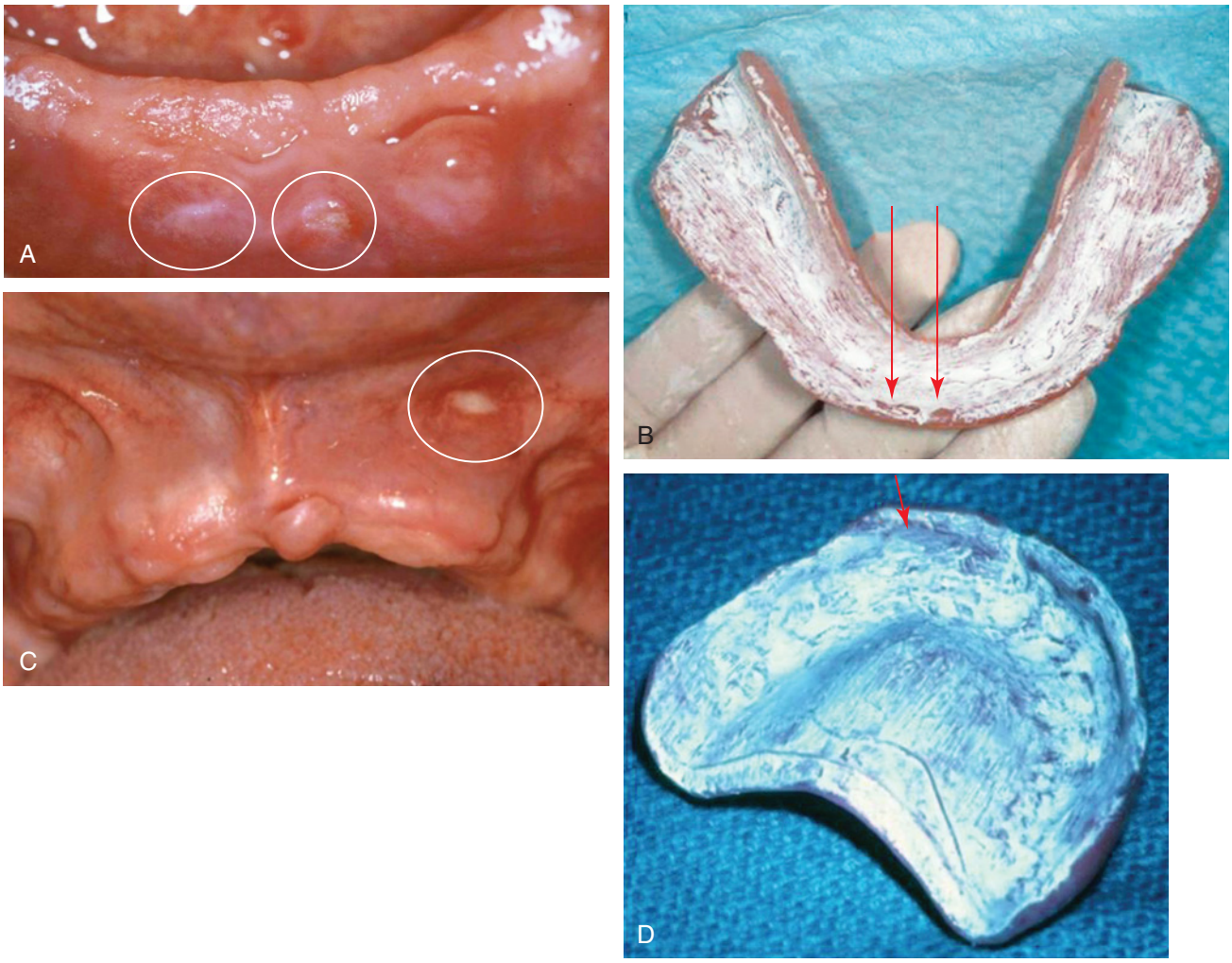


Figure 12-26 **A,** Note the lesions associated with the anterior mandibular denture border. **B,** They correspond to the pressure-indicating paste pattern *(arrows)*. **C,** Note the irritation associated with the denture border overlying the canine eminence. **D,** The pressure spot *(arrow)* shown by the pressure-indicating paste will be relieved and adjusted.

this point. If the posterior palatal seal is inadequate, modeling compound can be added to reshape this part of the maxillary denture and help alleviate the situation. Then the modeling compound can be replaced with acrylic resin. The occlusion may also be a factor because shifting of the denture bases affects the posterior palatal seal.

On occasion, patients will state that the maxillary denture comes loose when they open their mouth wide to bite into a sandwich or to yawn. Generally, this complaint indicates that the distobuccal flange of the maxillary denture is too thick and interferes with normal movements of the coronoid process (Fig. 12-28). The borders of the maxillary buccal flanges should properly fill the buccal vestibule. However, the distal corners of the denture base below the borders must be thin to allow the freedom necessary for movement of the coronoid process.

Again, in discussions with patients, it may be revealed that the maxillary denture tends to loosen during smiling or other forms of facial expression. Excessive thickness or height of the flange of the maxillary denture in the region of the buccal notch or distal to the notch may cause this problem (Fig. 12-29). As the buccal frenum moves posteriorly during function, it encroaches on a border that is too thick, and the denture becomes loosened. Reduction of the width of the border posterior to the maxillary buccal notch often will relieve this problem.

SUBSEQUENT ORAL EXAMINATIONS AND TREATMENTS

Dentures require inspection and sometimes further adjustment after they have been used by the patient. During the first several weeks, the acrylic resin absorbs water. This can result in small changes in the size and shape of the dentures. Even though the alterations are small, they may be sufficient

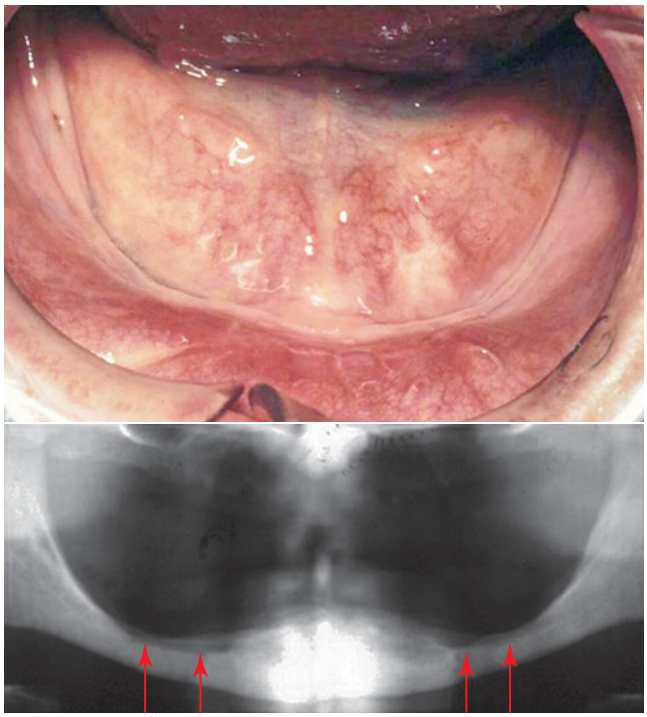


Figure 12-27 In patients with severe resorption of the alveolar ridge, a portion of the inferior alveolar nerve may be exposed *(arrows)*. Pressure in these areas may cause significant pain.

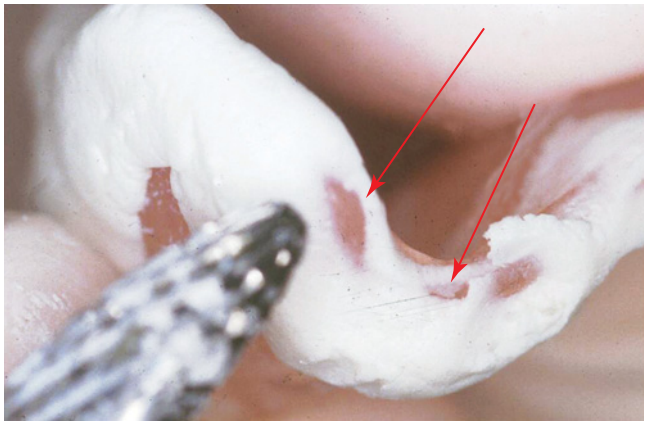


Figure 12-28 The distobuccal flange of the maxillary denture is too thick below the border *(arrows)*. Using disclosing wax along the border periphery and the thickness of the flange reveals the overextended areas.

to change the occlusion. Minute changes in the occlusion can create discomfort by making the dentures shift or slide in function. Soreness reported by patients in this situation is most likely on the lingual side of the mandibular ridge in the region of the canine and first premolar and is most likely due to deflective occlusal contact between the last molar teeth diagonally across the mouth, often between the balancing inclines of the mandibular second molars.

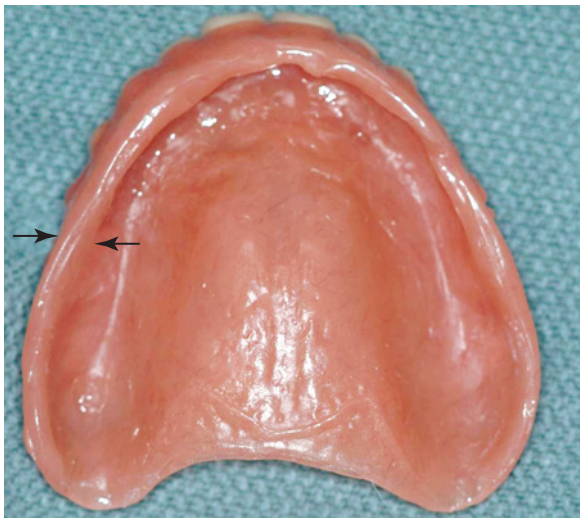


Figure 12-29 Notice the left buccal border in the region of the buccal notch *(arrows)*. The buccal frenum, moving posteriorly over this border during facial expression, can loosen the maxillary denture. This area can be discerned from patient's complaint and checking with disclosing wax.

In most instances, the occlusal error can be observed and corrected by placement of the dentures in their original remount casts on the articulator. If, however, the bases have changed and no longer fit onto the remount casts the way they did originally, it will be necessary to make new remount casts and new interocclusal records. The facebow remount jig record can be reused to remount the maxillary denture without making a new facebow transfer record.

After the new records are made, the occlusion is corrected by selective grinding with the same procedure as was used at the time of the dentures' insertion. It may be noted that the occlusal changes will likely be small, but the soreness they produce is very real and disturbing. Dentists should not succumb to the temptation to grind from the denture base without determining the real cause of the trouble.

Sometimes generalized irritation or soreness of the basal seat will develop. Although this condition may be attributable to a number of factors (such as an excessive VDO, nutritional or hormonal problems, or unhygienic dentures), it is more likely due to the occlusion. As indicated previously, errors in occlusion should be suspected whenever a patient states that the dentures are "tight when I first put them in my mouth in the morning but seem to loosen later in the day." A collection of calculus on the teeth on one side of the denture also indicates the need for correcting the occlusion.

Certain symptoms at an adjustment appointment suggest excessive VDO. The patient may comment, "After I've worn the new dentures for several hours, my gums get sore and the muscles in the lower part of my face seem tired." On removal of the dentures, the mucosa of the basal seat often will exhibit a generalized irritation. These symptoms

indicate that when the patient's mandible is in the resting position, there is not sufficient space between the opposing teeth to allow the supporting structures of the residual ridge and the involved muscles to rest normally. If this is true, several options exist. Sometimes creating a small amount of additional interocclusal distance will solve the problem, and the dentist can do this by returning the dentures to the articulator and grinding the denture teeth to reduce the VDO; esthetics and the amount of clearance between the anterior teeth are the limiting factors in this procedure, and another 1 to 1.5 mm of interocclusal distance can thus be created. Other times it may be necessary to reset the artificial teeth of one or both dentures; the decision as to which teeth should be moved is based on esthetics and the VDO. Finally, in some instances, the dentures will have to be remade.

PERIODIC RECALL FOR ORAL EXAMINATION

When patients are judged to be successfully treated and the necessary adjustment appointments after denture insertion are completed, patients are instructed to call for an appointment if they have any problems. Patients with some of the more difficult problems should be scheduled for appointments periodically, perhaps at 3- to 4-month intervals. This will help their morale and may tend to eliminate their seeking adjustment appointments on a weekly basis or even more often.

Every denture-wearing patient should be in a recall program, just as any other dental patient is. The dentist should not hesitate to inform a patient that occlusal corrections, relining, new dentures, or other fairly involved procedures may be necessary as changes in the mouth continue to occur. A 12-month interval is the suggested time between recall appointments for most patients with complete dentures.

Bibliography

Basso MF, Nogueira SS, Arioli-Filho JN: Comparison of the occlusal vertical dimension after processing complete dentures made with lingualized balanced occlusion and conventional balanced occlusion, *J Prosthet Dent* 96(3):200-204, 2006.

Chai J, Takahashi Y, Takahashi T, et al: Bonding durability of conventional resinous denture teeth and highly crosslinked denture teeth to a pour-type denture base resin, *Int J Prosthodont* 13(2):112-116, 2000.

Chung KH, Chung CY, Chung CY, et al: Effect of preprocessing surface treatments of acrylic teeth on bonding to the denture base, *J Oral Rehabil* 35(4):268-275, 2008.

Felton DA: The ACP's evidence-based guidelines for the care and maintenance of complete dentures, *J Prosthodont* (8):591, 2010.

Ganzarolli SM, de Mello JA, Shinkai RS, et al: Internal adaptation and some physical properties of methacrylate-based denture base resins polymerized by different techniques, *J Biomed Mater Res B Appl Biomater* 82(1):169-173, 2007.

Kimoto S, Kobayashi N, Kobayashi K, et al: Effect of bench cooling on the dimensional accuracy of heat-cured acrylic denture base material, *J Dent* 33(1):57-63, 2005.

Lung CY, Darvell BW: Minimization of the inevitable residual monomer in denture base acrylic, *Dent Mater* 21(12):1119-1128, 2005. Epub Jul 22, 2005.

Polychronakis N, Yannikakis S, Zissis A: A clinical 5-year longitudinal study on the dimensional changes of complete maxillary dentures, *Int J Prosthodont* 16(1): 78-81, 2003.

Pronych GJ, Sutow EJ, Sykora O: Dimensional stability and dehydration of a thermoplastic polycarbonate-based and two PMMA-based denture resins, *J Oral Rehabil* 30(12):1157-1161, 2003.

Rizzatti-Barbosa CM, Ribeiro-Dasilva MC: Influence of double flask investing and microwave heating on the superficial porosity, surface roughness, and knoop hardness of acrylic resin, *J Prosthodont* 18(6):503-506, 2009. Epub Apr 21, 2009.

Schneider RL, Curtis ER, Clancy JM: Tensile bond strength of acrylic resin denture teeth to a microwave- or heat-processed denture base, *J Prosthet Dent* 88(2): 145-150, 2002.

Shigli K, Angadi GS, Hegde P: The effect of remount procedures on patient comfort for complete denture treatment, *J Prosthet Dent* 99(1):66-72, 2008.

Takahashi Y, Chai J, Takahashi T, et al: Bond strength of denture teeth to denture base resins, *Int J Prosthodont* 13(1):59-65, 2000.

CHAPTER 13

Modified Protocols for Immediate Dentures, Overdentures, and Single Dentures

Steven E. Eckert

The goal of this chapter is to expand on the content of Chapter 6 and emphasize the importance of defined clinical protocols.

IMMEDIATE DENTURES

When discussing immediate dentures it is prudent to understand that the term is not universally understood or applied. Some may consider an immediate denture as a prosthesis placed immediately following tooth extraction only to be readapted at some point in the future and used as a definitive restoration. Others may consider an interim or immediate denture as one that will be discarded after a period of time. The latter perception of this prosthesis implies a transitional prosthesis that is used to enhance esthetics, protect the extraction-related surgical wound, and provide function during healing without anticipation that such a prosthesis will serve as a "permanent" prosthesis. This type of transitional denture is often associated with a larger number of teeth being extracted on the day of prosthesis insertion and a higher degree of unpredictability relative to anticipated healing—hence the reasons for anticipation of the denture being discarded after a period of time. The primary purpose of this section is to describe an immediate denture that will ultimately be transitioned into a definitive prosthesis.

Patient assessment must be the first step when treatment is anticipated. The periodontal status, caries rate, and current state of edentulism must be considered, as should the patient's level of dedication to his or her dentition and willingness to perform the oral hygiene procedures necessary to maintain the dentition should retention of some teeth for an extended period of time be considered.

Initial treatment may well consist of the debridement of the existing teeth with an initial prophylaxis followed by oral hygiene instructions that may include the use of antibacterial rinses. Before initiation of definitive therapy, it is essential that the patient demonstrate a high level of compliance with oral hygiene measures. The health of the remaining dentition must be assessed and the strategic nature of salvageable teeth also should be considered. Although it is a dental axiom that dentists preserve teeth, there are instances where the retention of strategically malpositioned teeth could result in adverse force transmission to the underlying structures, thereby resulting in greater functional and anatomical deficit.

The opposing dentition also must be evaluated when an immediate denture is being considered. Because the long-term performance of the denture is highly dependent on the quality of the occlusion that is established, it is imperative that clinicians evaluate any irregularities in the occlusal plane and that these be addressed before the initiation of definitive treatment.

In some instances it may be prudent, even if the teeth could be amenable to aggressive periodontal therapy or caries control, to consider removal of teeth when the patient demonstrates little willingness to perform routine home-care. The decision to remove teeth should not be taken lightly and the patient deserves every opportunity to demonstrate an ability to maintain teeth. It must be considered, however, that maintenance of teeth in a diseased tissue bed could lead to adverse health consequences. Consequently the dentist carries the responsibility of making critical health care recommendations to the patient.

Once a decision is made to render a patient edentulous, it is important for the clinician to consider the impact on the patient both physically and emotionally. Transitioning from a natural dentition to a complete denture could prove to be a psychologically devastating experience for some patients. In many instances, the removal of posterior teeth with the retention of anterior teeth to allow healing in the extraction sites may be better tolerated by the patient than would be the case if an entire arch of teeth were to be removed. These are the situations where immediate dentures may be most applicable.

It is understood that the residual ridge resorption following tooth extraction progresses at a more rapid rate in the mandible than it does in the maxilla. Coupled with the

fact that the maxillary denture gains support from the hard palate, it appears that the fabrication of immediate dentures in the maxilla would be a more predictable procedure then is the fabrication of an immediate denture in the mandibular arch. This is not to say that immediate dentures should never be fabricated in the mandible, but it does suggest that a mandibular immediate denture could be considered as a higher risk procedure. For this reason the clinician may consider an immediate prosthesis in the mandible as a transitional prosthesis rather than a definitive one.

Identification of the strategically positioned teeth becomes a critical issue. In some instances the posterior teeth may provide a better short-term prognosis for retention of a transitional removable partial denture, but the removal of the posterior teeth demands a longer healing and remodeling time than does the removal of the single-rooted anterior teeth. In general, it is wise, when an immediate denture is being considered, to remove the posterior teeth, leaving the six anterior teeth in position, and to allow an adequate healing period of 8 to 12 weeks before the final impressions are made for the definitive prostheses.

PRELIMINARY IMPRESSIONS

Preliminary impressions are made for two primary reasons. The first is to use these impressions in the fabrication of casts that will then be used in diagnosis and treatment planning. It is not unusual, when evaluating diagnostic casts, to identify irregularities in the opposing arch that could create occlusal instability when the immediate denture is made. Likewise the diagnostic casts may assist the clinician in the evaluation of bone or soft tissue undercuts and unfavorable frenum attachments. Definitive treatment planning cannot be considered until all diagnostic aids are evaluated (Fig. 13-1).

The second purpose for the preliminary impression is creation of a cast that can then be used in the fabrication of a custom impression tray or trays. Regardless of the technique, the clinician will identify a peripheral extension to which the custom tray should extend. Then a custom tray is fabricated with an appropriate amount of space between the natural teeth and the impression tray. This relief is easily controlled by the application of a specified thickness of wax (generally 1 to 3 mm) that is adapted to the soft and hard tissues of the diagnostic cast.

FINAL IMPRESSION

Two fundamental techniques have been described to make final impressions for an immediate denture. The prudent clinician will understand both techniques and appreciate the situations in which each technique is preferred. The two techniques consist of using either a single impression tray that captures the natural dentition and the soft tissues simultaneously or creating an impression that uses a tray to capture the posterior soft tissue while a second tray is adapted to the first in an effort to capture the anterior teeth in the secondary impression.

A single impression tray may be used when anterior and/or posterior teeth remain (Fig. 13-2). This technique is most useful when the teeth maintain positional stability and would not be displaced by the impression. On the contrary, if the soft tissue is compressible, the single tray approach may provide an opportunity to impress this tissue while at rest, using the remaining natural teeth to act as a tray stop when inserting the impression tray. This technique may require border molding in the edentulous areas to establish the full peripheral extension. The flange in the dentate areas should be extended with border molding material toward the tissue reflection, but tissue undercuts may prevent the border molding material from establishing full contact with vestibular tissue. Once border molding is established, the final impression is made using an elastomeric impression material.

An alternative impression technique would be to use an impression tray in the posterior portion of the oral cavity to impress the soft tissue only (Fig. 13-3). This tray would then be indexed in such a way that it would connect to an anterior tray that would capture the likeness of the anterior teeth at rest. This approach is particularly effective when the anterior teeth are quite mobile and if the position of these teeth would be difficult to capture in a single impression technique. The difficulty with this technique is experienced when the indexing of the anterior and posterior segments is accomplished. After border molding the posterior impression tray, an elastomeric material is used to capture the tissues at rest. If no undercuts exist in the soft or the hard tissue, these tissues could be recorded with the dentist's preferred material, such as zinc oxide eugenol impression material. The anterior segment is recorded with an elastomeric impression material.

As mentioned previously, the greatest risk with the two-tray technique is found at the time when the two segments are joined. The more stable the indexing of the anterior and posterior components, the better this technique will perform. To accomplish this, the anterior impression tray may be extended in such a way as to capture a large segment of the posterior tray. Likewise it may be possible to create very specific irregularities on the occlusal surface of the posterior tray that would then be captured in the anterior portion of the tray.

POSTERIOR PALATAL SEAL

Regardless of the impression technique, the posterior limit of the maxillary complete denture must be established. The technique for doing so is identical to that used in complete dentures. Although a variety of techniques exist, with an immediate denture it may be most prudent to determine the position of the vibrating line and use this position as a guide to empirically relieve the master cast to create a posterior palatal seal.

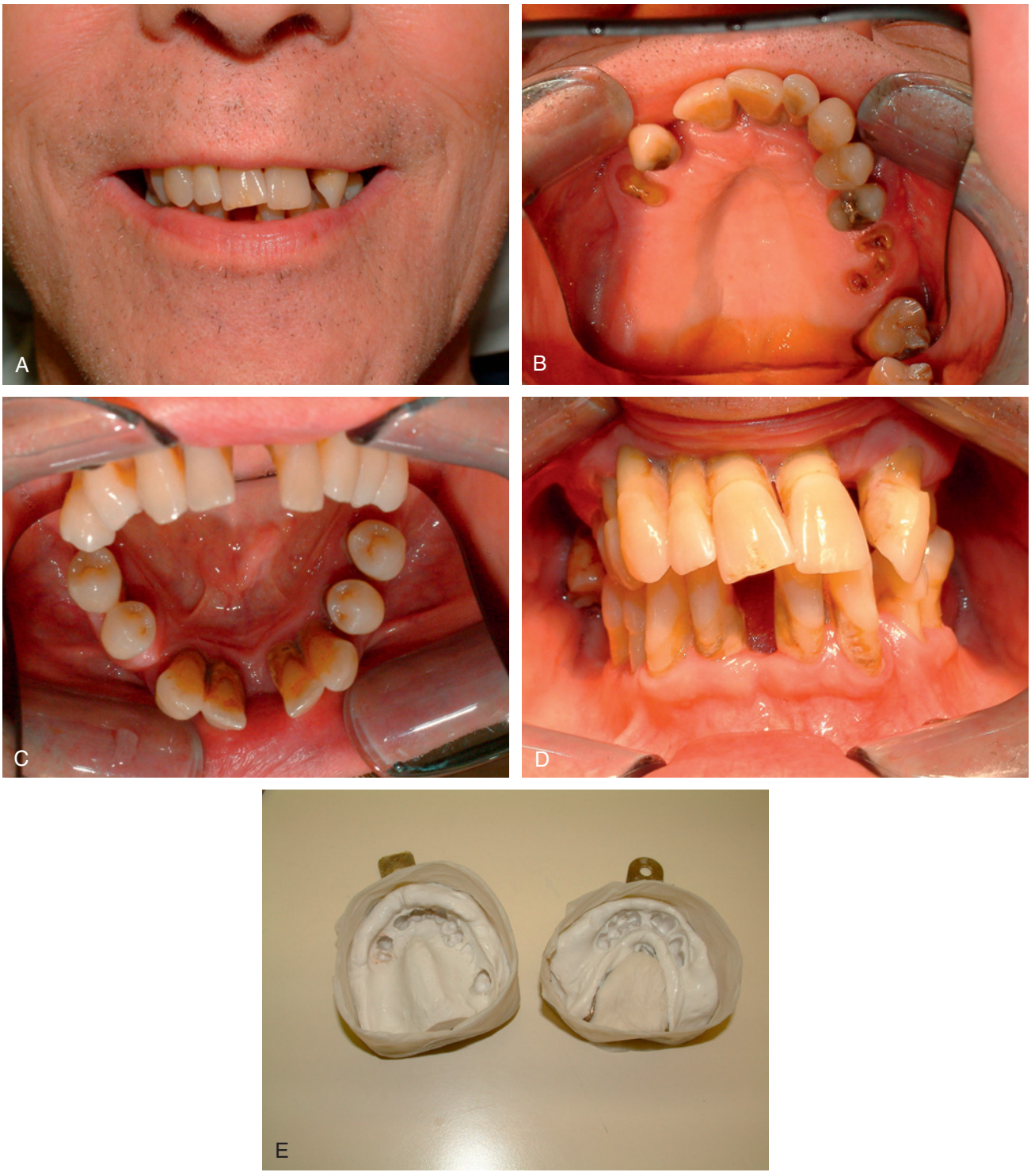


Figure 13-1 **A,** Smile showing uncomfortable, loose, extruded, drifted teeth with midline shift. **B,** Maxillary mirror image. Note fovea palatinae. **C,** Mandibular view mirror image. Excess calculus. **D,** Retracted view of occlusion. Upper teeth ready to fall out. **E,** Soft regular set alginate final impressions. All teeth are too loose for anything else.

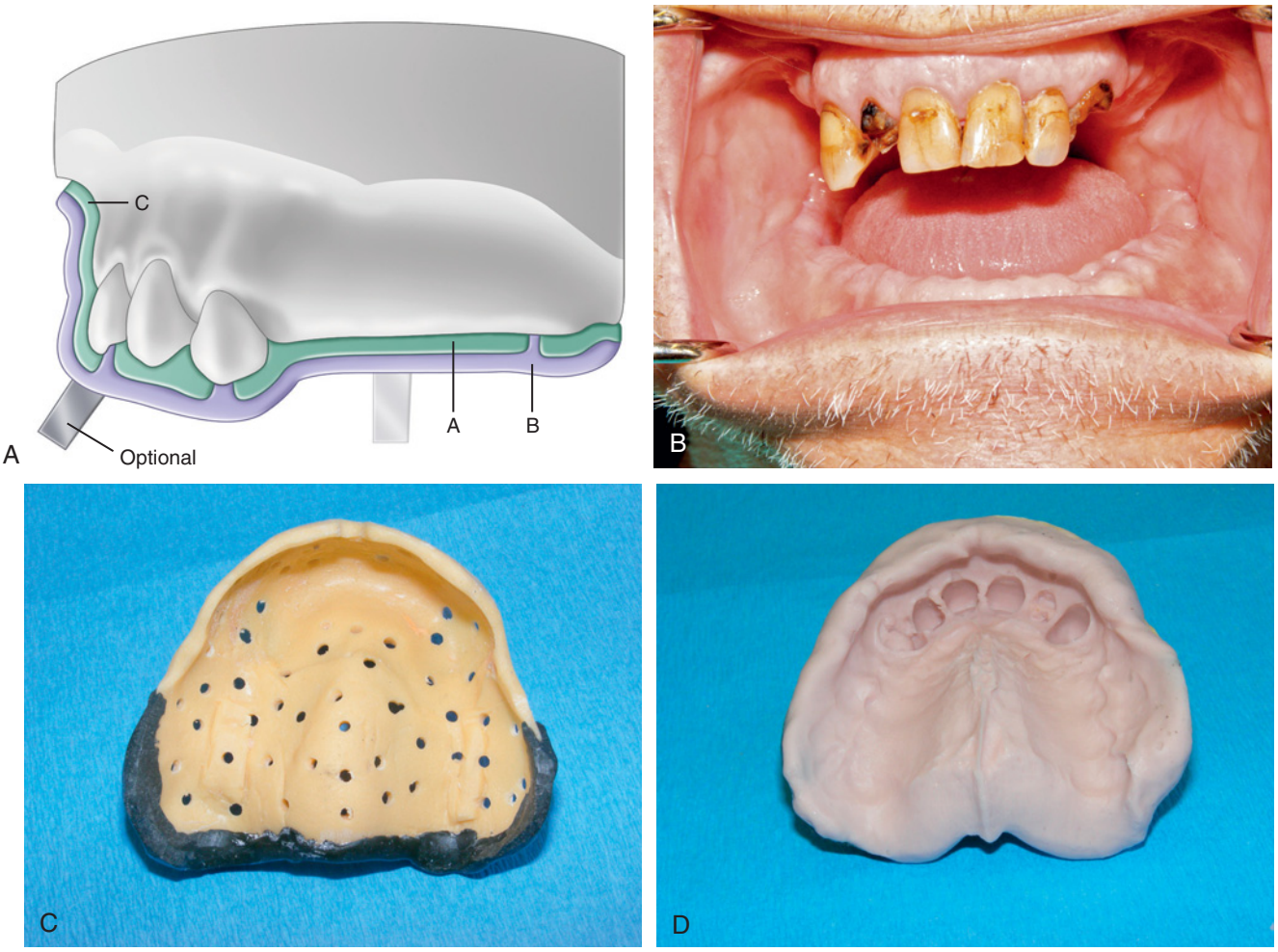


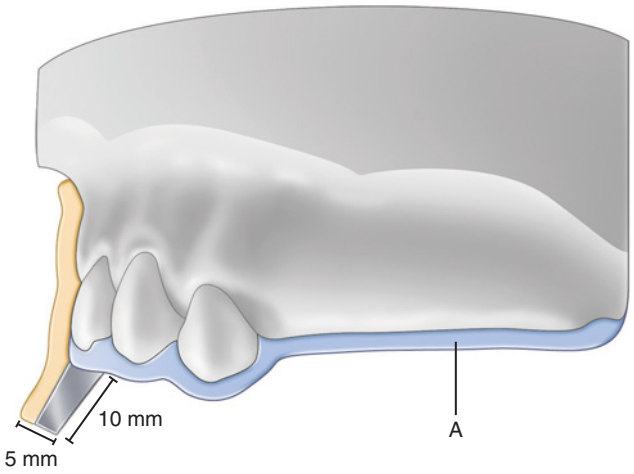
Figure 13-2 **A,** Wax relief and design for custom one tray immediate denture impression. **B,** Maxillary anterior teeth are nonsalvageable. Ready for immediate denture impression. **C,** Immediate denture custom tray perforated and posterior palatal seal enhanced. **D,** Alginate in custom tray impression for immediate denture.

MAXILLOMANDIBULAR RELATIONSHIP RECORDS

Denture tooth selection has classically been described as an effort to duplicate the natural dentition. Current emphasis on cosmetic dentistry may alter this approach in that patients need to be consulted regarding the shape, size, and shade of the prosthetic teeth that are selected for them. The historical approach of mimicking nature may not apply today because patient preference may dictate a different approach. There are factors, however, that do influence the selection, such as the occlusal anatomy of the posterior teeth and the size and shape of the posterior teeth, particularly as the length of the maxillary and mandibular teeth need to be coordinated. Careful assessment of the dentition in the opposing arch must be made, and any alterations in its form, so as to establish a more favorable occlusion, need to be captured with new impressions of the opposing dental arch.

Careful assessment needs to be made of the occlusal vertical dimension. Because many patients require removal of their remaining teeth because they have experienced advanced periodontal bone loss, it is not uncommon for these patients to experience a reduction in their vertical dimension of occlusion (VDO). Clinicians are encouraged to use multiple methods (as described in Chapter 9) such as evaluation of rest position, tactile sensitivity, and phonetics to establish the proper VDO.

The centric relation record is made directly at the established vertical dimension using the clinician's material of choice (Fig. 13-4). These materials could consist of bite registration wax, plaster or zinc oxide, and eugenol. Elastomeric "bite" registration materials may be less desirable because the materials could flex or spring back when the



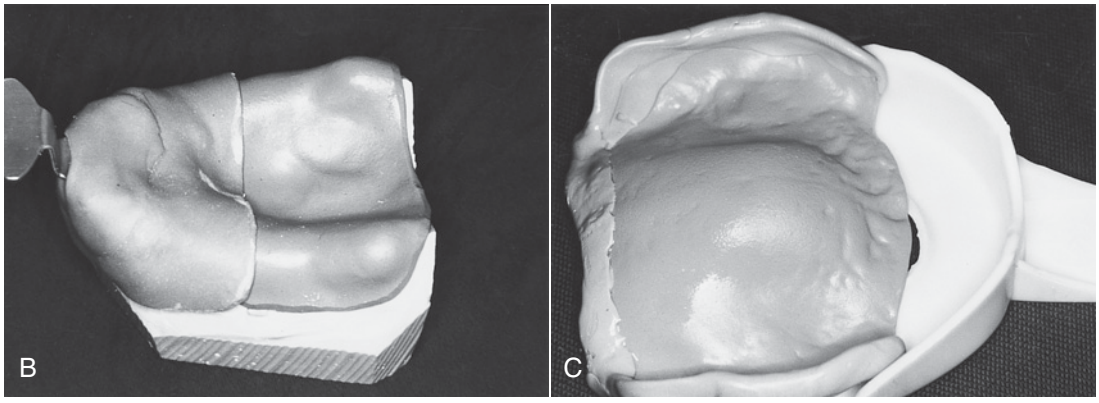




Figure 13-3 **A,** Diagram of the sectional or two-tray impression method. **B** and **C,** Posterior tray for mucosal impression picked up by anterior tray for teeth. **D,** Posterior mucosal border molded impression.

Continued

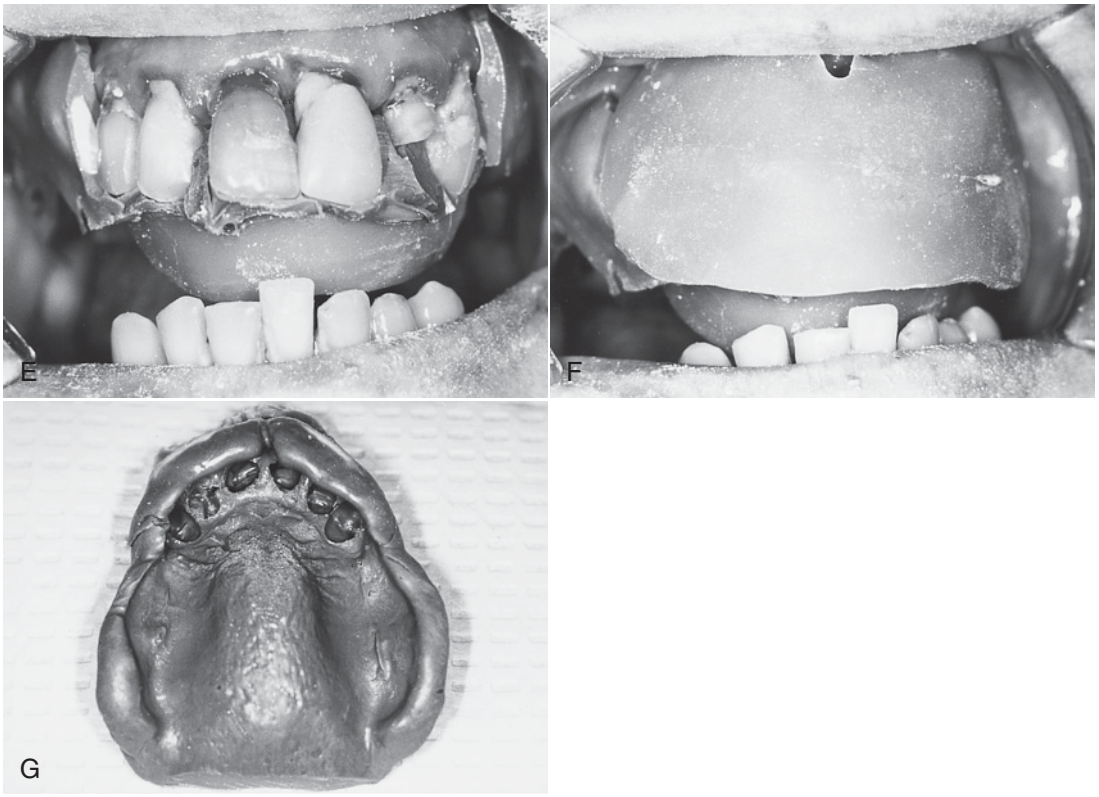


Figure 13-3, cont'd **E,** Make sure the posterior impression is accurately replaced in mouth and then covered by anterior sectional tray for teeth. **F,** Anterior of two trays records anterior anatomy and indexes the posterior impression tray. **G,** Two trays removed together to make one immediate denture impression.

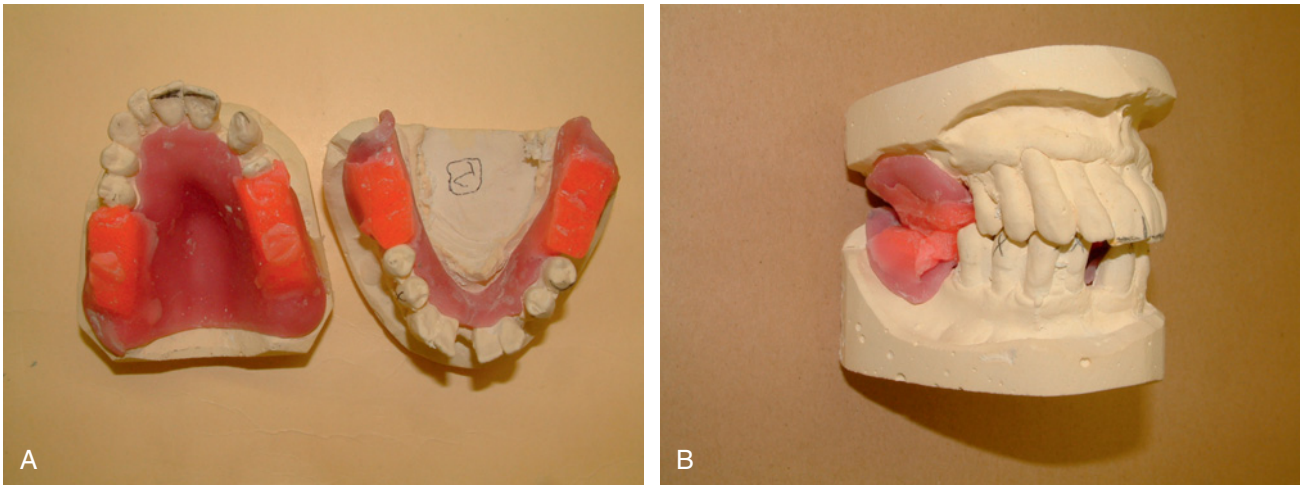


Figure 13-4 **A,** Registration tripod of posterior wax cones in notches and anterior tooth contact. **B,** Ready for mounting. Pencil notations of midline, incisal reduction and extractions planned.

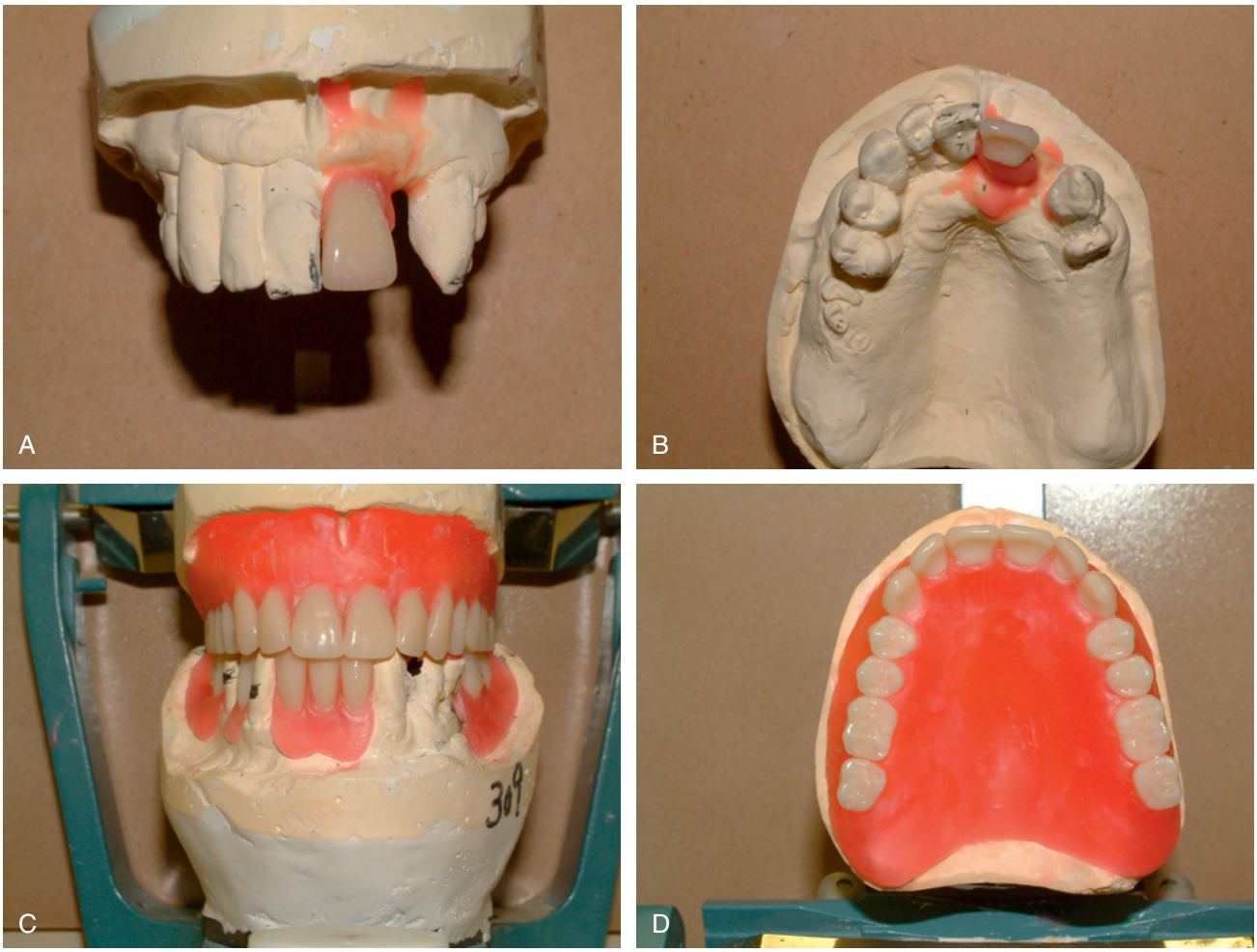


Figure 13-5 **A,** The critical consult. Patient and spouse view one tooth setup and agree to midline shift. **B,** Labial drift and midline improved and agreed. **C,** Second viewing. Agree on full wax-up, clasps, enamelplasty. **D,** Second viewing. Confirm acceptance of palatal coverage and arch form.

casts are mounted on the articulator with or without a facebow transfer.

DENTURE TEETH ARRANGEMENT

Denture teeth are arranged using traditional methods. The exception to this would occur when a single denture is fabricated. These special circumstances are described later in this chapter. The clinician is advised to carefully assess the patient's facial midline and to establish the midline of the immediate denture in that same position and orientation (Fig. 13-5).

Likewise any discrepancies in the occlusal plane between what is seen in the mounted casts and the patient presentation should be clearly identified as corrections may be possible.

The posterior teeth may then be used in a clinical trial of the wax trial denture to ensure that the appropriate vertical dimension and centric occlusion positions have been established. Once again phonetics and facial support will all be considered when confirming the vertical and horizontal positions.

LABORATORY PROCEDURES

The immediate denture differs from the traditional denture in that the cast must be modified to represent the anticipated changes in contour that will occur with surgical removal of teeth. If the dental midline and the facial midline are not coincidental, it is imperative that the facial midline be established by removing the central incisor that is most closely approximated to the facial midline as the preliminary step in cast modification. The midline has been marked in pencil on the cast. The posterior teeth will already have been arranged; consequently, the remaining teeth may be removed from the stone cast and the cast adjusted to simulate the soft and hard tissue contours that would be anticipated following removal of teeth (Fig. 13-6).

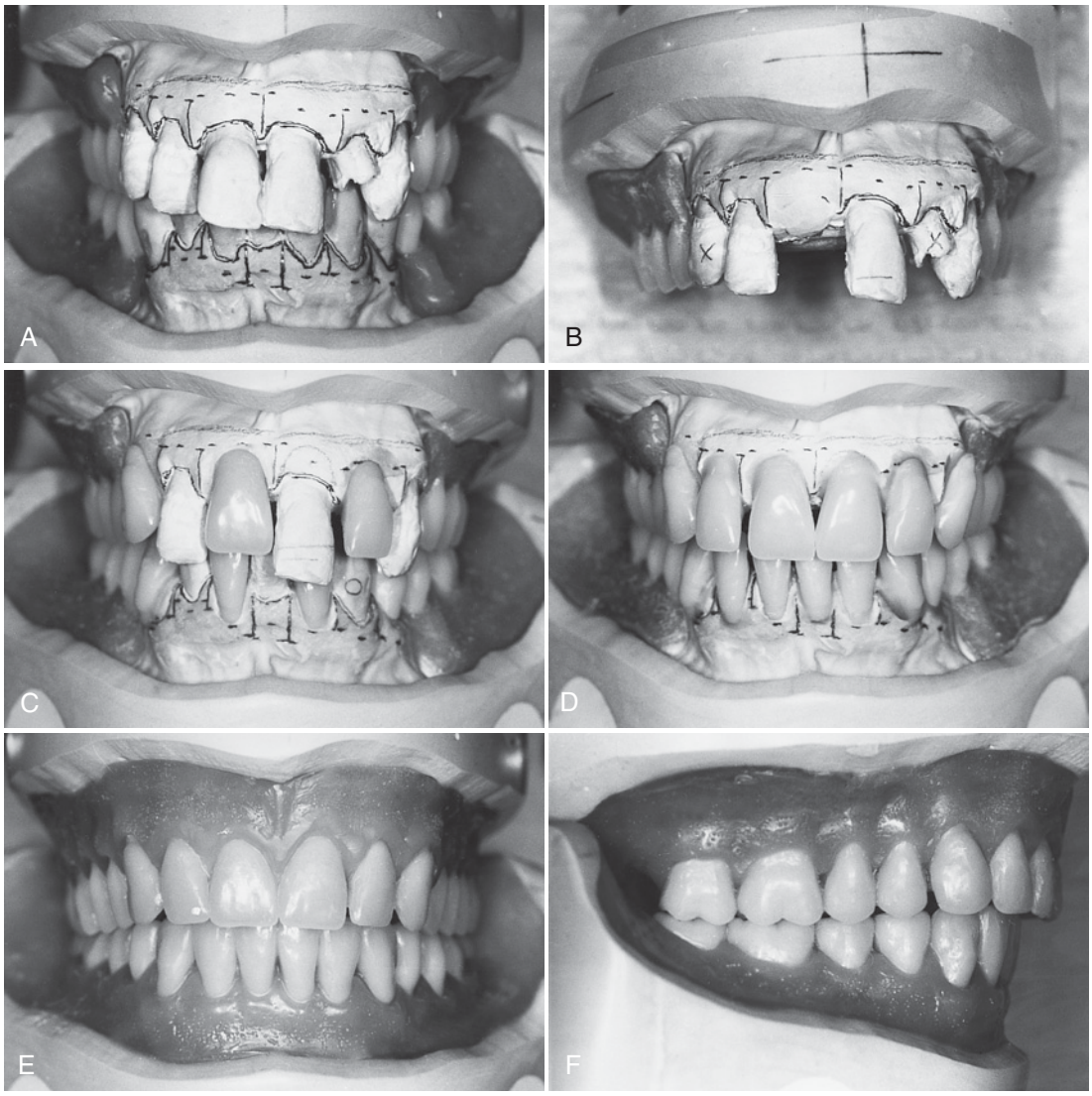


Figure 13-6 **A,** Bone loss penciled on model to estimate stone trimming and space for tooth setup. **B,** Alternate stone teeth removed and ridge trimmed for tooth setup. **C,** Set alternate teeth. Adjacent teeth are reference for incisal, labial, contact position. **D,** Remaining stone teeth removed and replacements set. **E** and **F,** Setup and wax-up completed for patient viewing and agreement before processing.



Figure 13-7 Clear surgery template constructed on duplicate "surgerized" stone model (another patient).

The clinician needs to remain aware that natural teeth are supported in an alveolus that may be as little as 2 mm below the free gingival margin or could be as much as a centimeter or more below this soft tissue margin. It is critical that the tissue depth be understood because this will influence the thickness of the tissue beneath the immediate denture. Periodontal probing depths are valuable to the clinician in predicting the changes after tooth extraction. If the labial plate of bone is relatively intact within a few millimeters of the free gingival margin before removal of the tooth from the cast, then the clinician would likely remove the tooth from the cast at the gingival crest and then hollow grind the cast a similar number of millimeters to simulate tooth removal. *Simply put, more pocketing demands deeper preparation of the cast*. Once the depth of the alveolus is approximated, the labial soft tissue can then be reduced to simulate the drape of the tissue over the labial plate of bone. Suggestions have been made regarding the contouring of the cast when cast surgery is performed. Although general guidelines may be helpful, the clinician may find it more useful to simply consider the presurgical anatomy within the oral cavity and then communicate this throughout the laboratory phases of treatment. If this approach is used, the clinician must communicate to the laboratory technician the anticipated dimensions of the residual ridge in contrast to the dimensions that would be seen through simple extraction of the teeth. Failure to communicate this information could result in overreduction or underreduction of the cast.

Once "cast surgery" has been performed and the irregularities on the cast have been corrected through smoothing and polishing, the remaining denture teeth may be arranged. The complete wax trial denture may then be removed from the cast so that a duplicate impression can be made. This duplicate impression would then be poured with stone and two layers of baseplate wax adapted to it; this will be invested, packed with clear acrylic resin, processed, finished, polished, and used as the surgical template (Fig. 13-7).

The denture is fabricated using similar traditional technology using a split pack or injection molding techniques. Following processing, the denture(s) are deflasked and remounted. Occlusal adjustment is performed to eliminate processing error, to reestablish the predetermined occlusal vertical dimension, and to provide bilateral balanced occlusion. The denture is then finished and polished.

TEETH REMOVAL AND DENTURE INSERTION

Numerous techniques have been advocated to achieve profound local anesthesia in the anterior portions of the jaw without creating distortion of the vestibule through local infiltration. The use of regional anesthetic blocks may assist in this regard. Other methods such as injections into the periodontal ligament space have also been described. Tooth removal is performed carefully to maintain the integrity of the labial and palatal or lingual bony plates. If the decision was made to alter the contour of the bone, this will be accomplished at this time. The surgical template will be inserted before closure of the surgical site and any areas of tissue blanching, which will be evident through the clear template, should be corrected by minor alveoloplasty. Once the clinician has eliminated areas of tissue blanching, the immediate denture will then be inserted on a trial basis. Pressure indicator paste may be valuable to identify areas of tissue impingement. If identified, these areas will be immediately relieved (Fig. 13-8).

The patient will be instructed not to remove their immediate denture for 24 hours. The patient will return to the dental office during that 24-hour time frame when the denture will be removed by the clinician and adjusted accordingly. It is not unusual to observe minor occlusal discrepancies at the time of prosthetic insertion. These should be adjusted and eliminated as a slide from centric occlusion to maximum intercuspation positions could result in soft tissue irritation and diminished denture retention.

POSTOPERATIVE CARE

The patient will be seen in 24 hours to evaluate denture retention, support, and stability. In the maxillary arch, an immediate denture is usually well supported. Retention is often dependent on the accuracy of the impression and the surgical management that mimics cast surgery. Denture stability could be influenced by occlusal contacts or by the choice of cusp form when the denture teeth were selected. In the mandibular arch, denture retention for an immediate denture is often limited. Likewise support of a mandibular immediate denture is dependent upon the number of teeth that were removed and the adherence to the surgical plan. As in the maxilla, discrepancies in the occlusion will lead to errors in denture stability and retention (Fig. 13-9, *A* to *D*).

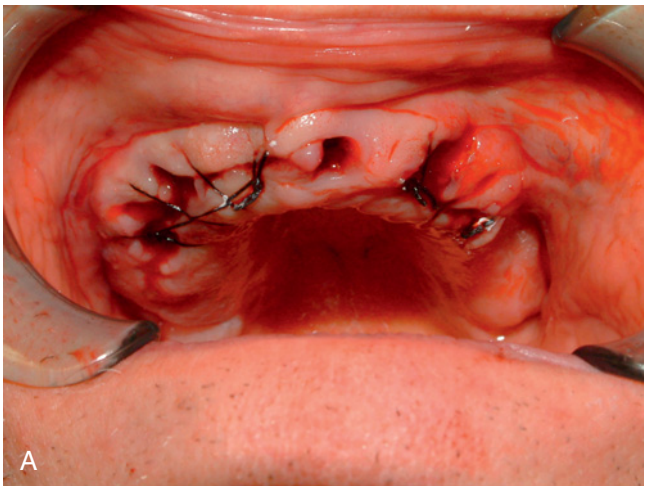






Figure 13-8 **A,** The tooth exchange. Extractions and sutures. **B,** The immediate insertion of complete upper and partial lower dentures. **C,** Patient is able to leave with teeth and postoperative instructions.

Patients may need to be seen for a series of visits during the initial 2 to 3 weeks after insertion of an immediate denture. It is anticipated that gradual residual ridge resorption will occur over the first 3 to 6 months, which may necessitate readaptation of the denture to the tissue surface (Fig. 13-9, *E* and *F*).

A reline or rebase of the denture is anticipated within the first year of clinical service (Fig. 13-9, G to *K*). The need for relining is established through observation of diminished adaptation to the underlying soft and hard tissue (Fig. 13-9, *L*).

OVERDENTURES

It is well recognized that the presence of teeth helps maintain the residual alveolar ridge. When teeth are healthy, the periodontal ligament maintains the structure of the alveolar ridge, but when periodontal disease is present, ongoing loss of the alveolar structure is evident. Removal of teeth also removes the periodontal ligament and its organizational influence on surrounding bone integrity.

Consequently, the retention of natural tooth roots—even if submerged beneath the soft tissue—has been observed to preserve surrounding alveolar structure. For this reason an approach has been espoused to retain the roots of natural teeth beneath a complete denture. This method has been described as an overdenture because the removable denture rests over the retained root(s) (Fig. 13-10).

The overdenture concept must be carefully considered. Should only one natural tooth be retained, bone preservation will result in one projection of alveolar bone within an arch. This would obviously not serve a useful purpose; consequently, the use of retained roots to support an overdenture is most effective when there is a strategic distribution of roots throughout the arch. Ideally the roots of a first molar or second premolar in conjunction with the roots of two canine teeth would provide stimulus for retention of most of the alveolar structure within the jaw. It is this strategic distribution of teeth that could effectively address a reduction in residual ridge resorption.

Through a reduction of the crown to root ratio, it is distinctly possible that retained roots could support retentive elements that would be used to secure a dental prosthesis. The combined benefits of reducing the pathological condition of residual ridge resorption while improving the retention of dentures create a compelling argument for the use of the overdenture.

Recently the introduction of dental implants that provide predictable and reliable "root analogues" has created renewed enthusiasm for the use of the overdenture concept. Obviously this approach does not maintain the periodontal ligament, but if the implants are placed before loss of the residual alveolar ridge height, it appears that the endosseous implant may serve to maintain the ridge while being forever

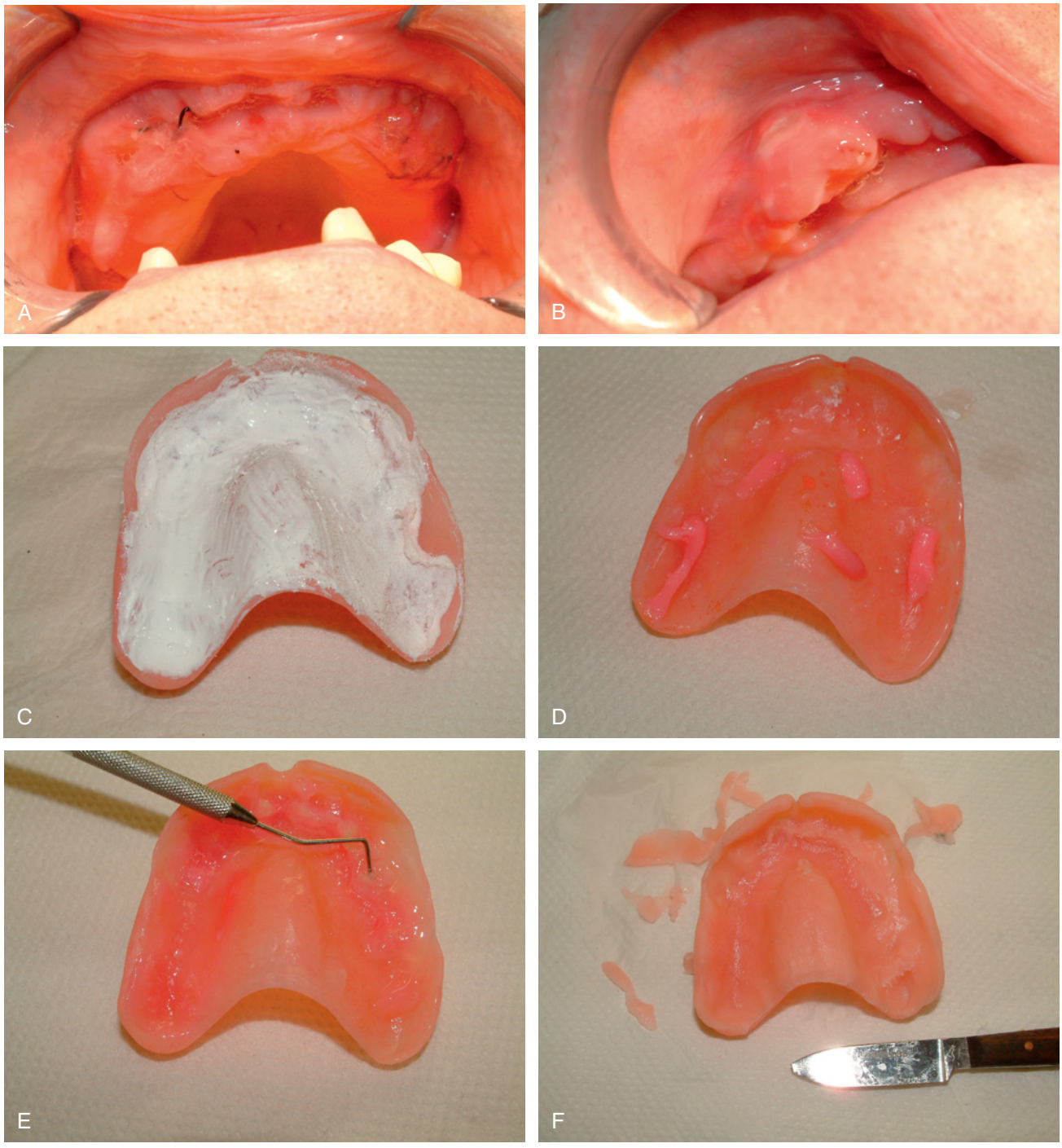


Figure 13-9 **A,** Five days later. Suture removal and adjustments. **B,** Despite planning, a large buccal pressure ulcer has developed. **C,** Pressure-indicating paste (PIP) and adjustment for pressure ulcer. **D,** Denture adhesive for retention as swelling diminishes. **E,** Weeks later, previous advanced periodontal disease has created much tissue change. **F,** Soft liner molded and excess trimmed.

Continued

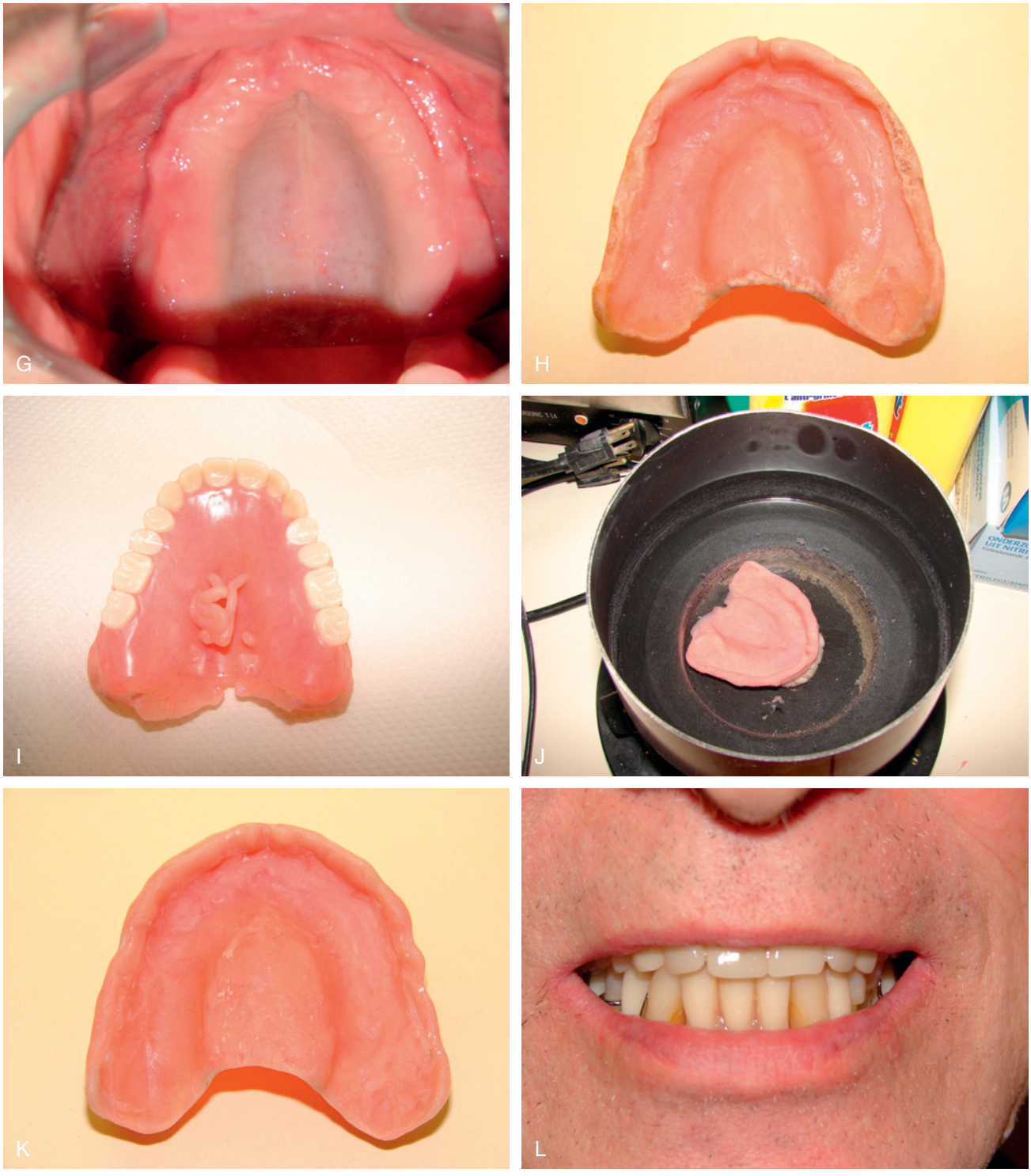


Figure 13-9, cont'd **G,** Months later, mucosa is healthy and stable and further resorption is minimal. **H,** Soft liner is still present. Porous and rough surface needs changed. **I,** Soft liner completely removed. Palatal vent drilled. "Chairside" hard reline placed at correct occlusion and VDO. **J,** "Hard" reline cured out of mouth for 20 minutes in hot water bath. **K,** Reline trimmed and polished after curing. This protocol is good for a few months while the patient decides on a final treatment choice. **L,** One year of smile and function from "immediate" complete upper and lower partial dentures.



Figure 13-10 Alveolar bone preserved with overdenture retained roots.

resistant to dental caries, a disease that could affect retention of tooth roots (Fig. 13-11).

TREATMENT PLANNING FOR OVERDENTURES

The clinician must face a number of decisions when planning for an overdenture. The first step is to identify those teeth that have the adequate residual tooth structure and adequate periodontal support and are located strategically so as to provide support and possibly retention for an overdenture prosthesis. Because the teeth will be reduced in height, the crown to root ratio is not as critical for a tooth supporting an overdenture as it would be for a tooth retaining a removable dental prosthesis or a fixed dental prosthesis.

Patient susceptibility to dental caries is another factor that must be considered. Patients must be motivated to maintain the roots that are being retained for overdenture support. The use of topical fluoride (neutral sodium fluoride), antibacterial agents, and routine oral hygiene methods are all components in the daily routine that must be adopted by a patient considering an overdenture. Failure to comply with oral hygiene measures will likely result in loss of the teeth secondary to dental caries as the overdenture could prove to be a harbor of bacteria on the retaining teeth.

Periodontal support of the retained roots must be adequate for long-term retention of the root. Although the mobility and loss of periodontal support are factors affecting the retention of teeth in conventional prostheses, both of these factors are favorably managed in the overdenture patient simply because the crown root ratio of the tooth is altered so dramatically in the preparation of the tooth for an overdenture. Obviously a tooth that exhibits mobility in the occlusogingival direction may not be suited for use as an overdenture retainer, while mobility found in the medial distal or buccal lingual dimensions may be less critical of a







Figure 13-11 **A,** Modern overdenture therapy. The logical extension of the concept to implants instead of deteriorated roots. **B,** Retentive elements in the denture base are adjustable and replaceable. **C,** Implant overdenture security, retention, and comfort make patients happy.

prognostic factor. When considering any tooth for retention as an overdenture abutment, the location of the tooth within the arch, the complexity of the root structure, and the supporting alveolar architecture that influences the decision to retain a root are more important than traditional factors.

If a root is to be retained, endodontic therapy is often needed. The position of the root canal space relative to the anticipated point of crown resection should be evaluated for every patient because there are some who could undergo crown resection without a need for root canal therapy. Obviously if the periapical health of the planned retained root is in question, then root canal therapy is mandatory. Endodontic treatment on an overdenture abutment lends itself to the use of a cast post that may be placed into the root canal space, thereby providing support for a retentive element that could then be connected to the overdenture. In this situation the retention of the denture also may be improved. Of course, when a retained root is used to provide additional retention to the denture, the forces on that tooth will be increased. Consequently, the clinician is cautioned to select such teeth carefully because additional demands are placed on the residual and oftentimes compromised periodontal support.

One of the complicating factors with retention of natural tooth roots relates to the anatomy of the alveolar structure. Many teeth have undercuts on the facial aspect of the root surface. These facial undercuts are likely the result of the anatomy of the natural tooth because most teeth have conical root structures relative to the coronal structures. The conical shape of the root results in more prominent bone near the coronal aspect of the residual alveolar ridge. Management of this undercut often results in the creation of a dead space between the denture and the oral mucosa. It certainly would be possible to consider grafting procedures to recontour the ridge, but this approach may not prove practical because soft tissue grafting alone may not be long-lasting, while soft and hard tissue grafting would be time consuming, unpredictable, and cost prohibitive.

The use of dental implants for overdenture support and retention appears to be far more effective. The implants themselves are not susceptible to dental caries, the facial bony undercut that is a ubiquitous concern with the natural dentition is rarely a concern with the overdenture supported by implants, and the ideal position of the overdenture retainers is not dictated by the residual teeth.

The distribution of the retainers for an overdenture already has been described in Chapter 6. Ideally four retained roots or placed implants that are distributed far from each other would provide four points of contact upon which denture support would be ideal. Likewise if four retentive elements were placed onto the roots/implants and if these roots/implants were distributed in the four-corner pattern described previously, denture retention would be favorable.

Unfortunately cost considerations frequently interfere with the ability to provide treatment for patients.



Figure 13-12 **A,** Tooth-supported overdenture especially valuable to avoid a single denture opposing natural dentition. **B,** Mandibular overdenture stabilized with two roots.

Consequently the overdenture approach has often been applied when roots/implants are located only in the anterior portion of the oral cavity (Fig. 13-12).

In this situation there is an inevitable fulcrum line created between the two supporting elements. Rotation around this fulcrum line must be considered. A straight line that is located too far to the posterior will create an unfavorable situation in which there is rotation forward and back around the fulcrum line, whereas two roots/implants in the lateral incisor or canine region may provide a more ideal arrangement considering the forces that are anticipated.

RETENTION

Retention of an overdenture can be improved by the use of retentive elements that are placed in the retaining roots/implants (Fig. 13-13).

These devices may be placed internal (intracoronal or within the implant), thereby known as a matrix, or external, known as a patrix. Clinician preference is probably the primary factor in selection of a retentive element. Clinicians must be constantly aware of the height of the retentive components that connect to the tooth/implant and the components that must be situated within the

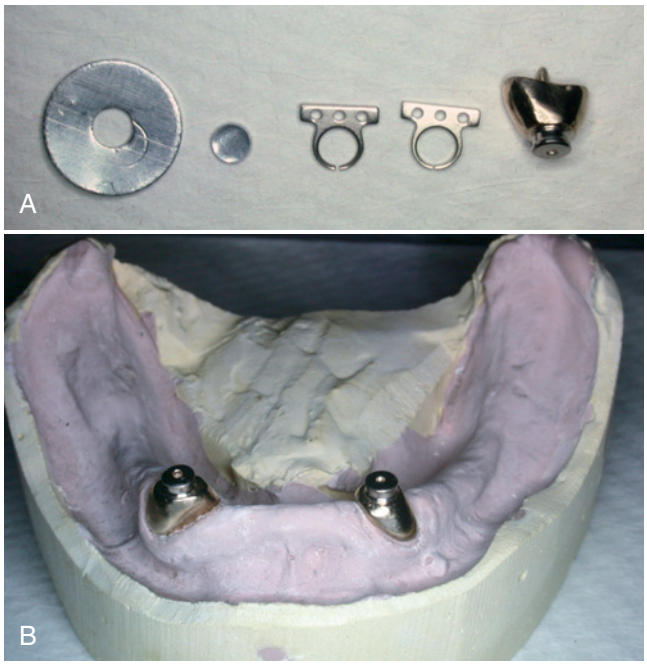


Figure 13-13 **A,** If roots have length for an adequate post, attachments can make overdentures more retentive. **B,** Retentive elements need space. Avoid thin areas in the overdenture.

denture. Each component has a specific minimum height and it is not uncommon for these components to interfere with the external contours of the denture.

INSERTION

The retentive elements associated with an overdenture may be processed into the denture at the time of denture fabrication, or they may be oriented in a clinical setting. Clinical orientation allows the clinician to place the retentive element under occlusal load, which then means that the retentive element is passive when the prosthesis is at rest. This approach may lead to reduced wear of the retentive elements and may improve the long-term performance of the elements.

Durability of retentive elements is an issue. Manufacturer claims may be true for the average patient, but some patients will experience retentive issues in very short time periods. This may result in maintenance concerns and may affect the cost of therapy.

Whether or not retentive elements are used, the retention of a root/placement of an implant results in decreased amount of denture base material where the overdenture abutment is located. A reduction in denture base material creates a weak area within the denture base, and this may be a starting point for denture fracture. If the prosthesis acts as a fulcrum, allowing forward and backward movement from the supporting elements, the risk of denture fracture may be even greater (Fig. 13-14).

CLINICAL AND LABORATORY PROCEDURES

Clinical and laboratory procedures will vary depending on whether a tooth-supported complete denture is being constructed or a tooth-supported immediate complete denture is planned.

TOOTH-SUPPORTED COMPLETE DENTURE

The important principles of complete denture construction must be respected, and when required, matched to the technical and laboratory dictates of the selected attachment type. These principles are identical to those described in subsequent chapters, and they should be meticulously observed.

One frequently encountered problem of tooth-supported complete denture service is the tendency for an unfavorable gingival response around the abutment teeth (see Fig. 6-11). The following may cause gingival irritation: (1) movement of the denture base (more apparent in mandibular dentures), with the development of a loading factor at the gingival margins; (2) poor oral hygiene with failure to remove plaque or to pay sufficient attention to tissue rest and periodic recall assessments; and (3) excess space in the prosthesis around the gingival margins of the abutment teeth, which leads to the development of a "dead space" (a potential source of inflammation and tissue hypertrophy).

Clinical experience suggests that a slight space around the gingival margin is essential to avoid overloading this particularly vulnerable site, especially with mandibular dentures because they appear to become dislodged more easily than maxillary dentures. Conversely, a dead space may lead to a combined hypertrophic/hyperplastic response of the gingival margin similar to that elicited by a relief chamber in a complete maxillary denture. One way to avoid this is to hollow out an area in the resin overdenture over the abutment site and line it with a tissue conditioner at the time of denture placement. The resiliency of the liner, combined with its need for frequent replacement, can create an optimal schedule for recall appointments. However, there also may be subsequent deterioration of the material and, with it, the risk of gingival tissue damage. Our preference therefore is to use an autopolymerizing hard acrylic resin to reline the abutment area at delivery of the prosthesis.

TOOTH-SUPPORTED IMMEDIATE COMPLETE DENTURE

The procedures for immediate tooth-supported complete dentures are identical to those described earlier when making immediate dentures. The exception is that the coronal reduction of the selected abutment teeth is done at the time the remaining teeth are extracted (Fig. 13-15).

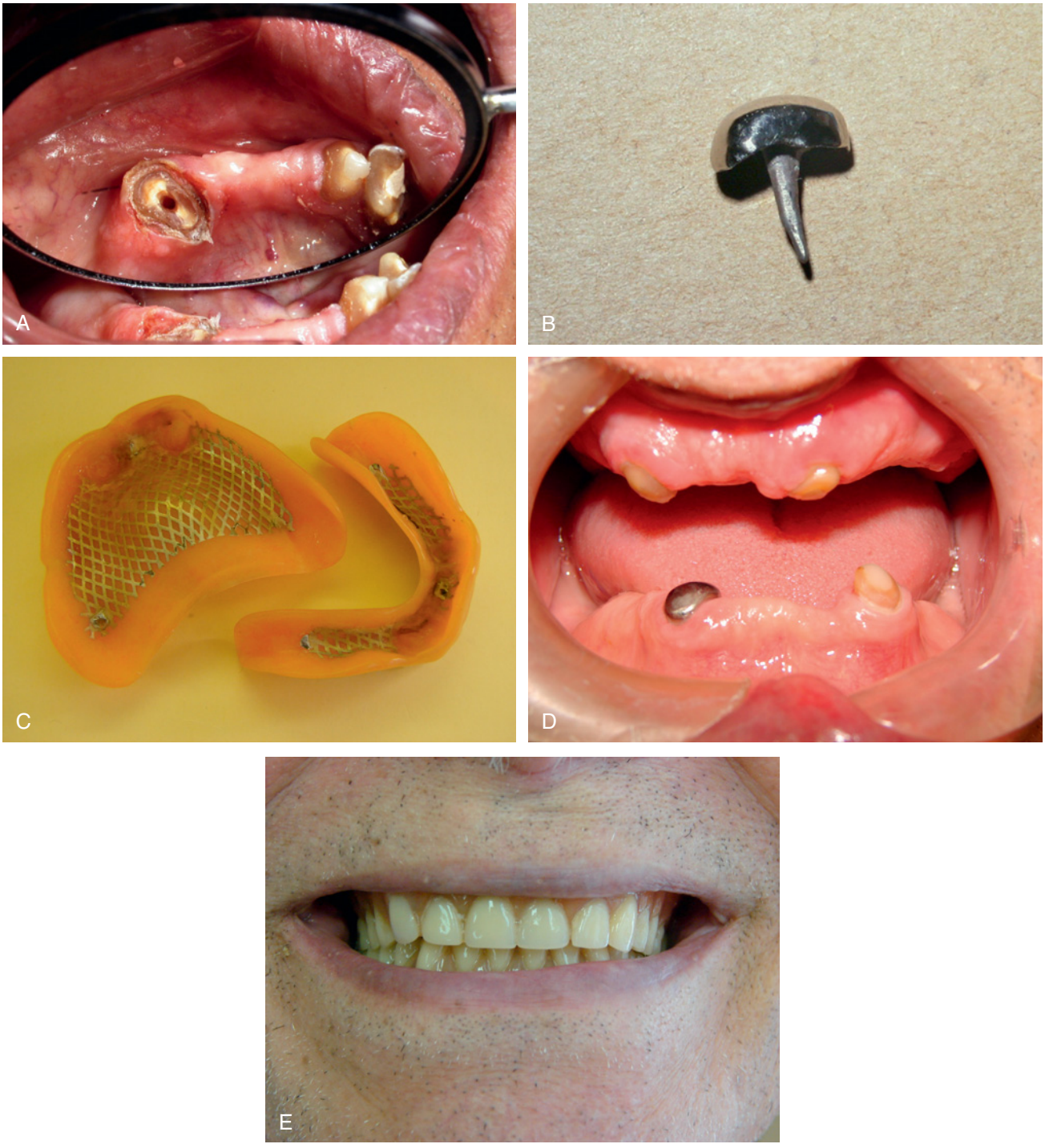


Figure 13-14 **A,** Compromised teeth need a casting to protect. Electrosurg and sulcus expansion cord in place. **B,** Overdenture casting. Chamfer subgingival margins and post retention. **C,** Overdentures reinforced with cast Cr-Co mesh. **D,** Five-year follow-up. Three roots protected with composites, bonding resin, and fluoride. One casting to restore domed contour just above gingival. **E,** Root-stabilized overdentures give this smiling tuba player the security he needs to manage his embouchure and mouthpiece.



Figure 13-15 **A,** Immediate overdenture solution. Failing fixed prosthesis and patient wants to keep teeth, not get implants. **B,** "Immediate" overdenture ready for insertion. **C,** Nonvital teeth remaining. Too few and too weak for fixed prosthesis. **D,** Prepared tooth roots for immediate overdenture insertion. Smooth, fluoride, and cover with bonding resin. **E,** Overdenture insertion. Direct reline to prepared tooth roots. **F,** Smile restored with tooth-supported single overdenture.

The teeth to be retained are prepared on the master cast to the approximate shape of the pending abutment, and the remaining teeth are trimmed from the cast in the usual manner. The processed immediate denture thus demonstrates depressions on its impression surface that will conform to the teeth that are being retained. The endodontic treatment is completed during one or more appointments before the immediate denture insertion or just before the combined surgical-prosthetic appointment. Some dentists prefer the latter because removal of the tooth crown facilitates the endodontic procedures. Immediate denture insertion and follow-up are performed in the usual manner. The need for refining the impression surface of the denture in the extraction and abutment sites, by the addition of a treatment resin, is essential because rapid tissue changes are to be anticipated. When healing has occurred and tissues and remodeling bone have achieved a stable contour, additional coping preparation may be necessary with refitting of the prosthesis in this area.

MAINTENANCE

When natural teeth are retained to support an overdenture, the clinician must arrange ongoing maintenance much as would be done with a traditional fixed or removable prosthodontics patient. The use of topical fluoride and antibacterial rinses and brushing and flossing are all critical for the survival of these retained roots (Fig. 13-16).

When dental implants are used, the risk of dental caries is eliminated and the potential for periodontal-like disease appears to be diminished. Consequently, retained root-supported overdentures may demand 6-month follow-ups, while implant-supported overdentures may require only annual follow-up if the retentive elements remain sufficiently tight. In essence, it is the performance of the retentive element that dictates the interval between maintenance visits for the implant overdenture patient.

When patients return for maintenance, it is essential that the clinician assess anterior posterior movement in the prosthesis. If there is residual ridge resorption in the posterior portion of the jaw, the denture will need to be readapted to compensate for this resorptive process.



Figure 13-16 **A,** Success depends on recall maintenance. Fluoride, dentin bonding, and plaque control against gingivitis and caries. **B,** Overdenture is ideal tray for fluoride gel 3 times per week.

SINGLE DENTURE

When the health and morphological status of the dentition in one arch prevents restoration of teeth, it may be necessary to consider the fabrication of a single complete denture. The opposing natural dentition could consist of natural teeth only or a combination of fixed or removable prostheses (Fig. 13-17).

This situation occurs most often when the maxillary teeth are lost and the mandibular arch is maintained with some, or all, natural teeth. The support provided by the maxillary denture base as it contacts the hard palate is far superior to that provided by the buccal shelf area of the mandibular denture. Although the situation is more favorable when the denture is found in the maxilla, there remain a number of concerns with the single denture that demand special consideration when the prosthesis is made.

DIAGNOSIS AND TREATMENT PLANNING

One of the primary objectives of prosthodontic treatment is to preserve remaining structures. This is achieved through management of adverse biologic phenomena and through appropriate application of biomechanical principles to avoid tissue injury. The biologic factors that must be considered in the management of the single denture are related to dental caries, periodontal disease, and residual ridge resorption. Of these three factors, it is evident that residual ridge resorption may be accelerated through adverse force concentration on the residual ridges. This observation links the biologic and biomechanical components as cofactors that contribute to changes in the residual alveolar ridges.



Figure 13-17 **A,** A mandibular single denture may need a resilient liner for patient comfort. **B,** Processed silicone denture liner for single mandibular prosthesis. Try regular base first.

When considering the biomechanical factors, a number of considerations demand attention. Establishment of an appropriate interocclusal distance, creation of bilateral posterior tooth contacts in a retruded mandibular position, directing forces down the long axis of teeth or prostheses, and avoidance of adverse tooth contacts throughout a small range of mandibular movements are all considered critical when diagnosis and treatment planning are performed.

These factors are generally well controlled when complete dentures are simultaneously made in each arch. However, when one arch is completely edentulous and the other is partially or fully dentate the ability of the clinician to meet the aforementioned considerations is diminished. Although it may be possible to establish bilateral tooth contact in a retruded jaw position, it is often difficult to create the range of functional teeth contact movement and establish axial forces. Consequently it is not unusual to experience morphological changes in the denture foundation that are related to adverse force transmission through the overlying denture and its underlying mucosa. This situation is compounded by excessive force as occurs when the remaining teeth in the opposing arch demonstrate an asymmetrical distribution and, consequently, an unfavorable force concentration (Fig. 13-18).

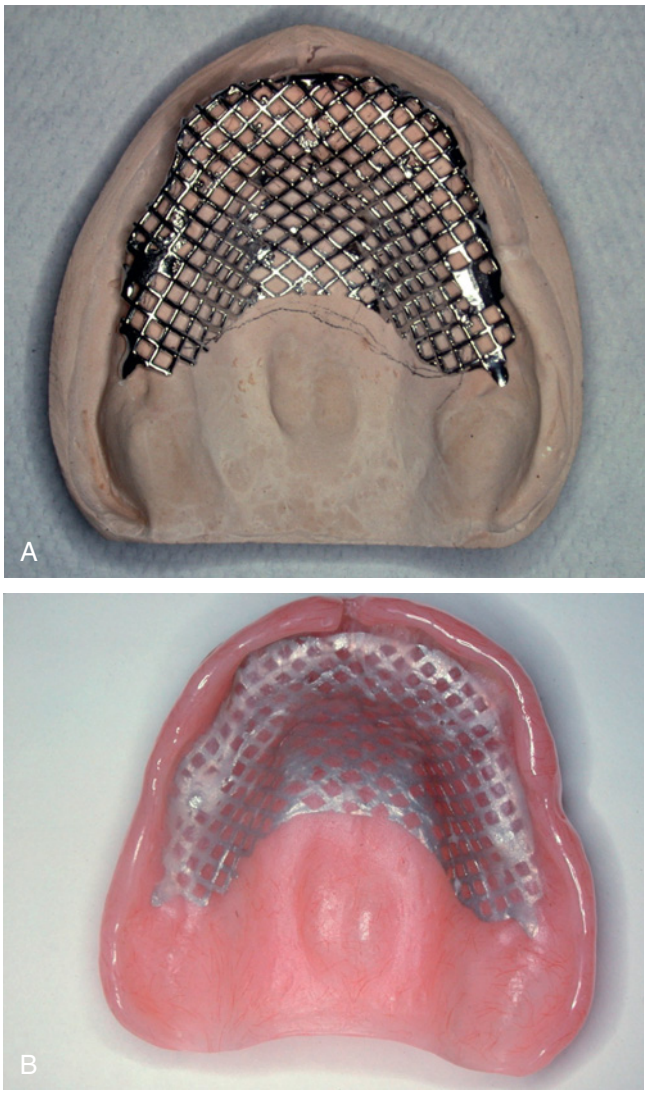


Figure 13-18 **A,** Plan on cast Cr-Co mesh reinforcement if intact arch and heavy function. **B,** Cast mesh is embedded in PMMA at processing.

Most reports suggest that the mandibular anterior sextant represents the last teeth to be lost. Assuming that the mandibular anterior teeth oppose a maxillary complete denture, it is easy to understand how these natural teeth could create excessive force on the maxillary anterior residual ridge that would cause destruction of the underlying bone. Forces applied to maxillary anterior denture teeth will create a forward rotation of the denture. The position and orientation of anterior denture teeth cause increased leverage to the underlying ridge, thereby further exaggerating the forces to the underlying structures that could cause additional loss of supporting bone (Fig. 13-19).

TEETH ARRANGEMENT

When a single denture opposes the natural dentition, the clinician must pay particular attention to the dimensions of the prosthetic teeth and to the cusp form of these teeth. In

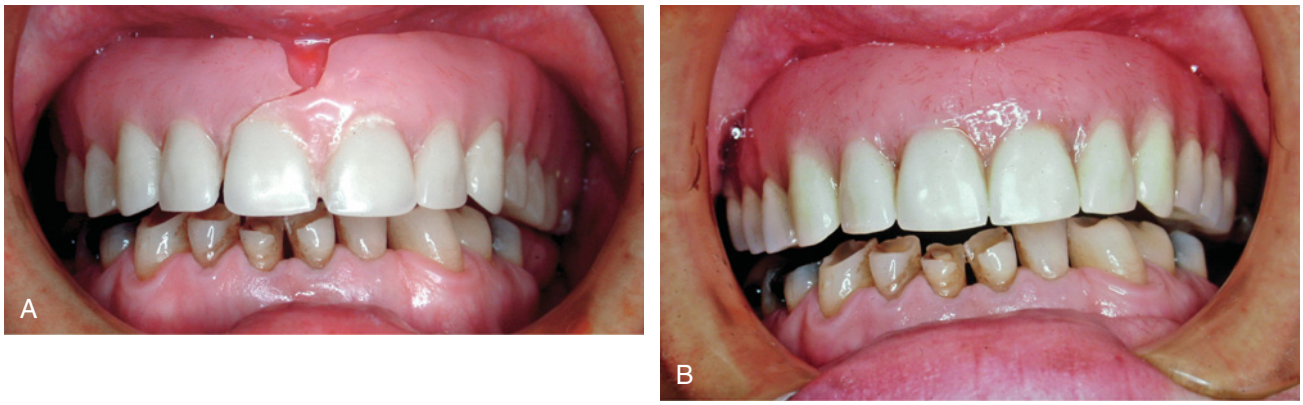


Figure 13-19 **A,** Parafunctional patient could still fracture reinforced single denture. Note wear on lower teeth. **B,** Frenectomy needed to restore labial flange integrity and strength. No more fractures occurred.



Figure 13-20 **A,** Single prostheses have to match existing teeth. Use a facebow to best orient models on articulator. **B,** Opposing occlusion creates need for custom setting and adjustment of denture teeth. **C,** Posterior crossbite may best satisfy maxillary single denture stability.

all likelihood the denture tooth will not match the size or form of the natural teeth, thereby making it difficult to establish a bilateral balanced occlusion (Fig. 13-20).

The arch form in the dentate jaw may not coordinate with the requisite arrangement of the denture teeth. Furthermore, the natural tooth occlusal plane is unlikely to allow occlusal balance.

When planning treatment, the clinician may consider modification of the natural tooth occlusal plane. An occlusion rim may be used in the edentulous arch to identify the most favorable occlusal plane. The clinician should contour the occlusion rim using anatomical landmarks such as the retromolar pad, the neutral position, parotid papillae, and/or parallelism with Camper's plane (a plane extending from the inferior border of the ala of the nose to the superior border of the tragus of the ear) to establish a favorable plane. By applying some or all of these methods, the clinician would be able to identify modifications to the opposing arch through selective recontouring of the opposing teeth.

In essence, the anatomy, arch form, tooth size, and orientation of the occlusal plane all contribute to the difficulty in creating a favorable occlusal scheme. Different techniques have been proposed to address these problems. Use of large prosthetic teeth with steep cusp forms may provide sufficient prosthetic tooth volume to allow the clinician to adjust the prosthetic teeth sufficiently to allow establishment of a bilaterally balanced occlusion. If it is not possible to match the prosthetic teeth with the natural teeth, it may be prudent to consider the use of cast gold restorations to overlay the prosthetic teeth. These cast gold occlusal surfaces could be created using a semiadjustable articulator in an effort to simulate eccentric jaw motion. They also may be established using a functionally generated occlusal path to record the effects of cusp movement through a functional range.

One final approach that has been suggested is to arrange the prosthetic teeth in such a way as to establish an arrangement with cusp tips of posterior natural and prosthetic teeth coming into direct contact. In this situation the results will be most favorable if the patient does not exhibit a wide range of eccentric motions (Fig. 13-21).

SUMMARY

Complete dental prostheses are used to compensate for loss of the natural dentition. They are unlikely to ever approach the functional, esthetic, or comfort levels that can be

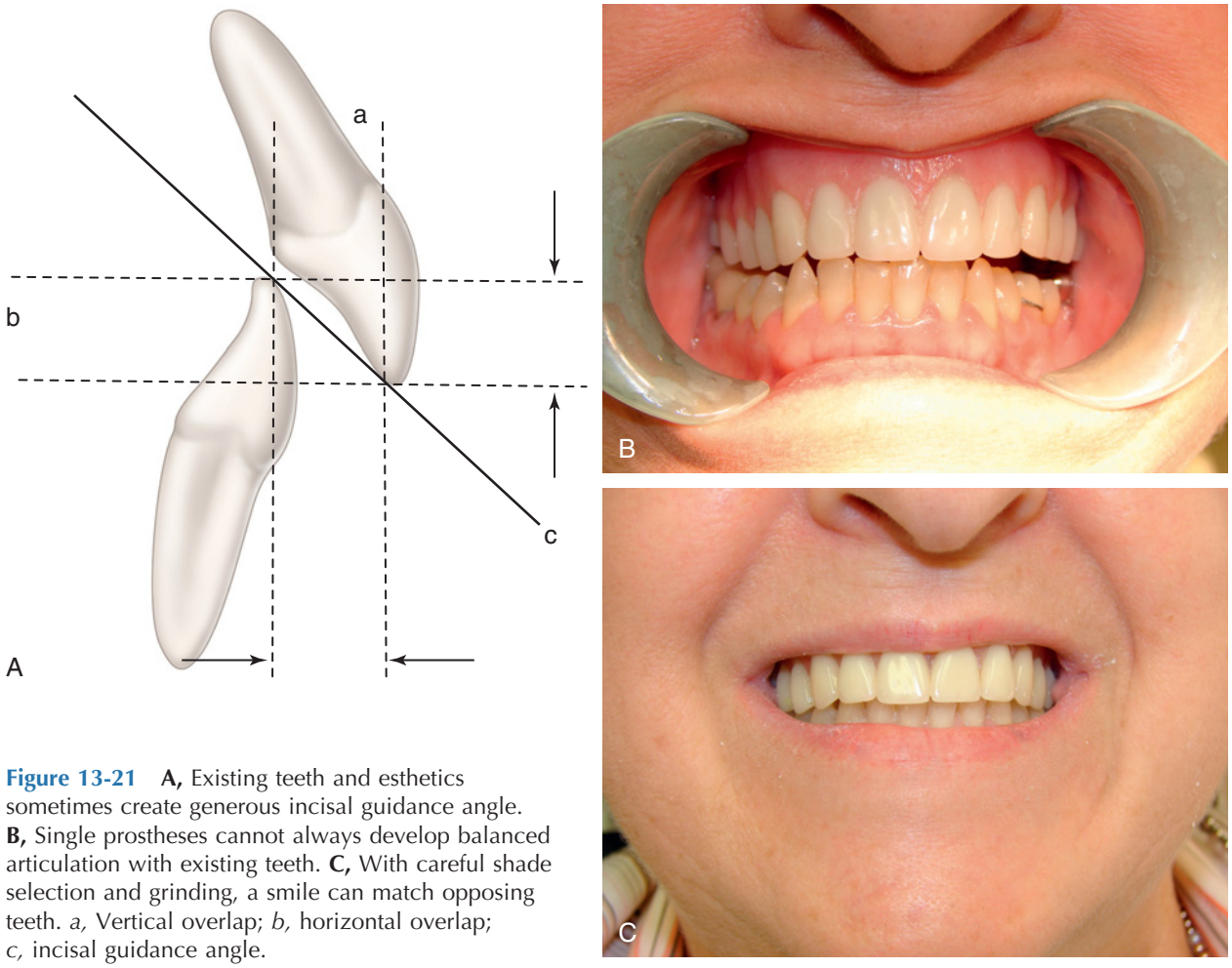


Figure 13-21 **A,** Existing teeth and esthetics sometimes create generous incisal guidance angle. **B,** Single prostheses cannot always develop balanced articulation with existing teeth. **C,** With careful shade selection and grinding, a smile can match opposing teeth. *a,* Vertical overlap; *b,* horizontal overlap; *c,* incisal guidance angle.

achieved with the natural dentition; however, it is readily apparent that many patients are able to use the prostheses with remarkable success.

When complete dentures are simultaneously made in the maxilla and mandible, the clinician has good control over the clinical outcome irrespective of whether natural teeth or abutments are used for adjunctive support and retention. In the event that the dentition is adequate in one jaw and terminal in the opposing one, it may be necessary to fabricate a single denture. This single dental prosthesis frequently creates a series of compromises that could interfere with the clinician's ability to satisfy the patient's demands. In this situation it is essential that the clinician carefully consider all alternative methods to maximize a favorable clinical outcome. Alteration of the occlusal plane in the dentate jaw may be necessary, just as it is important for the clinician to counsel the patient regarding methods to compensate for the unfavorable tooth contacts.

Bibliography

Atwood DA: Reduction of residual ridges: a major oral disease entity, *J Prosthet Dent* 26(3):266-279, 1971.

Budtz-Jorgensen E: Prognosis of overdenture abutments in elderly patients with controlled oral hygiene. A 5 year study, *J Oral Rehabil* 22(1):3-8, 1995.

Cune MS, de Putter C, Hoogstraten J: Treatment outcome with implant-retained overdentures: Part I—clinical findings and predictability of clinical treatment outcome, *J Prosthet Dent* 72(2):144-151, 1994.

Cune MS, de Putter C, Hoogstraten J: Treatment outcome with implant-retained overdentures: Part II—patient satisfaction and predictability of subjective treatment outcome, *J Prosthet Dent* 72(2):152-158, 1994.

Davis DM: Role of implants in the treatment of edentulous patients, *Int J Prosthodont* 3(1):42-50, 1990.

Denissen H, Kalk W, van Waas M, et al: Occlusion for maxillary dentures opposing osseointegrated mandibular implants, *Int J Prosthet* 6:446-450, 1993.

Derkson GD, MacEntee MM: Effect of 0.4% stannous fluoride gel on the gingival health of overdenture abutments, *J Prosthet Dent* 48(1):23-26, 1982.

Ettinger RL, Bergman W, Wefel J: Effect of fluoride on overdenture abutments, *Am J Dent* 7(1):17-21, 1994.

Ettinger RL, Jakobsen J: Periodontal considerations in an overdenture population, *Int J Prosthodont* 9(3):230-238, 1996.

Farmer JB: Surgical template fabrication for immediate dentures, *J Prosthet Dent* 49(4):579-580, 1983.

Geertman ME, van Waas MA, van't Hof MA, et al: Denture satisfaction in a comparative study of implant-retained mandibular overdentures: a randomized clinical trial, *Int J Oral Maxillofac Implants* 11(2):194-200, 1996.

Griess M, Reilmann B, Chanavaz M: The multi-modal prosthetic treatment of mentally handicapped patients—necessity and challenge, *Eur J Prosthodont Restor Dent* 6(3):115-120, 1998.

Hansen C, Clear K, Wright P: Simplified procedure for making gold occlusal surfaces on denture teeth, *J Prosthet Dent* 71:413-416, 1994.

Holt RA, Jr: Instructions for patients who receive immediate dentures, *J Am Dent Assoc* 112(5):645-646, 1986.

Hussey DL, Linden GJ: The efficacy of overdentures in clinical practice, *Br Dent J* 161(3):104-107, 1986.

Jacobs R, van Steenberghe D, Nys M, et al: Maxillary bone resorption in patients with mandibular implant-supported overdentures or fixed prostheses, *J Prosthet Dent* 70:135-141, 1993.

Jensen ME, Kohout F: The effect of a fluoridated dentifrice on root and coronal caries in an older adult population, *J Am Dent Assoc* 117(7):829-832, 1988.

Jerbi FC: Trimming the cast in the construction of immediate dentures, *J Prosthet Dent* 16(6):1047-1053, 1966.

Johnson GK, Sivers JE: Periodontal considerations for overdentures, *J Am Dent Assoc* 114(4):468-471, 1987.

Jonkman RE, Van Waas MA, Kalk W: Satisfaction with complete immediate dentures and complete immediate overdentures. A 1 year survey, *J Oral Rehabil* 22(11):791-796, 1995.

Keltjens HM, Creugers TJ, van't Hof MA, et al: A 4-year clinical study on amalgam, resin composite and resin-modified glass ionomer cement restorations in overdenture abutments, *J Dent* 27(8):551-555, 1999.

Keltjens HM, Schaeken MJ, van der Hoeven JS, et al: Caries control in overdenture patients: 18-month evaluation on fluoride and chlorhexidine therapies, *Caries Research* 24(5):371-375, 1990.

Mericske-Stern R, Zarb GA: Overdentures: an alternative implant methodology for edentulous patients, *Int J Prosthodont* 6(2):203-208, 1993.

Mericske-Stern RD, Taylor TD, Belser U: Management of the edentulous patient, *Clin Oral Implants Res* 11(Suppl 1): 108-125, 2000.

Pietrokovski J, Tamary I: The single denture, *Quintessence Int* 20(11):793-801, 1989.

Tallgren A: The continuing reduction of the residual alveolar ridges in complete denture wearers: a mixed-longitudinal study covering 25 years, *J Prosthet Dent* 27(2):120-132, 1972.

Toolson LB, Taylor TD: A 10-year report of a longitudinal recall of overdenture patients, *J Prosthet Dent* 62(2): 179-181, 1989.

Van Waas MA, Jonkman RE, Kalk W, et al: Differences two years after tooth extraction in mandibular bone reduction in patients treated with immediate overdentures or with immediate complete dentures, *J Dent Res* 72(6): 1001-1004, 1993.

van Waas MA, Kalk W, van Zetten BL, et al: Treatment results with immediate overdentures: an evaluation of 4.5 years, *J Prosthet Dent* 76(2):153-157, 1996.

Zarb GA, Schmitt A: The edentulous predicament. II: The longitudinal effectiveness of implant-supported overdentures, *J Am Dent Assoc* 127(1):66-72, 1996.

CHAPTER 14

Prolonging the Useful Life of Complete Dentures: Relines, Repairs, and Duplications

John A. Hobkirk, George Zarb

The biological supporting tissues and materials used in complete denture fabrication are vulnerable to time-dependent changes. Both the denture base material and artificial teeth can discolor, deteriorate, and fracture, with the teeth particularly prone to wear. Changes in the prostheses may be managed by repair, typically where the failure is sudden and catastrophic, or by refurbishment of the worn material, although the two procedures are not always mutually exclusive. However, irreversible changes in the tissues supporting the prostheses can only be partially compensated for. This point was emphasized in Part I as an unavoidable sequela of the edentulous state. Meticulous attention and care in the construction of complete dentures can minimize adverse changes in the supporting tissues and in the associated facial structures as well, but it cannot preclude them. Thus the need for "servicing" complete dentures to keep pace with their changing environment becomes mandatory.

The clinical efforts that aim at prolonging the useful life of complete dentures involve a refitting of the impression surface of the denture, occlusal correction, and a minor spatial reorientation of the prosthesis. Two techniques are available: (1) relining, a procedure used to resurface the tissue side of a denture with new base material that provides accurate adaptation to the changed denture-foundation area, and (2) rebasing, the laboratory process of replacing the entire denture base material in an existing prosthesis. The alternative (at some point a necessary one) to this sort of "servicing" is the more expensive periodic remaking of the complete dentures.

REBASING/RELINING

The relining or rebasing of a complete denture essentially involves the recording of an impression within its support surface so as to correct the deficiency that has arisen as a result of tissue changes. By definition, this involves an alteration in the relationship between the occlusal and incisal surfaces of the teeth and the underlying jaw. Where the impression records little more than the deficiency, then this change will be minimal; however, it is quite possible to record an impression with a thicker layer of material than is desirable. This provides the potential for the relationships between the teeth and the supporting tissues to change vertically and horizontally and for the denture to rotate around vertical, transverse, and anteroposterior axes. The resultant changes in the vertical dimension of occlusion (VDO), positions of the teeth, and orientation of the occlusal plane can be extremely troublesome to manage. This potential for harm is not always recognized, and the rebasing of complete dentures is perceived as a simple procedure that is often not allocated adequate clinical time, further compounding the problem. Unless great care is taken by the clinician and technical team, the procedure can result in the patient's situation being made worse rather than better.

TREATMENT RATIONALE

The foundation that supports a denture changes adversely as a result of residual ridge resorption (RRR). This occurs in a nonuniform pattern at an exponentially reducing rate that varies markedly among patients but is progressive and inevitable. It is usually accompanied by one or more of the clinical changes listed in Fig. 14-1. The variable reduction in the VDO and resultant spatial reorientation of the dentures also lead to changes in circumoral support and, consequently, the patient's appearance. The changes in occlusal relationships also can induce more adverse stresses on the supporting tissues, which increase the risk of further ridge resorption.

One compelling conclusion that can be drawn from clinical experience and research involving denture-wearing patients is that dentures need regular attention for maintenance purposes. Such attention can be achieved only by patient education and a regular recall schedule. During the recall appointments the dentist reconciles a patient's

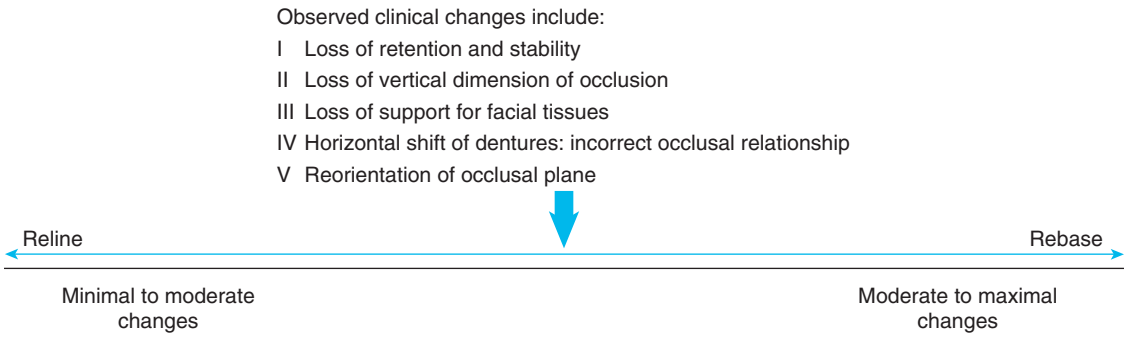


Figure 14-1 A number of changes can occur in the tissues that support complete dentures and are more common under mandibular than under maxillary dentures. They may be encountered under either, particularly when a maxillary denture is opposed by a natural or restored dentition. The magnitude of the changes is what determines the nature of the resurfacing or refitting prescribed. If a new thin layer of resin is added to the denture base, the resurfacing is called a reline. If more material is added (as for a maxillary denture resting on severely resorbed residual ridges), extensive refitting and replacement of the denture base are necessary, which is called a rebase.

reported denture experiences with information derived from clinical examination. The magnitude of the observed changes will indicate whether the prescribed servicing of the prosthesis will necessitate a laboratory reline, a rebase, or a remake. This decision also will be influenced by any wear or deterioration of the polished and occlusal/incisal surfaces of the dentures, which may indicate the need for remaking the prostheses rather than rebasing them.

The relining procedure is the most frequently prescribed intervention and involves adding a new layer of processed denture material to the denture base. This can be done without adversely affecting the occlusal relationships or the esthetic support of the lips and face. When minimal or moderate tissue changes are evident, relining is the treatment of choice. A thin layer of impression material is used to compensate for resorptive changes that have occurred in the basal seat. Then, in the dental laboratory, the material is replaced with a new layer of acrylic resin that bonds to the original fitting surface of the denture. The compensation for the resorbed tissues results in a slightly thicker acrylic denture base.

If extensive tissue changes are encountered, the dentist must compensate not only for the reduced supporting tissue but also for the reorientation of the dentures. This necessitates a simultaneous correction of the impression surface of the denture with its vertical and horizontal repositioning in the mouth. The resultant increase in the bulk of the prosthesis usually indicates the prescription of a laboratory rebasing procedure that will provide a thinner palatal section in the maxillary denture. This reorientation of the dentures may require that the clinician use various materials and techniques to stabilize the prosthesis in its correct position before making the impression of the entire basal seat.

Relining can be done simply, accurately, and inexpensively. However, rebasing a complete denture involves all the problems of making new dentures without the flexibility to reposition individual teeth. Consequently, a rebase prescription may be regarded as an inferior clinical alternative to the more expensive and time-consuming provision of new dentures. Therefore at times a clinician may choose to reline one prosthesis and remake, rather than rebase, its counterpart. Socioeconomic realities and common sense dictate that these techniques must be provided frequently, and clinical experience certainly justifies their use.

DIAGNOSIS

Patients who have had dentures successfully for a long time often present complaining of looseness, soreness, chewing inefficiency, and perceived esthetic changes. These difficulties may have been caused by (1) an incorrect or unbalanced occlusion that existed when the dentures were inserted or, more likely, (2) changes in the structures supporting the dentures that are now associated with a disharmonious occlusion. It is essential that the cause or causes of the reported difficulties be determined before any attempt is made to correct them, and a diagnosis of the changes that have occurred must be made before any clinical procedures are started. It is also necessary to determine their nature, extent, and location and to understand what changes may occur and their associated signs and symptoms.

Dentures with built-in occlusal errors may only require this to be corrected rather than relined. Simple tests of individual denture bases may show that stability and retention have not been lost, even though the patient reports that the dentures are loose. In this situation the fault may lie in occlusal errors producing excessive displacing forces. The stability and retention of the base of either prosthesis should be examined independently. The denture is lightly seated against the ridges and moved horizontally in both

lateral and anteroposterior directions. A well-adapted denture is unlikely to move more than 1 to 2 mm, which is consistent with tissue displaceability. Vertically loading each denture independently may exhibit rocking. Upward or labially directed forces on the anterior maxillary teeth test both the denture's fit and posterior border seal. Generally, denture movement or rocking indicates the need for a reline procedure.

If this evaluation reveals a stable and retentive prosthesis, the occlusion may be the culprit. In this situation, the supporting tissues may be asymmetrically inflamed. Treatment involves keeping the dentures out of the mouth for 1 to 2 days to allow the deformed tissues to recover and then reevaluating the denture fit with pressure indicator paste. After correcting errors on the mucosal surface the dentures should be remounted on an articulator and occlusal adjustment performed. These procedures will eliminate the cause of the problem and make the dentures comfortable and serviceable without relining.

A change in the basal seats of the dentures is usually revealed by looseness and movement of the prostheses on clinical examination, general soreness and inflammation, discernible loss of the occlusal vertical dimension and compromised esthetics, or disharmonious occlusal contacts. An examination of the oral mucosa that supports the dentures will indicate its health. When this tissue is markedly inflamed, occlusal disharmony associated with loss of the VDO should be suspected. This also can cause unsatisfactory changes in esthetics, even though the teeth may seem to occlude properly. Overextension of denture flanges may have been present when the dentures were first made or arisen as a result of alveolar resorption and can result in ulceration or hyperplastic tissue in the sulci. If the supporting tissue is traumatized, surgical correction to eliminate the hyperplasia may be necessary before relining impressions are made. This, however, should not be done until the effects of robust reduction of the flanges and placement of a tissue conditioning material have been assessed. Alternatively the patient may be able to refrain from denture wear for 1 to 2 weeks. Either of these frequently results in complete resolution of the soft tissue hypertrophy.

Individual changes in the morphology of the bone supporting the dentures are unpredictable and their effects must be carefully assessed (Fig. 14-2). They can cause not only alterations in the VDO but also changes in the relative horizontal relations of the dentures as they move because of their poorer adaptation to the supporting tissues. A loss of vertical dimension will also automatically cause the mandible to have a more forward position in relation to the maxillae than that at the original occlusal vertical dimension. This situation can exist even though the jaws are maintained in the centric relation (CR) position.

Resorption of the maxillary bone usually permits the upper denture to move up and back in relation to its original position. Consequently patients may complain of pain in the anterior vestibule below the nose. However, the occlusion also may force the maxillary denture forward. The lower denture usually moves down and forward, but it may move down and back relative to the mandible as resorption occurs. Concurrently, the mandible closes, and the patient's VDO is less than that before the resorption occurred. This movement is rotary around an axis approximately through the condyles. Because the occlusal plane and the body of the mandible are located below the level of this axis, the mandible moves forward as the space between the maxillae and mandible is reduced from that existing when the dentures were constructed originally. Such rotational forward movement of the body of the mandible is not necessarily eccentric as the CR position of the condyles may be retained despite the apparent anterior movement of the mandible when observed in relation to the maxillae.

The effects of this rotary movement vary from patient to patient and appear to result from a complex interaction of several features, particularly the duration and magnitude of bone resorption and the mandibular postural habit (Fig. 14-3).The mandible's rotation may have a number of consequences that frequently occur simultaneously: (1) loss of the centric relation occlusion (CRO) in the dentures, (2) changes in the structures that support the upper denture, and/or (3) either backward displacement of the lower denture so that it impinges on the lower ridge or forward displacement with an ensuing prognathic appearance (Fig. 14-4).

It appears then that mandibular rotation can elicit severe damage in the denture-supporting tissues over a long period of unsupervised denture wear. The stresses are probably augmented by the use of cusped posterior teeth and by the resultant incisal guidance, resulting in interlocking of the dentures. Although proponents of the use of "cuspless" teeth cite this as an advantage of the technique compared with the use of "cusped" teeth, no research evidence is available to support either school's claim that its tooth choice minimizes changes in the denture-supporting tissues.

The horizontal position of each denture in relation to its own supporting ridge must be considered, so that a determination can be made as to whether it has moved forward or backward because of occlusal forces. Furthermore, one or both dentures may have rotated in relation to the supporting structures. The occlusion in the mouth cannot therefore be used as a guide to the horizontal repositioning of either denture. A new determination of the vertical dimension of the face must be made by reestablishing a normal interocclusal distance, using the principles employed in the construction of complete dentures. Examination of the esthetics in profile, as far as the support of the lips in an anteroposterior direction is concerned, will serve to guide the orientation of the dentures in relation to their respective foundations. The relation of the teeth to the ridges must be observed for accuracy. If resorption has been only in the

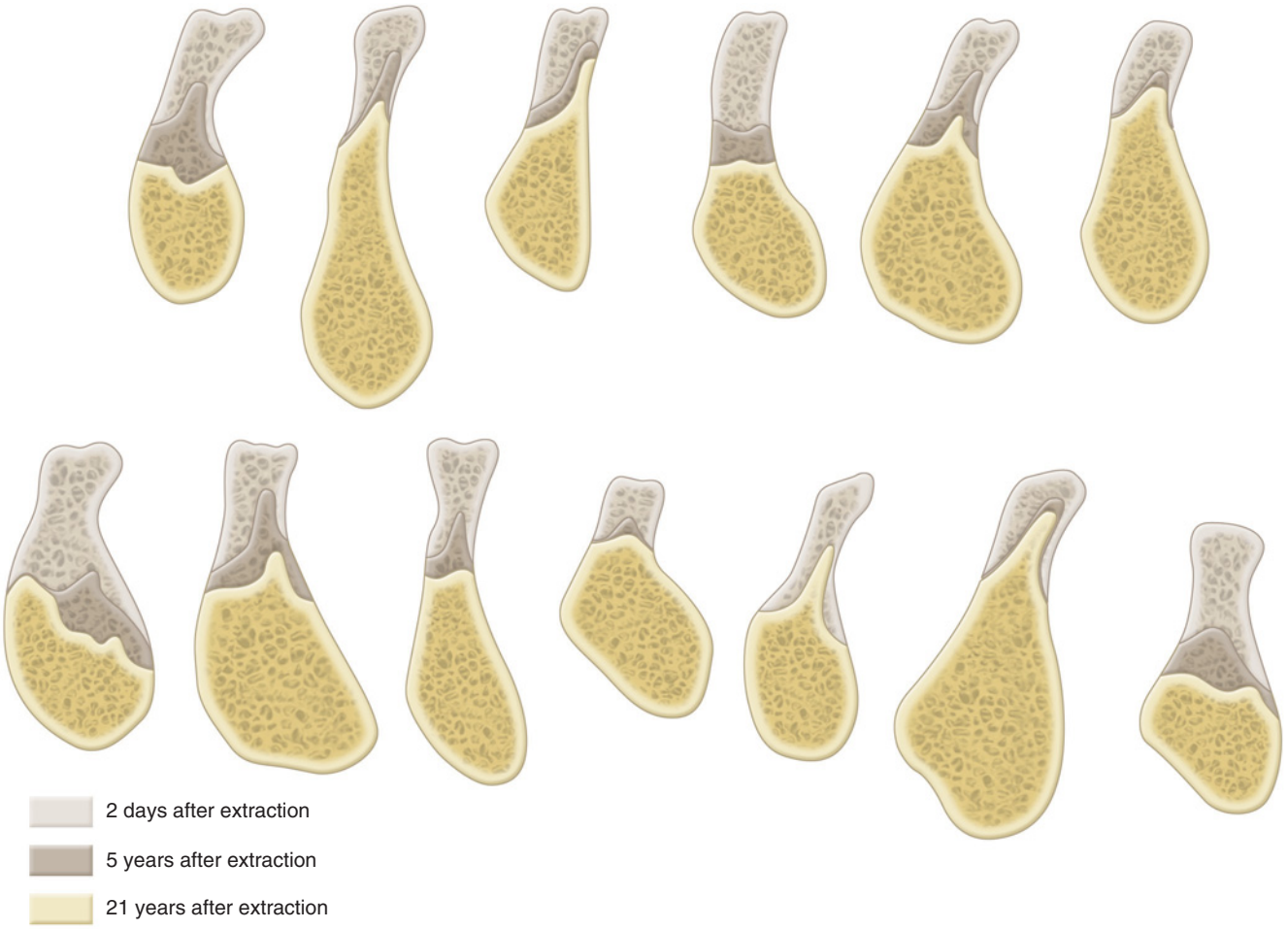


Figure 14-2 Bergman's and Carlsson's research comprised sequential cephalometric tracings from the mandibular symphysis region in 13 denture-wearing patients. The latter had been treated with immediate complete dentures and observed for 21 years after their extractions; all patients wore opposing complete maxillary dentures. All 13 composite tracings underscore the range and unpredictability of the morphological outcome. The data from this research serve as a strong reminder that clinical judgment regarding the mandibular denture's repositioning for relining purposes requires an understanding of resultant bone resorption outcomes. However, comparable information of similar changes in edentulous maxillae is not as compelling.

vertical direction (allowing the jaws to approach each other more closely than they should when occlusal contacts are made), the occlusion cannot be presumed to be correct, even though there has been no anterior or posterior movement of the dentures.

It also must be determined whether remodeling of the jaws has been uniform under both dentures and whether one ridge has been destroyed more than the other. The latter will result in changes in the orientation of the occlusal plane, which will cause occlusal disharmony in eccentric occlusions, even when the occlusal vertical dimension is reestablished by relining. A visual comparison of the size of the ridge with the size of the alveolar groove in the denture can serve as a guide.

PRELIMINARY TREATMENT

If the dentures have been made relatively recently, then resorption may not have been too dramatic, the esthetics of the facial profile only compromised by a few millimeters, and the teeth still in place relative to the mandibular ridge. Such circumstances suggest that a reline procedure of both dentures may be successfully accomplished. However, if greater errors in the fit, occlusion, occlusal plane, esthetics, and optimal relationship of the teeth to their original location are evident, then the clinician may be wise to advise the patient that new dentures are necessary or that any changes in the existing prostheses should be performed





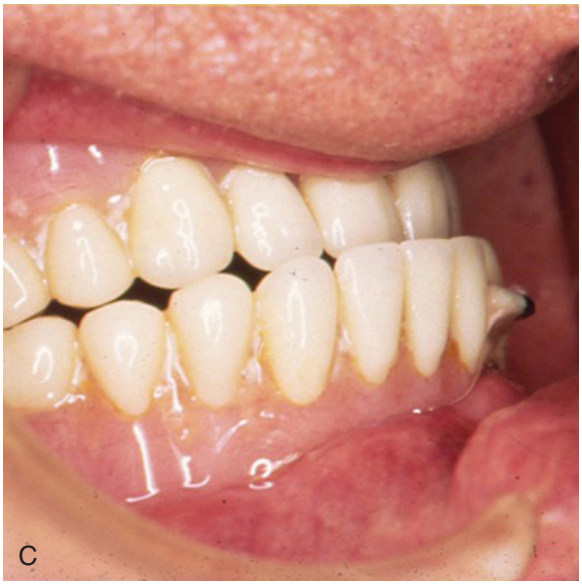






Figure 14-3 **A** to **C,** A composite traditional depiction of profiles and circumoral appearance that suggest aging, reduced, or collapsed VDO and the effects of ridge reduction on the appearance and occlusal relations of prolonged and unserviced denture wearing. **D** and **E,** Edentulous maxillae can be "hammered" into accelerated residual ridge reduction in the presence of severe occlusal overload. Maxillary complete dentures in these situations are likely to require frequent relining efforts.

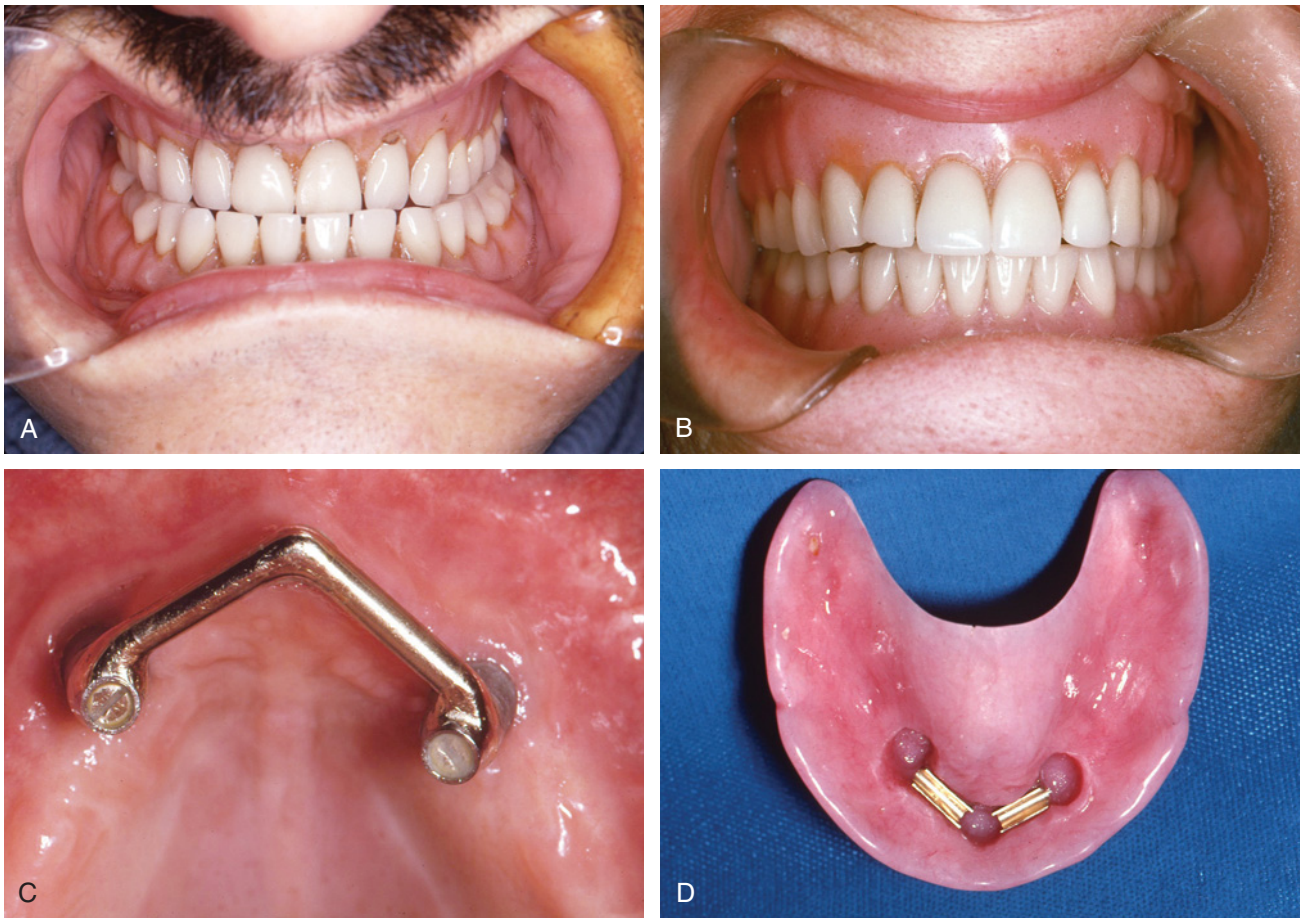


Figure 14-4 Loss of bone structure under both dentures, especially mandibular ones **(A),** permits the mandible to move upward a corresponding amount. As the mandible rotates to a closed position without translation of the condyles, it frequently moves forward, leading to a prognathic appearance. The clinical challenge is to determine the amount of change that has occurred in both basal seats and estimate the resultant dentures' shifts. The occlusion is clearly incorrect when observed in the mouth of the patient seen in **A,** or it may appear deceptively adequate as in the patient seen in **B,** because the extraoral close-mouthed appearance can be almost identical in both situations. **C** and **D,** The edentulous maxilla had been previously opposed by a natural mandibular dentition for many years, with a resultant heavy biological price exacted from the integrity of the maxillary edentulous ridge. The resulting facial appearance and mandibular forward posturing demanded rectification via an implant-supported maxillary overdenture to achieve an esthetic result that was satisfactory for the patient. This situation had advanced beyond a straightforward maxillary denture reline solution. Note the unusual bar design associated with the anterior residual bone. A stud attachment (see Chapter 17) would include the need for such a retentive mechanism.

solely for diagnostic purposes and to temporarily improve their comfort. Managing so many interrelated variables when rebasing dentures, without having control of the dentition, often results in revised prostheses that require major modification of the teeth to achieve occlusal harmony. Severe revisions of the dentition often produce poor esthetic results that the patient will not accept.

Should the clinician choose to proceed with modifications to the basal seats and possibly occlusion of the existing dentures, then some preliminary steps are required before the actual reline procedure. These have the following objectives: (1) reestablishing the height, orientation, and esthetics of the occlusal plane by modification of the mandibular denture (usually, though not necessarily, done first) and (2) relating the maxillary and mandibular dentures while the correct occlusal and esthetic position of the maxillary denture is being established. Both objectives may be achieved more or less automatically using a tissue

conditioner as a provisional reline material, particularly if the adverse changes to be corrected are mild to moderate (see Chapter 7). On the other hand, severe changes may necessitate using combinations of compound stops, tissue conditioners, occlusal adjustment, and augmentation of the denture's occlusal surfaces with tooth-colored autopolymerizing resin. This is routinely done to compensate for extensive vertical occlusal changes.

The obvious advantages of using tissue conditioners include simultaneous restoration of a healthy basal seat and the ease with which the liners can be modified for maximal function and cosmetic results.

Once the supporting tissues are healthy, the dentist should check for errors in the occlusion and occlusal vertical dimension that should be corrected, as well as any other changes to the prostheses that might be required before the final procedure is undertaken. Such measures may require several patient visits over a number of weeks while the tissues recover normal health and an appropriate occlusion is established. If this requires more than minor occlusal adjustments, the clinician may choose to maintain the patient with these "temporary" dentures while new prostheses are fabricated, guided by the diagnostic findings determined from working with the patient over several weeks.

CLINICAL IMPRESSION PROCEDURES

Clinically relining or rebasing can be achieved with either (1) a static impression technique, or (2) a functional impression technique, or (3) the so-called chairside technique. Whichever technique is employed, it is important to ensure that there are no undercuts within the support surface of the denture because these will hinder its removal from any cast that is ultimately poured in the impression.

STATIC IMPRESSION TECHNIQUE

The static impression technique involves the use of either a closed- or open-mouth reline/rebase procedure. In the former, the dentures are used as impression trays and either the existing CRO is used to seat the dentures with the lining impression material in place or the CR is recorded (in the registration medium of choice) before the impressions are made. Often only the mandibular denture requires relining, and this can be done with the prosthesis in occlusion with the maxillary denture. It has been suggested that the maxillary prosthesis be additionally secured with denture adhesive powder when employing this protocol. The clinician seats the mandibular denture as close as possible to its appropriate position, and the patient then closes into the selected occlusal position. If the maxillary denture needs relining, the impression can be recorded with the prosthesis in occlusion with the mandibular denture. Care should always be taken that the posterior borders of the dentures do not make contact during the impression procedures. This can often go unobserved and cause severe occlusal discrepancies that become evident at delivery.

In the so-called open-mouth method, the dentures are used essentially as trays for making the new impressions, which may be done for both jaws at the same appointment. The existing centric occlusion (CO) is not used, and a new CRO record is obtained after the impressions have been made. This is a demanding and laborious technique. Again, the clinician should position the dentures in the mouth at the preferred positions using low-fusing compound tissue stops to ensure that they are reproducible when recording the final impressions. This will ensure that the appropriate occlusal contacts, occlusal plane, and esthetic position of the anterior teeth are maintained. Any minor occlusal discrepancies may subsequently require correction using a remount procedure.

The closed-mouth reline/rebase method is preferred when the static impression technique is used. Several variations have been suggested, all based on using the denture as an impression tray and the actions of the patient to mold the peripheries. The prosthesis is held in position by the patient occluding on the opposing denture before which the occlusion should be corrected either in the preliminary treatment or by modification with hard wax or compound. Box 14-1 presents three primary areas that must be addressed

Box 14-1 Necessary Steps for a Closed-Mouth Reline Technique

1. Record Centric Relation
   - Existing correct intercuspation (CRO) used to stabilize dentures
   - Wax interocclusal record made at CR
   - Corrected during reestablishment of a new VDO by occlusal adjustment or use of autopolymerizing resin on the occlusal surfaces of posterior teeth
2. Denture Preparation for the Impression Protocol
   - Large undercuts relieved
   - Hard resin surfaces relieved 1 to 2 mm
   - Tissue conditioner removed or relieved
   - "Escape" holes drilled, particularly in the maxillary base; this also will assist easy removal of palatal portion during laboratory rebase
   - Denture periphery shortened to create a flat border
3. An Impression Procedure
   - Border molding achieved with preferred material (e.g., low-fusing compound)
   - Border molding retained from polymerized tissue-conditioning material
   - Posterior palatal seal achieved with low-fusing compound
   - Border molding achieved by choosing impression material that is soft and yet viscous enough to support and register peripheral detail (e.g., one of the polyether impression materials)

and meticulously followed when making a denture reline impression. Doing so will produce repeatedly good results. Finally, the dentures are sent to the laboratory with a prescription containing directions to the laboratory technician including the specifications for alterations, materials, finish, remount casts, and remounting of the upper denture.

FUNCTIONAL IMPRESSION TECHNIQUE

The so-called functional impression technique is both simple and practical and has gained considerable clinical support. It is based on the use of tissue conditioners as functional impression materials and depends on a thorough understanding of their properties. The relative ease with which these temporary soft liners can be used as functional impression materials has regrettably led to their abuse and to criticism of the technique by many dentists. However, they are excellent for refitting complete dentures when used carefully and meticulously. Improvements in these materials include their retaining compliance for many weeks, their good dimensional stability, and their excellent bonding to the resin denture base.

The signs and symptoms indicating a need to refit a denture typically include reduced retention, sore spots, and variable hyperemia of the denture-bearing tissues. The denture should be observed intraorally to assess the need for peripheral reduction or extension. Frequently a posterior palatal seal extension is required using an autopolymerizing resin or modeling compound. (Infrequently, if extensive ridge resorption and overt loss of VDO have occurred, three compound stops may be required on the impression surface of the denture to reestablish a proper occlusal relationship or to improve the occlusal plane orientation.) A treatment liner is next placed inside the denture. The lining material should flow evenly to cover the whole impression surface and the borders of the denture with a thin layer. If voids are evident, they should be filled with a fresh mix of liner material.

Unsupported parts of the liner may occur on the borders of the denture, and this indicates that localized border molding with stick modeling compound, autopolymerizing resin, or a VLC material may be needed before the placement of a fresh mix of liner. Occasionally borders are formed that are thin and very flexible, which is also indicative of inadequate peripheral extension of the denture and should be corrected as above. Tissue liners function best when well-supported and where this is not the case, they will tend to slump while "setting." (Such materials do not set in the conventional sense, that is, by chemical reaction.) The patient's mandible should be guided into a retruded position, which is one of maximum intercuspation, to help stabilize the denture while the lining material is setting. Excess material may then be trimmed away with a hot scalpel or wax knife. Most of the materials used for this purpose progress through plastic and then elastic stages before hardening, which can take several days (Fig. 14-5). The plastic stage permits movement of the denture base or bases so that they are more compatible with the existing occlusion, and it allows the displaced tissues to recover and assume their original contours.

Keeping the soft liner in good condition can be accomplished either by replacing it every 2 to 5 weeks, depending on the choice of material, or by treating the temporary liner and especially the seam between the soft liner and the denture base with a sealant that can be made up using an autopolymerizing acrylic resin powder and a solvent such as 1-1-1 trichloroethane. The patient should be instructed regarding care of the prosthesis and its lining material. It should be noted that the strength of the processed resin may be reduced by the addition of a tissue conditioner, and the processed resin may therefore have to be reinforced on the polished surface by the addition of autopolymerizing resin; it is also prudent to warn the patient of the increased risk of denture fracture.

Research and clinical experience have shown that a number of commercially available denture cleansers and other preparations that may be helpful in the control of

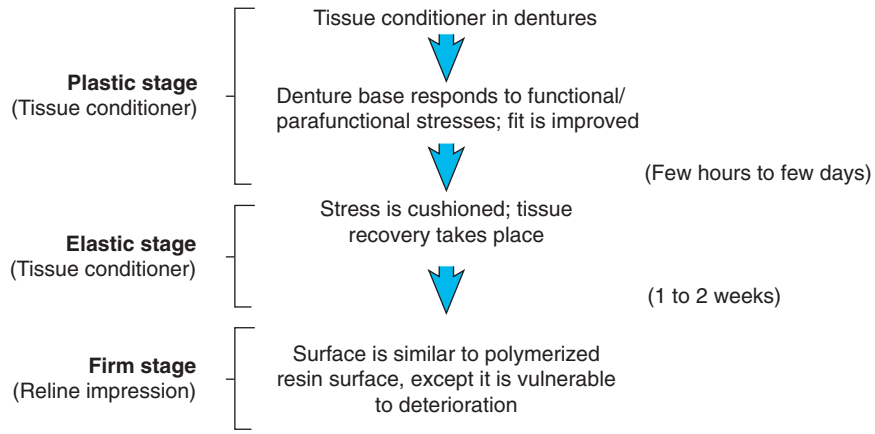


Figure 14-5 The physical stages of tissue conditioners/treatment liners permit their versatile use for different clinical stages and objectives. Soft liners are primarily used to distribute functional stresses on residual alveolar ridges and reduce the amount of energy transmitted during both functional and parafunctional contact movements.

plaque on dentures cause significant deterioration of tissue conditioners in a short time. Apparently, simple rinsing of the temporarily lined denture and gentle brushing with a soft toothbrush are good interim measures to minimize damage to the lining. Clinical experience also indicates that a suitable time interval—usually 10 to 14 days—should elapse before the material is firm enough to proceed with the clinical reline sequence.

At the next appointment, the mucosa should appear healthy and the temporarily relined denture be well retained, with suitably rounded peripheral borders. It has been observed that the tissue-conditioning materials may create problems when used for recording impressions. The gradually increasing elasticity of the material in the mouth can lead to changes in its shape when the load is removed, that is, when the impression is removed from the mouth. It is thus important to delay using the impression until the material has become firm.

Furthermore, these materials tend to deteriorate rapidly in some patients, which precludes their use in this manner. If the dentist has any doubt about the quality of the surface appearance of the hardened liner, the reline procedure should be carried out as described earlier in this chapter, after the interim treatment liner has been removed or relieved. If, however, the surface or peripheral deterioration is slight, these areas can be trimmed with a carbide bur and the denture or dentures prepared for a secondary, or wash, impression with a light-bodied impression material. The stone cast must be poured immediately after removal of the relined denture base from the mouth.

The physical properties of the tissue-conditioning materials mean that certain precautions must be taken when using them as impression materials. In particular, the material should not be plastic when the impression is poured because the weight of the material itself, or that of the dental stone used to form the cast, will cause it to distort. The initial plasticity of the material also means that it does not cause significant tissue displacement at the posterior border of the upper denture. A seal can therefore only be achieved in this region by cutting a post-dam in the cast or placing a narrow strip of a more rigid material such as impression compound or visible light cured (VLC) resin in this region, thus ensuring tissue displacement.

The making of a new CRO record and use of a remount procedure are recommended to ensure an optimal prosthodontic occlusion. Researchers have demonstrated that the functional status of dentures relined with treatment liners used as impression materials is as good as that of dentures relined by border molding and then refined with a light-bodied impression material.

Both the static impression technique (and its variations) and the functional impression technique are well-accepted and experience-proven procedures. They can be used for simple situations (where denture settling is minimal) and complicated situations (where excessive tissue changes have taken place). It appears that the choice between the two methods is based on the dentist's skill in manipulating the materials and the patient's convenience.

CHAIRSIDE TECHNIQUE

Several attempts had been made to produce an acrylic or other plastic material that could be added to the denture and allowed to set in the mouth to produce an instant chairside reline/rebase. These have met with failure for several reasons: (1) the materials often have produced a chemical burn on the mucosa; (2) the resulting material was often porous and subsequently developed a bad odor; (3) color stability was poor; and (4) if the denture was not positioned correctly, the material could not be removed easily to start again.

The more recent introduction of VLC resin systems has produced promising results when used in a wide range of prosthodontic activities. These materials can be partly polymerized at the chairside using handheld curing lights, but require a more powerful light chamber device for complete curing. Biological testing indicates that they are more biocompatible than self-curing materials. Ongoing research also appears to have improved their properties (such as fit, strength, ability to polymerize with reduced unreacted components, ease of fabrication and manipulation, patient acceptance, ability to bond with other denture base resins, and low bacterial adherence). VLC materials are available in a wide range of formulations of varying viscosity, including flowable presentations. The VLC resins are useful for the temporary modification of dentures, including corrections to the posterior border seal on the upper denture and the extension of flanges, and may be employed for relining dentures.

The VLC resin relining materials are employed in a similar manner to a tissue conditioner, with all the possibilities of instant modifications because the flow of the material can be regulated by selection of appropriate viscosity, working temperature, and partial intraoral polymerization with a handheld curing light**.** The relined denture is then taken to the laboratory for immediate and more thorough curing of the new layer of material in a dedicated light chamber device. The technique is not, however, suited to situations where there are undercut areas on the dental ridges because the reline material can be distorted during removal and becomes rigid once cured. The VLC materials are also relatively brittle, but when supported by the original processed denture base and flanges, they have appropriate strength for interim clinical applications based on the authors' experience.

RELINING/REBASING MATERIALS

For many years, it was thought that the strains inherent in the processed denture base would be released by subsequent processing resulting in its warpage. The dimensional change in the resin has been reported as 1.5% to 3% by many

authors, and it has been advised that the laboratory technician should use a lower temperature for heat processing as opposed to a boiling technique. However, dentures also can be adequately relined with one of the autopolymerizing resins, allowing trial packing to control vertical dimension and the thickness of the material, without concern for temperature changes and warpage.

When autopolymerizing resin is used, the processed dentures can be ready for insertion on the same day that the impressions are made. The protocol described in Chapter 12 (i.e., prosthesis insertion) should be followed and occlusal refinement done intraorally or on the articulator. Follow-up instructions are similar to those provided when new dentures are inserted.

REPAIRS

Complete dentures are predominantly fabricated from acrylic resin, with the occasional use of porcelain teeth, and may incorporate metallic components, principally as denture bases and retention devices where implant stabilization is used. Acrylic resin is relatively weak and prone to fatigue and impact fracture. Porcelain teeth tend to chip and are prone to impact fracture, and both they and metallic components can lose their bond with the acrylic parts of the prosthesis. As a result, the dentist will be regularly called upon to repair dentures. Sometimes this may be carried out at the chairside, although typically the work will need to be done in a dental laboratory. By their very nature, repairs are usually required at short notice, and because few patients have well-functioning spare dentures, this work must be done as quickly as possible. There is consequently a tendency to carry out the repair without fully investigating its causes, the management of which may well require more than the rejoining of the fractured components. Repeated similar repairs to the same prosthesis can become cumulatively expensive of time and money and do little for patient confidence.

In addition to sudden and catastrophic failure, dentures also are prone to gradual wear, particularly of the occlusal and incisal surfaces of the teeth, and to deterioration of the materials from which they are fabricated. The management of these is usually carried out as part of a relining/rebasing procedure.

Fracture of acrylic denture bases is a common problem that can result from impact, fabrication errors, inappropriate design, excessive loading, alveolar resorption, and wear of the teeth. Impact fracture usually results from dropping the denture either onto the floor or into a sink while cleaning the prosthesis. The latter can be avoided by filling the sink with water. The elderly often have reduced manual dexterity and are thus more likely to drop their dentures. Typical fabrication errors include excessive thinning of the palate of the upper denture; an inadequate cross section in the midline of the lower denture; and excessively accentuated frenal notches that act as stress raising features, resulting in crack initiation and subsequent propagation. Excessive loads typically arise when a complete denture is opposed by natural teeth, although some edentulous individuals use very high masticatory forces with similar effects. Alveolar resorption in the upper jaw can result in the denture being flexed around the midline during mastication, with the loads being enhanced by the leverage effects. Wear of the occlusal surfaces of the artificial teeth can sometimes result in the surfaces of the mandibular molars facing buccally and the maxillary molars lingually. As a result, when the patient occludes, the upper denture will tend to be flexed around the midline.

Management of a fractured denture is relatively straightforward, provided that there is a clean break and the fractured components are available and may be accurately reassembled. In these circumstances a laboratory repair can be readily carried out. Where reassembly is challenging, then it can sometimes be helpful to locate the remaining components using the occlusal contacts with the opposing denture as a guide to their positioning. In extreme circumstances, there may be no recourse other than to make a new denture. Where indicated, the patient also should be advised on appropriate handling of the dentures to avoid reoccurrences. If the fracture is associated with design faults or has resulted from alveolar resorption, then it is usually preferable to either reline or rebase the denture once it has been repaired, remedying any design faults at that stage. Where the cause of the fracture is thought to be excessively high masticatory loads, then consideration should be given to making a new denture with either a metal-reinforced or fiber-reinforced acrylic base (see Chapter 7).

Fracture of a denture tooth usually occurs as a result of impact and requires the removal of the remaining portion and its replacement with a new tooth. This procedure is best carried out in the dental laboratory.

Loss of a tooth from a denture also can occur as a result of impact or because of inadequate bonding of the tooth to the denture base. This can result from contamination of an acrylic tooth during denture fabrication and is also more common when using porcelain teeth, which are retained purely mechanically. A similar difficulty is sometimes encountered when using highly cross-linked acrylic teeth. Again, replacement is best carried out in the dental laboratory for which clinical records are not normally required, provided that the opposing denture or a cast of the opposing dentition is available.

Fractures associated with metallic components are, in the case of denture bases, almost exclusively related to failure of the bond between the acrylic resin and metal. This can arise from inadequate retention features on the metal base or as a result of fatigue failure. This is often accentuated by alveolar resorption, which places excessive stresses on the bond between the acrylic and metal components.

Failures associated with the retention components used to link complete dentures to dental implants can present

either as fracture of the component or failure of its bond with the denture base. This can arise as a result of design or construction errors or following alveolar resorption, which results in the denture rocking around the retention components with resultant stress concentration in these regions. Repairs are best carried out in the dental laboratory and require clinical records so that the technician can precisely position the retaining component. There are principally two methods of doing this; one employs a localized "pick-up" impression, while the other essentially involves the recording of a reline/rebase impression. In the case of the former, a hole needs to be made in the denture over the relevant implant, with which the retaining component is fully engaged. If the manufacturer recommends the use of a spacer when locating the attachment, then this should be used. The retaining component is then linked to the seated denture using either autopolymerizing acrylic resin or a low viscosity VLC resin applied with a disposable brush. Care must be taken to avoid placing an excess of resin, which can lock the denture to the implant. The prosthesis may then be sent to the laboratory for repair. Where the retention component has been lost or severely damaged, then it will be necessary to use a premanufactured impression coping in its place. Should the fracture be associated with faults in the denture that require it to be relined/rebased, then this procedure may be carried out at the same time. However, it is then necessary to record the positions of all implant-linked retaining components. This will require the use of an impression coping on each implant, although where these are linked with a retaining bar, then alternatively this may be picked up in the impression. To do so the prosthetic screws will need to be replaced with guide pins inserted through suitably located holes drilled in the denture base. These may need to be remarkably large if the long axes of the implants are markedly diverged. Apart from the specific needs associated with the recording of the positions of the implants, the procedure is essentially similar to that when rebasing/relining a denture.

There are very occasionally situations of extreme urgency when it may be necessary to attempt a temporary repair at the chairside. This should only be done when a laboratory repair is impossible and when the related components are available and may be accurately located. The procedure should be limited to situations where the repair can be carried out using acrylic resin. The process essentially involves locating the components, securing them in position, and then carrying out the repair. Location can usually be accurately done by hand and the components then temporarily secured with cement wax or a low-viscosity VLC resin, applied by an assistant. They should next be stabilized using a mix of impression plaster, although where this is not available, a heavy-bodied elastomeric impression material may suffice. The fractured surfaces should then be trimmed and smoothed so as to allow a small amount of autopolymerizing acrylic resin to be run into the interface. Once this has polymerized, then the repair may be smoothed and polished. Such repairs can be enhanced if a pressure-curing vessel is available.

DENTURE DUPLICATION (SEE CHAPTER 23)

Successfully functioning complete dentures can provide useful information when fabricating new prostheses, even where they are poorly adapted to the supporting tissues and exhibit deterioration of the materials from which they have been fabricated. There exist a number of techniques for duplicating dentures ranging from the creation of a simple replica in wax or acrylic resin to a fully functioning prosthesis. These can be useful in a limited number of circumstances and in particular (1) when fabricating a spare denture, (2) when making new dentures for an elderly patient who has an old but much loved prosthesis to which they have adapted well, and (3) as an aid to the planning and fabrication of implant-stabilized dentures where the existing prostheses are satisfactory apart from a lack of stability.

On occasion, a patient may request a spare set of dentures for personal reasons. These are best fabricated at the same time as making a new set because the dental technician can use the available clinical records for this purpose, duplicating casts where necessary. However, when the patient makes this request in relation to a recently constructed and satisfactory set of dentures, then these can be duplicated in the laboratory using standard techniques.

Duplicated dentures also can be useful on occasion when making new prostheses for elderly patients with reduced adaptive capacity who have become accustomed to using their existing dentures over an extended period. Such patients do not always respond well to significant, albeit theoretically correct, changes in their new prostheses. In these circumstances, it is possible to duplicate the existing dentures, usually in wax with an acrylic base plate that can then be employed to record both working impressions and the jaw relationship. This facilitates the making of new dentures that retain some of the characteristics of the old while correcting their significant deficiencies such as poor adaptation to the supporting tissues and occlusal errors. Although such dentures may not meet the theoretically optimal requirements for appearance, tissue support, and full restoration of the VDO, they may nevertheless provide such patients with more satisfactory function than more conventionally designed and constructed dentures.

Duplicate dentures also can be useful when providing implant treatment for a patient who is using recently constructed and inherently sound complete dentures, apart from a lack of stability, which it is intended that the implants will correct. Duplicate dentures in these circumstances provide a valuable indication of the prosthetic envelope when planning implant placement and superstructure design and also can be used as custom trays and record rims,

thus saving laboratory and clinical time and ensuring that the implant-stabilized prostheses will provide a similar appearance to the existing dentures.

Bibliography

Ali IL, Yunus N, Abu-Hassan MI: Hardness, flexural strength, and flexural modulus comparisons of three differently cured denture base systems, *J Prosthodont* 17(7): 545-549, 2008.

Bergman B, Carlsson GE: Clinical long-term study of complete denture wearers, *J Prosthet Dent* 53:56-61, 1985.

Braden M, Wright PS, Parker S: Soft lining materials—a review, *Eur J Prosthodont Res Dent* 3:163-174, 1995.

Dorner S, Zeman F, Koller M, et al: Clinical performance of complete dentures: a retrospective study, *Int J Prosthodont* 23(5):410-417, 2010.

Duthie N, Lyon FF, Sturrock KC, et al: A copying technique for replacement of complete dentures, *Br Dent J* 144(8):248-252, 1978.

Kanie T, Arikawa H, Fujii K, et al: Flexural properties of denture base polymers reinforced with a glass cloth-urethane polymer composite, *Dent Mater* 20(8):709-716, 2004.

Murata H, Taguchi N, Hamada T, et al: Dynamic viscoelastic properties and the age changes of long-term soft denture liners, *Biomaterials* 21:1421-1427, 2000.

Polyzois GL, Kakaboura AI, Eliades GC: Curing efficiency of visible light- and dual-cured denture reliners, *Int J Prothodont* 13(6):520-525, 2000.

Yemm R: Replacement complete dentures: no friends like old friends, *Int Dent J* 41(4):233-239, 1991.

CHAPTER 15

Speech Considerations with Complete Dentures

Li-Deh Lin

Oral motor functions, such as mastication and speech production, share many common features. They are intimately related because the mouth, lower jaw, lips, teeth, and tongue are used for both activities. Because a major portion of speech articulation takes place within the oral cavity, complete dentures may alter those structures and will inevitably mediate a disturbance in speech production. The disturbance may be minor or more substantial in importance, depending on individual responses. Fortunately, the phonetic problems that arise when speaking with new dentures rarely pose serious difficulties. Because most patients' ability to adapt is good, initially experienced speech disturbances will be transient. Nevertheless, the treatment objective is to make complete dentures conform to the individual patient's existing neuromuscular patterns, rather than rely too much on the patient's ability to adapt.

In this chapter, some basic background factors for speech production are described to provide knowledge of possible speech problems induced by the fabrication and wearing of complete dentures.

SPEECH PRODUCTION

Controlling the airstream that is initiated in the lungs and passes through the larynx and vocal cords produces all speech sounds. Subtle adjustments in air flow contribute to variations of pitch and intensity of the voice. The structural controls for speech sounds are the various articulators or valves made in the pharynx and the oral and nasal cavities (Fig. 15-1). Speech articulation takes place when any approximation or movement of the articulators constricts, impedes, or diverts the airstream to produce a single sound. The role of teeth and other oral structures forming these articulators (valves) in speech production is discussed in the next section.

Because nearly all speech sounds are emitted from the mouth, the nasopharynx (airway into the nose) is closed off from the oropharynx during speech. Closure is performed by an upward lift of the soft palate. A rapid, continuous movement of the entire length of the soft palate takes place during speech. Intimacy of pharyngeal wall contact, as well as magnitude of movement by the soft palate, varies with the nature and sequence of the speech sounds. As the outgoing air passes through the mouth, the tongue, lips, and mandibular oscillations modify it. The tongue has a critical impact on speech production and needs optimal mobility to lift, protrude, flatten, form a groove(s), and contact adjacent tissues freely. Jaw and tooth relationships enable the tongue to articulate against the maxillary teeth or alveolus, permit the maxillary teeth and lower lip to make easy contact, and allow the lips to touch.

Speech production includes large numbers and sequences of innate and learned motor acts produced in rapid sequences of 12 to 16 sounds per second in a rhythmic behavior. It has been hypothesized that the premotor and motor cortex are required for processing of skills as they become automatic. For the precise movements executed in speech production, the pyramidal motor system has the primary role. Still, there is no convincing evidence to explain fully the mechanisms behind these very rapidly occurring events.

A precise coordination between different articulators is essential for the final sound production. Feedback plays an important role in the learning and control of most motor events, including sequencing and timing of speech movements (Fig. 15-2). Proprioceptive mechanosensitive afferents will establish the timing of certain aspects of the very fast motor pattern and in synergy with cortical information will generate the final motor output and rhythm. Adaptation after an oral rehabilitation may involve the formation of a new speech motor programming. A prerequisite for satisfactory speech sounds and adaptation is an intact general feedback system, including both orosensory and audio feedbacks. Gradual hearing loss could be present at older ages, and the process of adaptation to dental prostheses could be impaired.

It appears that adaptation to complete dentures may be explained by feedback mechanisms related to speech motor programming. Initially, a complete denture wearer attempts to overcome problems related to the new prosthesis by the help of auditory and orosensory feedbacks during function. After a while, only the patient will be aware of remaining articulatory difficulties, which often are related to certain specific sounds. The listener (dentist) is, however, not able

to detect any speech production disturbances. At this stage, there is still sensory stimulation from orofacial afferents to central areas. Finally, if the process of adaptation proceeds, the patient will not be aware of any articulatory difficulties or distortional sounds caused by the prosthesis. New speech production central engrams have been established, and adaptation and habituation to the complete denture occur.

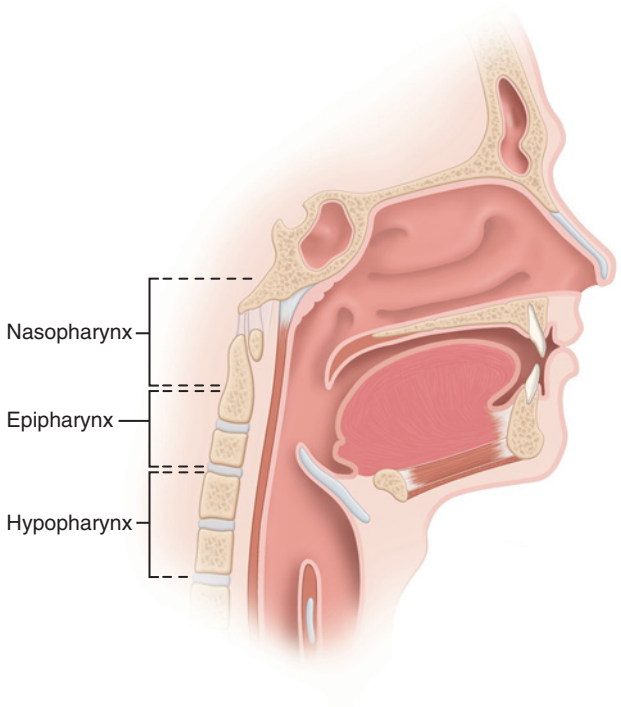


Figure 15-1 The different valves and articulators in the pharynx and the oral and nasal cavities that provide structural controls for speech sounds.

SPEECH PRODUCTION: THE ROLE OF TEETH AND OTHER ORAL STRUCTURES

Because complete dentures may distort speech production, it can be used as a guide to position artificial teeth. However, tooth positions are sometimes critical for the production of certain sounds and not at all for others.

As the teeth are being arranged for esthetics, it is not the speech sound itself that is critical but rather, the interrelationships of the tongue, teeth, denture base, and lips. Speech production made by patients at the try-in appointment can never be as accurate as when the processed acrylic resin denture base has been substituted for the trial bases, and the patient has become accustomed to the new dentures. The following definitions and examples provide information for a tabular presentation of various sounds (Table 15-1). Vowels are voiced sounds; that is, the vocal cords are activated by vibration in their production. They are the free emission of a speech sound through the mouth and require subglottic pressure for the production. The vowels in English are *a*, *e*, *i*, *o*, and *u*, which require minimum articulation and are classified according to the tongue position in the oral cavity and the position of the lips. Consonants are produced as a result of the airstream being impeded, diverted, or interrupted before it is released, such as *p*, *g*, *m*, *b*, *s*, *t*, *r*, and *z*. Consonants may be either voiced sounds or breathed sounds, which are produced without vocal cord vibration. Most consonants may be classified in pairs that are formed

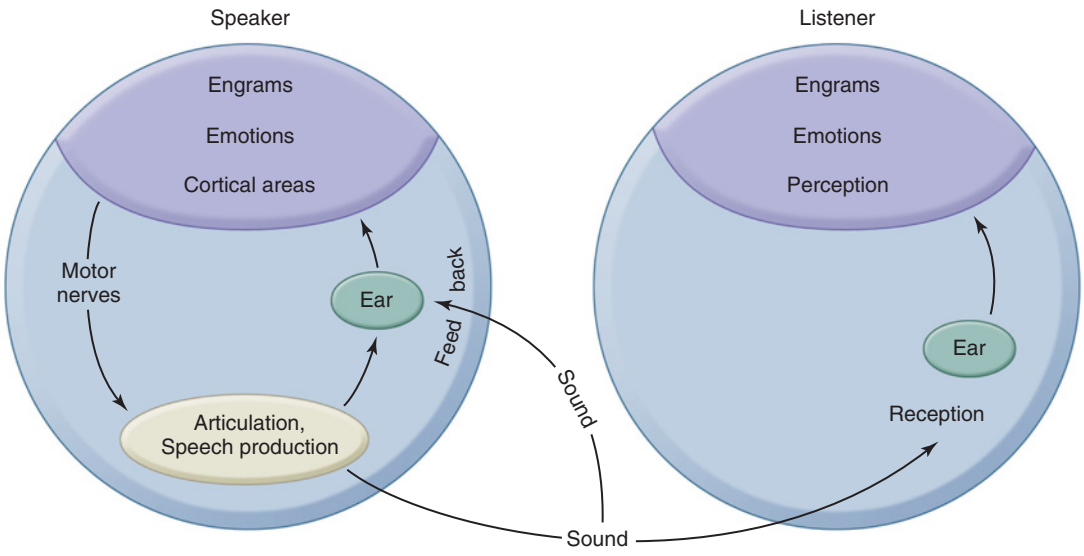


Figure 15-2 A general schema of speech production and communication.

TABLE 15-1 ENGLISH CONSONANTS: THEIR VALVE POSITIONS AND MODES OF PRODUCTION

	Mode of Production											
	Plosives (Stops)		Fricatives		Affricatives		Nasals		Liquids		Glides	
Valve Position	Breathed	Voiced	Breathed	Voiced	Breathed	Voiced	Breathed	Voiced	Breathed	Voiced	Breathed	Voiced
Bilabial	*p* (pay)	*b* (bay)						*m* (man)				*w* (witch)
Labiodental			*f* (fan)	*v* (van)								
Linguodental			*th* (thumb)	*th* (there)								
Linguoalveolar	*t* (to)	*d* (dot)	*s* (so)	*z* (zoo)				*n* (name)				
Linguopalatal			*sh* (shoe)	*z* (vision)	*ch* (chin)	*j* (jar)				*r* (rose)		*y* (you)
Linguovelar	*k* (back)	*g* (bag)	*h* (who)					*ng* (bang)				

in the same manner, except that one is breathed and the other voiced. For example, *p* is breathed; *b* is voiced. Consonants also are divided into groups, depending on their characteristic production and use of different articulators and valves. Plosive consonants, such as *p* and *t*, are consonant sounds produced by stopping the airflow in the vocal tract and releasing the air in an explosive way. On the other hand, fricatives, such as *s* and *z*, also are called sibilants and are characterized by their sharp and whistling sound quality created when air is squeezed through the nearly obstructed articulators. Affricative consonants are a mix between plosive and fricative ones. Nasal consonants are produced without oral exit of air (*m*, *n*, and *ng*). Liquid consonants are, as the name implies, produced without friction, and glides are sounds characterized by a gradually changing articulator shape.

As identified in Table 15-1, six different valves exist, of which five may be affected by teeth position.

BILABIAL SOUNDS

The sounds *b*, *p*, and *m* are made by contact of the lips. In *b* and *p*, air pressure is built up behind the lips and released with or without a voice sound. Insufficient support of the lips by the teeth or the denture base can cause these sounds to be defective. Therefore the anteroposterior position of the anterior teeth and thickness of the labial flange can affect the production of these sounds. Likewise, an incorrect vertical dimension of occlusion (VDO) or teeth positioning hindering proper lip closure might influence these sounds.

LABIODENTAL SOUNDS

The labiodental sounds *f* and *v* are made between the upper incisors and the labiolingual center to the posterior third of the lower lip. If the upper anterior teeth are too short (set too high up), the *v* sound will be more like an *f*. If they are too long (set too far down), the *f* will sound more like a *v* (Fig. 15-3).

However, the most important information to be sought while the patient makes these sounds is the relationship of the incisal edges to the lower lip. The dentist should stand alongside the patient and look at the lower lip and the upper anterior teeth. If the upper teeth touch the labial side of the lower lip while these sounds are made, the upper teeth are too far forward, or the lower anterior teeth are too far back in the mouth. In this situation, the relationship of the inside of the lower lip to the labial surfaces of the teeth should be observed while the patient is speaking. If the lower lip drops away from the lower teeth during speech, the lower anterior teeth are most probably too far back in the mouth. If, on the other hand, imprints of the labial surfaces of the lower anterior teeth are made in the mucous membrane of the lower lip or if the lower lip tends to raise the lower denture, the lower teeth are probably too far forward, and this means that the upper teeth also are too far forward. If the upper anterior teeth are set too far back in the mouth, they will contact the lingual side of the lower lip when *f* and *v* sounds are made. This may occur also if the lower anterior teeth are too far forward in relation to the lower residual ridge. Observing from the side and slightly above the patient will provide the necessary information for determining which changes should be made.

LINGUODENTAL SOUNDS

Dental sounds (e.g., *th* in this) are made with the tip of the tongue extending slightly between the upper and lower anterior teeth. This sound is actually made closer to the alveolus (the ridge) than to the tip of the teeth. Careful observation of the amount of tongue that can be seen with the words *this*, *that*, *these*, and *those* will provide information as to the labiolingual position of the anterior teeth. If about 3 mm of the tip of the tongue is not visible, the anterior teeth are probably too far forward (except in patients with a Class II type 1 malocclusion), or there may be an excessive vertical overlap that does not allow sufficient space for the tongue to protrude between the anterior teeth. If more than 6 mm of the tongue extends out between

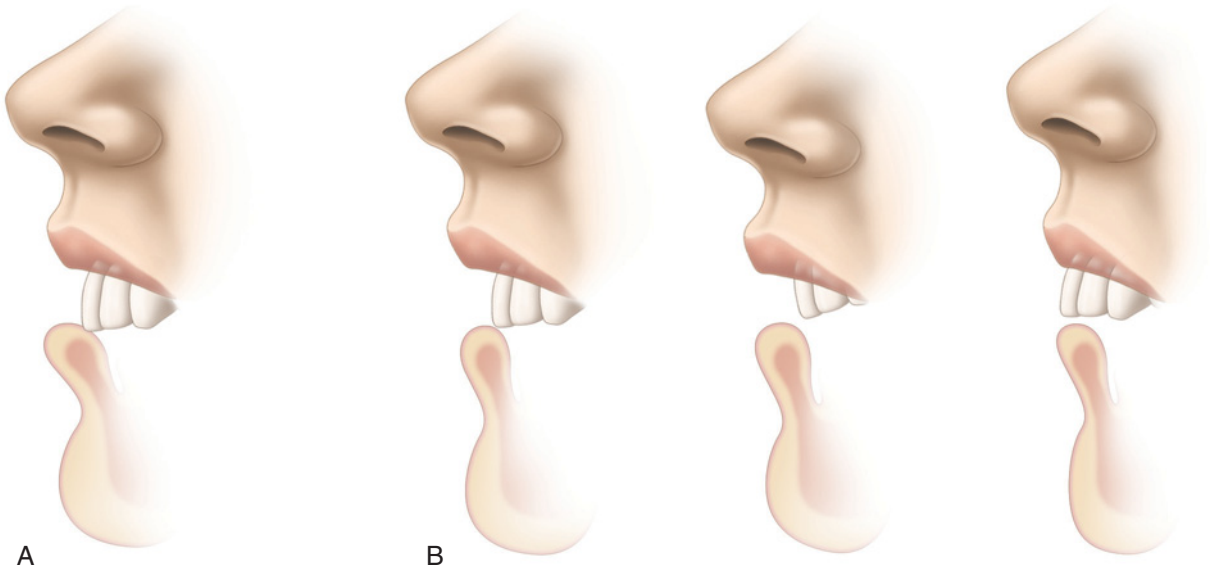


Figure 15-3 Effects of tooth positioning on *f* and *v*. **A,** Upper anterior teeth are too long. During the pronunciation of *f,* they will contact the lower lip in a position similar to *v,* and the sounds may sound alike. **B,** Effects of anteroposterior positioning of the teeth from left to right are correct, too far posterior, and anterior.

the teeth when such *th* sounds are made, the teeth are probably too far lingual.

LINGUOALVEOLAR SOUNDS

Alveolar sounds (e.g., *t, d, s, z, n,* and *l*) are made with the valve formed by contact of the tip of the tongue with the most anterior part of the palate (the alveolus) or the lingual side of the anterior teeth.

The sibilants (sharp sounds) *s, z, sh, ch,* and *j* (with *ch* and *j* being affricatives) are alveolar sounds because the tongue and alveolus form the controlling valve. The important observation when these sounds are produced is the relationship of the anterior teeth to each other. The upper and lower incisors should approach end to end but not touch (Fig. 15-4). A phrase such as "I went to church to see the judge" will cause the patient to use these critical sounds, and the relative position of the incisal edges will provide a check on the total length of the upper and lower teeth (including their vertical overlap). More important, a failure of the incisal edges to approach exactly end to end indicates a possible error in the amount of horizontal overlap of the anterior teeth (Fig. 15-5). This test will reveal the error but will not indicate whether it is the upper teeth or the lower teeth that are incorrect labiolingually.

From a dental point of view, the *s* sound is the most interesting one because its articulation is mainly influenced by the teeth and palatal part of the maxillary prosthesis. Clinical experience suggests that *s* and *t* can cause most problems in a prosthodontic context. In nearly all languages of the world, *s* is a common speech sound. Some languages (e.g., Finnish and Spanish) have diverging *s* pronunciation, but generally the interlanguage quality variation is small. On the other hand, the interindividual variation in articulatory details may be great because of individual variation in teeth, palate, lower jaw, and tongue shape and size. Given this variation, different speakers have to shape the detailed *s* gestures differently to achieve a similar *s* quality. The following phonetic properties, however, are common to all *s* sounds.

Articulatory Characteristics

- The tip of the tongue is placed far forward, coming close to but never touching the upper front incisors.
- A sagittal groove is made in the upper front part of the tongue, with a small cross-sectional area.
- The tongue dorsum is flat.
- Normally, the mandible will move forward and upward, with the teeth almost in contact.

Acoustic Characteristics

- The comparatively strong sound energy is concentrated to a high-frequency range, with a steep energy cutoff at about 3 to 4 kHz.

Auditory Characteristics

- The sound is fairly loud, with a light, sibilant (sharp) quality.
- The *s* sounds can be considered dental and alveolar speech sounds because they are produced equally well

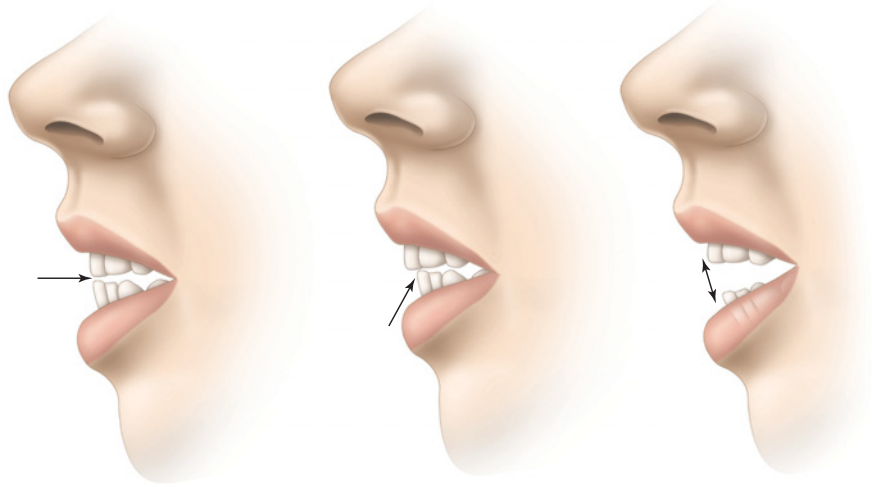


Figure 15-4 Vertical length of the anterior teeth during sibilant production from left to right is shown as correct, excessive, and with inadequate vertical overlap.

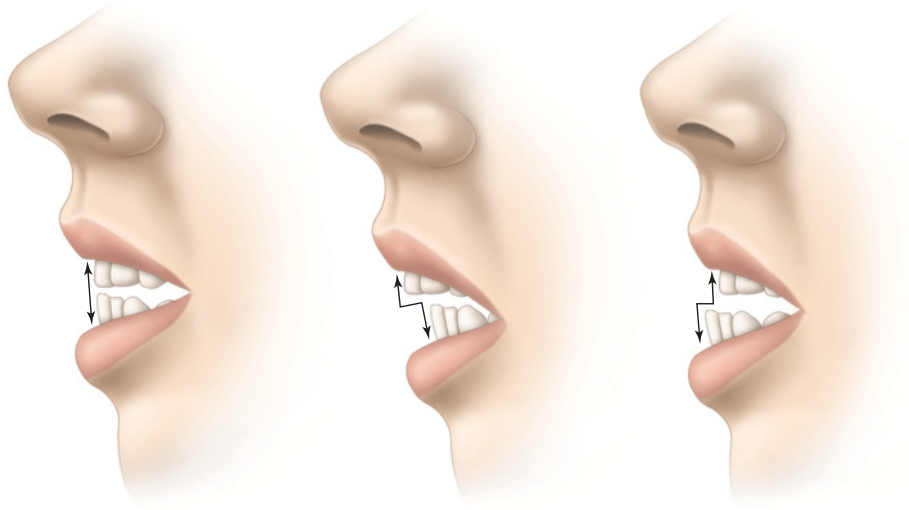


Figure 15-5 Horizontal relation of the anterior teeth during sibilant production from left to right is shown as correct, excessive, and with deficient overlapping.

with two different tongue positions, but there can be some variation even behind the alveolus. Most people make the *s* sound with the tip of the tongue against the alveolus in the area of the rugae, with but a small space for air to escape between the tongue and alveolus. The tongue's anterior dorsum forms a narrow groove near the midline, with a cross section of about 10 mm^2. The size and shape of this small space will determine the quality of the sound. Part of the sibilant sound is generated when the teeth are being hit by a concentrated air jet. If the opening is too small, a whistle will result. If the space is too broad and thin, the *s* sound will be developed as a *sh* sound, somewhat like a lisp. The frequent cause of undesired whistles with dentures is a posterior dental arch form that is too narrow.

- A sharp *s* requires accuracy of the neuromuscular control system for the creation of the groove and directing of the air jet. Even small deviations of only 1 mm will influence the quality. For example, if the tip of the tongue touches the upper front teeth, the result will be a lisped sound. The fact that the teeth play an important part in articulating this sound often has been neglected, and the oral aerodynamics involved are still an unexplored area.

LINGUOPALATAL AND LINGUOVELAR SOUNDS

The truly palatal sounds (e.g., those in *year*, *she*, *vision*, and *onion*) present less of a problem for dentures. The velar sounds (*k*, *g*, and *ng*) have no effect on dentures, except

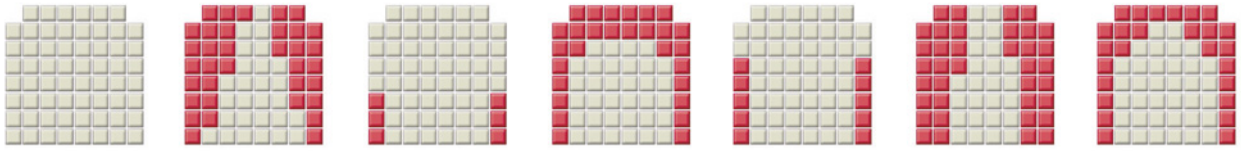


Figure 15-6 Typical electropalatography diagrams for the sounds in *"oh sadist."* Shaded area represents the contact between tongue and palate. Note the sagittal groove created when the *s* sound is uttered.

when the posterior palatal seal extension encroaches on the soft palate.

METHODS FOR SPEECH ANALYSIS

When patients have severe speech pathology problems, their clarity and pronunciation should preferably be analyzed by a speech pathologist. It would be valuable to do this before starting prosthodontic rehabilitation to establish a basis for future comparisons, and, if possible, identify problems.

A number of methods are available for speech analysis, with some more useful for the dentist than others. There are basically two categories: perceptual/acoustic analysis, and kinematic methods for movement analysis. An acoustic analysis is based on a broadband spectrogram recorded by a sonograph during the uttering of different phrases containing key phrases. Kinematic analysis includes such methods as ultrasonics, x-ray mapping, cineradiography, optoelectronic articulatory movement tracking, and electropalatography (EPG). Some of these methods play an essential part in both experimental and routine clinical evaluations of speech defects and treatment effects. EPG is used for registrations of tongue contact patterns during speech production and a mapping of the contacts could be achieved (Fig. 15-6).

However, none of these methods are used in routine practice but rather after the failure of conventional means to improve an impaired speech production.

PROSTHETIC CONSIDERATIONS

Speech problems usually are identified immediately after prosthetic treatment. Some elder complete denture wearers experience greater difficulties in adapting their speech to new prostheses and need longer time to regain their natural speech. A frequent cause is impaired auditory feedback, and therefore a simple auditory test might be useful in such patients to make a proper diagnosis. It also is important to listen to and analyze patients' speech sounds before the rehabilitation starts and even more important to inform patients that temporary speech sound deterioration may result from the treatment.

Speech adaptation to new complete dentures normally takes place within 2 to 4 weeks after insertion. If maladaptation problems persist, the dentist or a speech pathologist should take special measures. Particular attention should be paid to patients with long experience of wearing complete dentures. When new prostheses have to be made for these patients, certain difficulties in learning new motor acts may delay and obstruct the adaptation. Consequently, a virtual duplication of the previous denture's arch form and polished surfaces, especially the palate of the maxillary denture, will ensure a minimal period of postinsertion speech adaptation. Using old dentures as a guide and, if necessary, a virtual copy of the denture will frequently solve a problem that may arise as a result of speech and adaptation difficulties.

A prudent way to overcome possible problems is to study the profile form and lip line of the patient's face, which often is representative of the natural anterior tooth inclination. In such a situation, it would be logical to assume that this profile parallels a correct positioning of the anterior teeth, both for speech production and harmony in esthetics. If the teeth are too far lingual, the *t* in *tend* will sound more like a *d*. If they are too far anterior, the *d* will sound more like a *t*. The palate of a denture base that is too thick in the area of the rugae could have the same effect.

A cramped tongue space, especially in the premolar region, forces the dorsal surface of the tongue to form too small an opening for the escape of air. The procedure for correction is to thicken the center of the palate so the tongue does not have to extend up as far into the narrow palatal vault. This allows the escape way for air to be broad and thin. A lisp with dentures can be corrected when the procedure is reversed, and a narrow concentrated airway is provided for the *s* sound.

About one third of patients make the *s* sound with the tip of their tongue contacting the lingual side of the anterior part of the lower denture and arching itself up against the palate to form the desired shape and size of airway. The principles involved in such a palatal valve are identical to those involved in the other tongue positions. However, the mandibular denture can cause trouble. If the anterior teeth are too far back, the tongue will be forced to arch itself up to a higher position, and the airway will be too small. If the lingual flange of the mandibular denture is too thick in the anterior region, the result will be a faulty *s* sound. It can be corrected when the artificial teeth are placed in the same position that the natural teeth occupied and the lingual flange of the mandibular denture is so shaped that it does not encroach on the tongue space.

When the vertical dimension is established during the maxillomandibular registration, speech can be used for guidance to assess a correct VDO. Such a procedure is recommended by many dentists, but a dentist using this method needs longtime experience and knowledge to perform properly. During the pronunciation of the *s* sound, the interincisal separation, vertical distance, should average 1 to 1.5 mm. This also is referred to as the closest speaking space.

In a recent study, influence of alterations of VDO and palatal configuration on three consonants, *k, c*, and *s*, was investigated. It was concluded that malformation of the palatal parts of the denture influenced speech production of these constants more than differences in VDO did.

SPECIAL CONSIDERATION IN IMPLANT PROSTHODONTICS

Implant-retained or implant-supported prostheses have proven effective in treating edentulous patients. Although general satisfaction, comfort, stability, and general ease of chewing were significantly higher for the patients with a mandibular implant prosthesis than those with a conventional mandibular denture, there were no significant differences in their satisfaction with the ability to speak.

Speech problems with maxillary fixed implant prostheses are frequently reported, mostly during the first several weeks after delivery but may persist over several months. Sibilants, especially s, and some other fricatives have been reported to be affected in these patients. Space left between the alveolar ridge and a fixed maxillary prosthesis and air passing through it may be the cause of the higher error rate for linguoalveolar and linguopalatal stops and fricatives. The space also may have an impact on the buildup and release of intraoral pressure for bilabial stops and labiodental fricatives in some patients. It also has been suggested that the frontal width of the prostheses from a conventional denture to a fixed prosthesis may contribute to the changes in sound. In maxillary edentulous patients who receive an immediate loaded implant-supported prosthesis after wearing a denture for a long period, the patient should be informed about the possibility of a 3- to 6-month speech adaptation period and should not underestimate this problem. In a within-subject crossover study, maxillary implant overdentures with and without palates enable patients to produce more intelligible speech than fixed prostheses. The patients produced a significantly higher percentage of sounds correctly with overdentures than with fixed prostheses, especially for stops and fricatives, but not for vowels.

SUMMARY

Speech difficulty as a sequel of oral rehabilitation with complete dentures is generally a transient problem. When encountered, the difficulties may not be easily solved. Therefore efforts should be made to avoid them by pretreatment records or assessment of speech and provision of information to patients about likely initial deviations from normal speech immediately after the oral rehabilitation. If difficulties in pronouncing certain sounds or other speech disorders persist for more than 2 to 4 weeks, it is recommended that the dentist follow this protocol:

1. If the patient has a previous complete denture experience, compare the new set with the old one to diagnose possible design differences of significance for speech production. If, on the other hand, a remaining natural dentition is to be converted into a complete denture, a transfer of the original position of the natural teeth to the denture should facilitate adaptation.
2. Listen to the patient and then try to produce the very same distorted sound yourself. Observe the position of your own articulatory structures, tongue, lips, mandible, and so on, when producing this sound and transform them to the patient, thereby making it possible to identify the structures hindering a correct speech production.
3. Make the necessary modifications; soft wax might be helpful.
4. Have the patient's hearing checked. An auditory deficit will prolong the adaptation period and render it more difficult.
5. If the reported/perceived problem cannot be resolved by dental methods, the patient should be referred to a speech pathologist.

Bibliography

Farley DW, Jones JD, Cronin RJ: Palatogram assessment of maxillary complete dentures, *J Prosthodont* 7:84-90, 1998.

Grillner S: Possible analogies in the control of innate motor acts and production of sound in speech. In Grillner S, Lindblom B, Lubker J, et al, editors: *Speech motor control*, Oxford, 1982, Pergamon Press.

Heydecke G, McFarland DH, Feine JS, et al: Speech with maxillary implant prostheses: ratings of articulation, *J Dent Res* 83:236-240, 2004.

Ichikawa T, Komoda J, Horiuchi M, et al: Influence of alterations in the oral environment on speech production, *J Oral Rehabil* 22:295-299, 1995.

Lundqvist S, Lohmander-Agerskov A, Haraldson T: Speech before and after treatment with bridges on osseointegrated implants in the edentulous upper jaw, *Clin Oral Implants Res* 3:57-67, 1992.

Runte C, Tawanab D, Dirksen D, et al: Spectral analysis of /s/ sound with changing angulation of the maxillary central incisors, *Int J Prosthodont* 15:254-258, 2002.

This page intentionally left blank

PART V

Clinical Protocols Specific to Implant-Retained and Implant-Supported Prosthodontic Management

CHAPTER 16

The Science of Osseointegration

Tomas Albrektsson, Ann Wennerberg

Osseointegration, or predictable long-term anchorage of tooth root analogues in bone has been defined by Zarb and Albrektsson as "a time-dependent healing process whereby clinically asymptomatic rigid fixation of alloplastic materials is achieved, and maintained, in bone during functional loading." Such stable bone implants have an interface that consists mainly of bone tissue. This attachment mechanism differs from one retaining the natural dentition because teeth are anchored to their surrounding bone by means of a highly differentiated connective tissue attachment with ordered fibers, the periodontal ligament. Nobody has succeeded in creating and maintaining a replica of a periodontal ligament around an implanted alloplastic tooth root, and most past implant efforts ended up anchored in poorly differentiated soft tissues with poor clinical outcome results. This predicament provided the backdrop for the breakthrough introduction of osseointegrated oral implants in the early 1980s. It became possible to insert oral implants with a favorable, predictable outcome with an expected success rate of over 90%. At the beginning of the 1980s, oral implants were prescribed in small numbers and rarely in university clinics. Today, the situation is quite different, exemplified by an annual placement of more than 2 million oral implants in the United States alone. However, the current popular notion that every commercially available osseointegrated oral implant system will result in a success rate of more than 90% is misconceived; even in our new millennium, implant systems with unacceptable low levels of success have been launched. Failure may follow poor implant designs and clinical shortcuts that have at times been recommended by irresponsible commercial companies.

This chapter considers the unique self-repairing ability of the surgically prepared bony interface, which, if not unduly disturbed, will remodel sufficiently to carry clinical loads. The specific nature of the osseointegrated interface and its bonding implications are also discussed to provide information about how the osseointegrated interface may be sustained or threatened.

OSSEOINTEGRATED INTERFACE

In the past, direct contact (i.e., without interposed soft tissue layers) between bone and metallic implants was regarded as impossible to achieve. Experimental/clinical evidence from the 1960s and onwards demonstrated that this notion was not necessarily correct, with clear evidence of osseointegration first becoming available in the late 1970s/early 1980s. These results stemmed from new cutting and grinding techniques such as those developed at the laboratories of Karl Donath in Germany, which demonstrated the clear absence of soft tissue coatings on metallic implants. Subsequent investigations demonstrated that the

bone to metal interface did not achieve ultimate strength until at least 1 year after implantation.

The bond of an osseointegrated implant with the surrounding bone is probably a biomechanical one resulting from bone growth into surface irregularities of the implant with a resultant 3-dimensional stabilization. Design characteristics, such as implant threads, represent surface enlargements in the macroscale. On the other hand, surface irregularities (Sa) in the micron scale are theoretically important for osseointegration, and documented studies of implants with so-called moderately rough surfaces (Sdr%). Implants with an Sa between 1 and 2 μm combined with an Sdr% in the range of 50 have shown improved clinical results when implants were placed under challenging conditions (Fig. 16-1).

The experimental approach to osseointegrated implants is commonly used to measure removal torques or the amount of bone-to-implant contact. Whereas such measures are not without value, they may be difficult to directly translate to the clinical situation. It is still unknown how much bone contact is needed for an implant to be successful. If, for example, 60% bone-to-implant contact is found to be clinically satisfactory, then it may not necessarily be the case that 80% bone contact is more successful. From this reasoning, it follows that although in vitro or animal investigations may be of some value, they can never replace the controlled clinical study. To trust new innovations to be clinically valuable we need retrospective or preferably prospective studies documenting their efficacy.

FACTORS THAT DETERMINE SUCCESS AND FAILURE OF OSSEOINTEGRATION

Numerous reports confirm the clinical inadequacy and unpredictability of a soft tissue interface when compared with a bone-to-implant one. However, the latter one is not necessarily permanent because secondary osseointegration failure does occur, albeit infrequently. The clinical presentation of such failure is progressive or rapid periimplant bone resorption, which has regrettably been all too readily attributed to occlusal overload or an infectious process. The latter presumed etiology appears to be somewhat simplistic because the two interfaces are indeed different, and the pathogenesis of periodontal disease and that of osseointegration failure are likely to be quite different.

A possible reason for marginal bone loss may be theoretically explained by recognizing that the complex healing/adaptation of tissues around an implant may be disturbed by a multitude of factors, some of which are beyond the operator's control. They include improper surgery, the choice of unfavorable implant host sites from both a morphological and a healing potential point of view, incorrectly performed prosthodontic procedures, timing of prosthodontic procedures, behavioral considerations such as smoking history, and degradation of biomaterials in the body. Moreover, all of these factors may have cumulative and additive effects. Consequently, a poorly performed surgical procedure alone may not invariably result in marginal bone loss if the patient has a good and compensating bone stock. On the other hand, poor surgery combined with premature loading of the implant may compromise a successful outcome. The magnitude of the accumulated challenge also can determine the outcome. For example, too much surgical trauma will ensure outright implant failure, while trauma of a smaller magnitude will be followed by varying degrees of marginal bone loss. A healing/adaptation theory implies an eclectic understanding of the many factors that can impact the required healing response that ensures a long-lasting interfacial osteogenesis or osseointegration (Fig. 16-2).

In 1981 Albrektsson et al proposed six factors that are required for reliable osseointegration to occur. These factors together also may serve as additional background to the healing/adaptation theory; they are implant (1 to 3) biocompatibility, design, and surface characteristics; (4) patient host bed; (5) surgical technique; and (6) loading conditions. Clinical outcome depends on our control of the six factors; hence, their relevance for the healing/adaptation theory.

IMPLANT BIOCOMPATIBILITY

The most commonly used material for oral implants, commercially pure (CP) titanium has proven very biocompatible in numerous experimental studies. Titanium 6 aluminum 4 vanadium alloy has been demonstrated in several studies to elicit weaker bone responses than CP titanium (Fig. 16-3), but it is unknown whether this is clinically relevant in the light of several clinical studies published with good 5-year clinical outcomes using titanium alloy implants. Presumably, CP titanium would be the safest implant material to use if implants were to be placed in compromised bone beds. Zirconia is another biocompatible material that suffers not so much from issues related to tissue reactions but more significantly from the brittleness associated with ceramics. Other ceramics such as HA or aluminum oxides have demonstrated excellent short-term clinical results but an unacceptable long-term outcome because these materials have shown a tendency to time-dependent aging and increasing brittleness following implantation. Admittedly, it is unknown whether zirconia will share the shortcomings of previously studied ceramic materials, but since the material needs preparation to increase surface roughness, this may indicate increased brittleness. Hence, proper long-term positive documentation of zirconia implants would be required before recommending them for routine clinical use.

IMPLANT DESIGN

Previous clinical studies of nonthreaded cylindrical implants failed to provide any positive long-term follow-up, indicating the importance of employing threaded designs. The

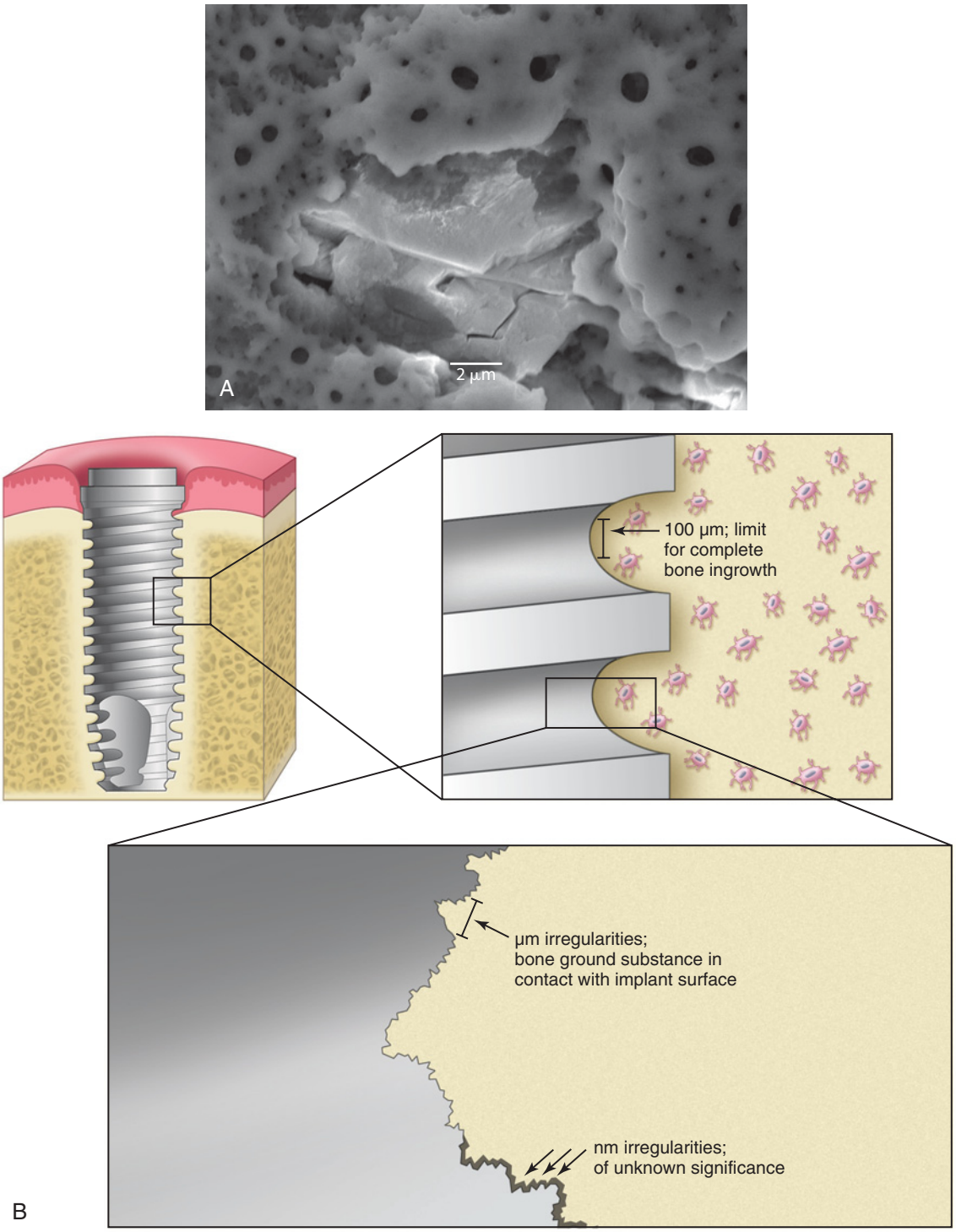


Figure 16-1 **A,** A moderately rough surface characterized by an Sa of 1 to 2 µm and an Sdr% of 25 to 75 may serve as an example of most commercially available modern implants. This image presents a moderately rough blasted and anodized surface, with typical porosity achieved by anodisation. **B,** Bone tissue including ground substance and cellular components will need pores of a minimal size of 100 µm for ingrowth. Calcified ground substance of bone responds differently to irregularities in the micrometer size that are important for the strength of the osseointegrated response. Implant irregularities in the micrometer range are, to date, of undetermined significance for osseointegration.

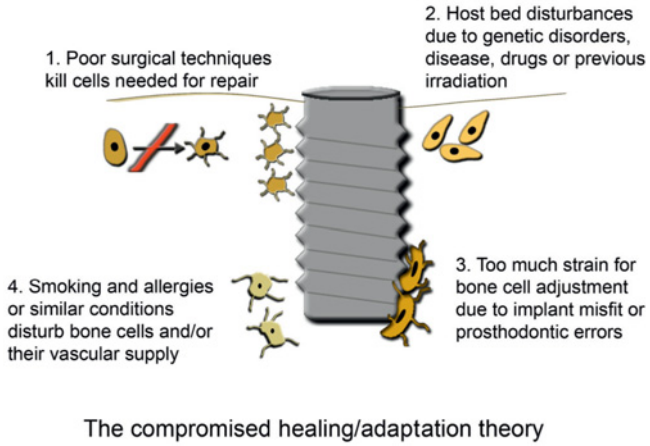


Figure 16-2 Marginal bone resorption is probably best explained by a compromised healing/adaptation theory, which suggests that the outcome of the healed interface will depend on a summation of the listed parameters. If this is of substantial magnitude, implant failure will occur, while a lesser magnitude may lead to bone resorption instead. This theory is strongly supported by clinical evidence that contrasts with other proposed theories for marginal bone resorption.

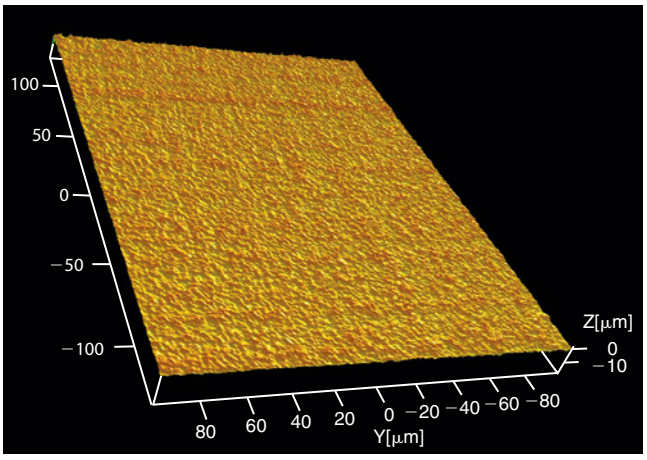


Figure 16-3 Implants manufactured from titanium alloy, which represents a hard material, may demonstrate a very smooth surface outcome if a similar manufacturing approach, such as with softer CP titanium, is applied. Nano Tite PREVAIL implant with an Sa of 0.3 µm and an Sdr% of 17.

only current exception to this principle is one particular implant design with a porous coating similar to those commonly used with orthopedic devices. There is limited documentation relating to this design, which is, however, positive over 5 years. Threaded implants have been produced with a range of thread designs; however, in general, information is lacking as to their relative merits. The one exception to this is the so-called microthread design, which uses such threads in the superior portion of the implant. Numerous studies have proven this to be efficacious in maintaining marginal bone heights, including two of a controlled nature. Currently many implants from different manufacturers incorporate such microthreads, with positive clinical records over about 5 years in many cases. Threaded implants over all have been documented for up to 25 years with good outcomes. In one such study, implants were followed up for 20 years and only 2% demonstrated so-called periimplantitis.

IMPLANT SURFACE

The implant surface may be modified topographically to form a decided microroughness. Currently there is considerable debate concerning the formation of nanoroughness and whether this may be optimized. Other potentially important surface features include surface physics and chemistry.

With respect to implant microroughness, there is clear experimental evidence of the benefits of a surface with an Sa of about 1.5 µm and an Sdr% of about 50. Such implants are called moderately roughened and represent the great majority of currently marketed devices. From a clinical aspect, there seems to be no reliable difference in outcome if modern moderately rough implants are compared with older turned surfaces in normal clinical settings. However, in compromised bone sites, there is clear clinical evidence favoring the moderately rough surface compared with smoother or rougher topographies. Regrettably, many experimental/clinical investigations of implants are supplemented with poorly controlled surface topographical analyses, making it often difficult to draw valid conclusions.

Whereas we have considerable knowledge about implant microroughness, we lack a great deal of information concerning the importance of *nanoroughness*. In vitro studies have demonstrated some impact of such topographies; however, such techniques are so different from clinical reality that we do not know whether the results are of any clinical significance. To date there have been very few published in vivo studies of the impact of surface characterization at the nanometer level. It is possible that any such influence is dominated by a much stronger effect at the micrometer level; nevertheless, we cannot exclude the possibility that nanoroughness alone may influence clinical outcomes, although the optimum value for this, if any, is unknown. However, it is noteworthy that novel implants from the major implant suppliers all share very typical nanopatterns, if only visible at 100,000 times magnification or more (Fig. 16-4), patterns that are clearly different from the respective predecessors of these implants.

Implant surface physics have been manipulated in one recently introduced "super hydrophilic" design, which is allegedly preferable because of this surface state. However, in reality the manufacturer had changed not only surface

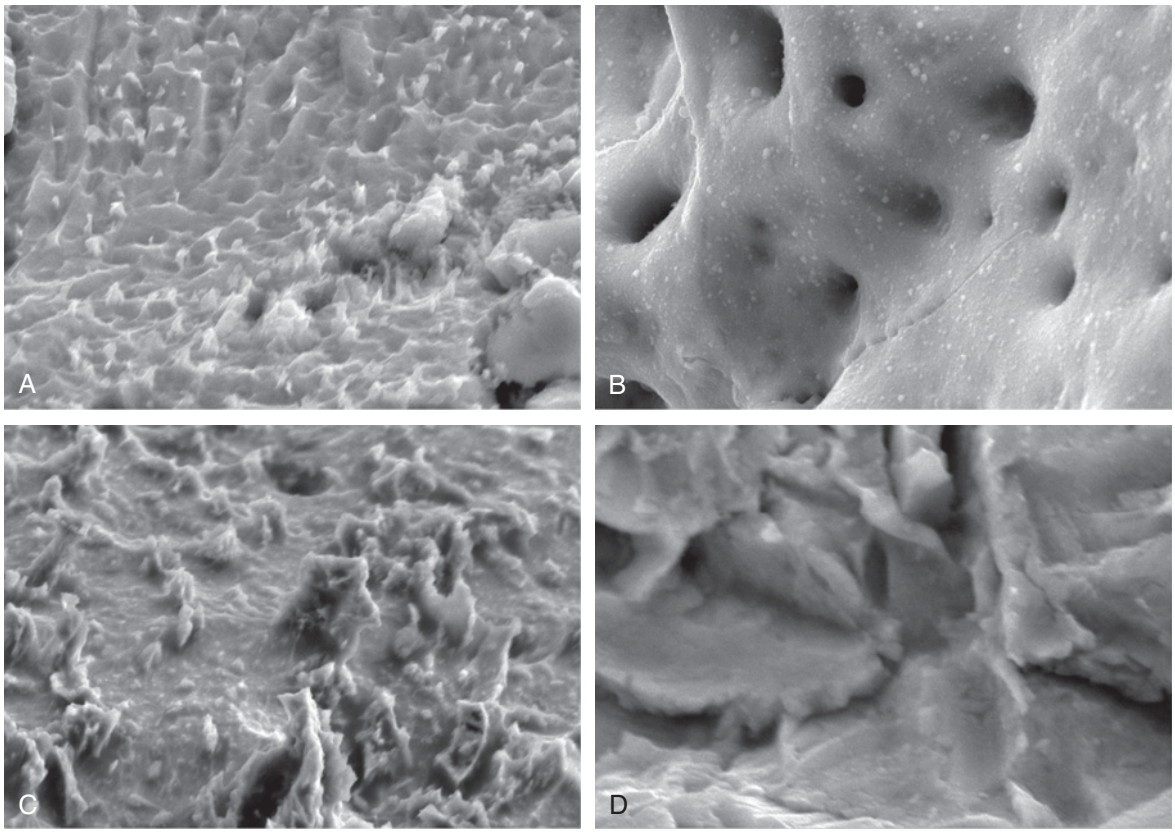


Figure 16-4 Modern implants display clear nanopatterns in contrast to their respective predecessors. **A,** Astra Tech OsseoSpeed implant. **B,** Nobel BiocareTiUnite implant. **C,** A Biomet 3i Nanotite implant. **D,** An example of a predecessor implant Astra TiOblast without the typical nanopattern. All images 50,000× or more in magnification.

energy, but also the implant microroughness and nanoroughness; hence, we cannot know which of the surface features resulted in the reported enhanced bone responses. From a clinical point of view, we totally lack evidence that hydrophilic surfaces outperform more hydrophobic ones. Unfortunately it is very difficult to change one surface parameter independent of the others; consequently, controlled studies of the impact of individual parameters remain difficult.

Implant surface chemistry has been altered in recently introduced designs by supplementation with fluoride, calcium, or magnesium ions or with nanocompounds of hydroxyapatite (Fig. 16-5). In all these cases, there is experimental evidence of stronger bone responses to the chemically altered implant compared with unaltered controls. In a few such studies, simultaneous change of implant microroughness was controlled, making it more likely that the results reflect a true surface chemical effect. From a clinical viewpoint, it seems probable, although not definitely proven, that chemical alterations may influence outcomes.

Another potential change of implant surfaces is represented by doping the surface with various bone-stimulating factors. This can be done with implants of any surface roughness. A number of these potentially bone-stimulating factors (growth factors) are present in our bodies and serve as important stimuli for the initiation of healing processes. However, external administration of growth factors may further support the tissue response to an implant, although many studies have demonstrated opposing results. There are inherent difficulties in these experiments because different concentrations and modes of administration have been tried experimentally, which may explain some of the contradictory results. From a clinical point of view, there have been many case reports claiming positive effects from the external administration of various growth factors, but properly controlled data are scarce. It also needs to be noted that such doped surfaces should preferably not be used without a properly conducted randomized clinical trial of the efficacy of the treatment.

HOST BED

A healthy implant site favors osseointegration. Patient characteristics, such as age and history of the proposed host site(s), or previous irradiation, will affect the outcome of the implantation procedure. It also is believed that a history of smoking may affect the healing response in

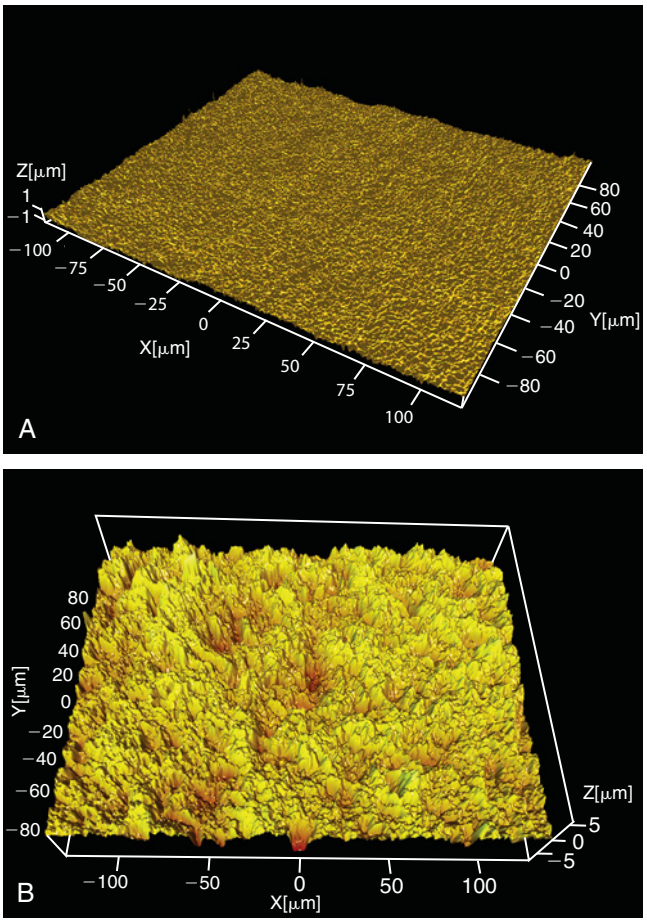


Figure 16-5 Implant topography is not all that matters. **A,** A blasted moderately rough surface whereas **B** is of a minimally rough (Sa 0.3 to 1.0 μm) implant reinforced with calcium ions. The two implants display a very similar bone response, presumably because implant chemistry (attached calcium ions) compensates for a smoother than ideal surface topography.

osseointegration. Other patient factors including allergy to titanium are much discussed at present. It must be stressed, however, that mere presence of a skin rash is not diagnostic of an allergy but may have other causes. Where an allergy is demonstrated, this requires identification of the allergen, and many dermatologists currently do not consider titanium to be an allergen. Several reports in the literature of allergic responses to titanium alloys may reflect reactions to aluminum or vanadium rather than titanium. The validity of a diagnosis of a titanium allergy would depend on proper patch tests to the metal, which have been seldom or never reported in the literature, while particular lymphocyte oriented tests (e.g., MELISA) have not been properly controlled from a scientific point of view.

Old age per se does not cause poorer implant results. However, extreme young age is a relative contraindication to the insertion of implants, since the integrated device remains in situ after the manner of an infraoccluded deciduous tooth, resulting frequently in prosthodontic problems. The current general recommendation is to await completion of growth before inserting oral implants in young individuals. In selected cases, where strong psychological motivation is present, oral implants may be inserted in children, but then preferably only in the anterior part of the mandible and in combination with overdenture therapy. This does not apply to the use of bone-anchored hearing aids or craniofacial implants to treat certain congenital disorders, which may be placed clinically when the child is only 2 to 3 years old in carefully selected cases. The motivation behind treating such young children is to avoid the potential social handicap of severe hearing impairment or of facial deformities that cannot be effectively treated in any other way.

Smoking has been reported to yield significantly lower success rates with oral implants. The mechanisms behind this are unknown, but vasoconstriction may play a role. Continuing substance abuse also may be a contraindication to implant treatment.

Previous irradiation is a relative contraindication for implant treatment. Where implant therapy is planned, patients treated with irradiation should be transferred to special clinics with sufficient experience in their management. A 1-year delay after irradiation before inserting implants has been recommended, but a more rapid approach has been tried at individual centers with good outcomes. Expected success rates are about 10% lower than for nonirradiated patients. Hyperbaric oxygen treatment in divers' chambers has been shown to improve the outcome in at least one 5-year clinical follow-up study. If, on the other hand, patients have implants already in situ and osseointegrated when the need arises for therapeutic irradiation, removal of the implants before irradiation is not recommended. There is experimental evidence that osseointegrated oral implants will remain stable in bone despite irradiation, whereas implants that are inserted immediately before irradiation will show a high failure rate (see also Chapter 22).

SURGICAL TECHNIQUE

Gentle handling of the tissues at surgery is essential for proper osseointegration. This objective depends on continuous and careful cooling when using a surgical drill to prepare implant sites. This should be done at low rotational speeds, with sharp instruments, and the use of a graded series of drills. Proper drill geometry is important as is intermittent drilling, especially if the bone is of a very dense structure. The insertion torque should be of a moderate level because high values may result in stress concentration around the threads of a screw-type implant, with subsequent risk of bone resorption, although safe torque levels have yet to be defined.

Data reported in the literature underscore the importance of the surgeon who places the implant. One study

reported that an individual surgeon working in a group with 10 peers was alone found to have operated on the great majority of those patients whose implants failed or demonstrated unacceptable bone loss. In all probability, the matter of personal skills may very well be of much greater magnitude than previously believed; it may even represent the major reason for implant failure.

LOADING CONDITIONS

The original recommendation to achieve osseointegration is still valid: a two-stage implant insertion. In this technique, the implant is first inserted in the bone, and then the soft tissues are sutured back so that the implant will be incorporated in bone under protected conditions. At a second surgical procedure some 3 to 6 months afterwards, the buried implant is exposed and connected to the oral cavity by means of a transepithelial abutment. This procedure guarantees that the implant is well protected during its incorporation in bone when the osseous interface has not been established properly, as shown by experimental and clinical studies. Clinical trials with various implant systems have now confirmed the feasibility of immediate functional (direct) loading protocols, particularly in the mandible and in the maxilla where there is good bone quality. Great caution is recommended with such an immediate loading protocol if the bone is of a poor quality. Furthermore, such direct loading places even greater emphasis on the skills of the surgeon and prosthodontist, which is why it is recommended that newly trained surgeons only use a two-stage procedure.

A recent Belgian-Japanese combined research effort demonstrated that whole body vibration resulted in increased bone responses to implants in the first few weeks after implant placement. Perhaps a time will come when scientists will have learned how to control and apply such stimuli in humans with resultant beneficial clinical applications.

SUMMARY

It is important to ensure that new biomaterials receive careful physical and engineering investigations to clarify their suitability in the implant field. In vitro studies may provide interesting information to the basic scientist, but one must remember that this is related to the controlled laboratory environment, which differs from in vivo testing with its hormonal, blood flow, and loading influences. However, none of these types of investigations may replace the one and only tool to evaluate whether a new implant functions properly or not—the clinical trial—be that of a retrospective or a prospective nature.

In the summary of current knowledge about the factors controlling asymptomatic implant function in the body, it must be acknowledged that the scientific community has made a great number of important findings in the past 25 years. However, researchers may very well be climbing the lower slopes of a mountain of unknown height. Major contributions will be gathered in the future from prospective and controlled treatment outcome studies in patients. The fundamental message in clinical epidemiology is that efficacy without effectiveness usurps the notion of a compelling scientific claim.

Bibliography

Albrektsson T, Brånemark PI, Hansson H-A, et al: Osseointegrated titanium implants: requirements for ensuring a long-lasting, direct bone anchorage in man, *Acta Orthop Scand* 52:155-170, 1981.

Balshe A, Assad D, Eckert S, et al: A retrospective study of the survival of smooth- and rough-surfaces dental implants, *Int J Oral Maxillofac Implants* 24:1113-1118, 2009.

Chvartszaid D, Koka S, Zarb G: Chapter 11, Osseointegration failure. In: *On continuing synergies in surgery, prosthodontics and biomaterials*, Chicago, 2008, Quintessence Co, pp 157-164.

Ogawa T, Zhang X, Naert I, et al: The effect of whole-body vibration on peri-implant bone healing in rats, *Clin Oral Impl Res* 22:302-307, 2011.

Wennerberg A, Albrektsson T: On implant surfaces: a review of current knowledge and opinions, *Int J Oral Maxillofac Implants* 24:63-74, 2010.

Zarb G, Albrektsson T: Consensus report: towards optimized treatment outcomes for dental implants, *Int J Prosthodont* 11(5):389, 1998.

CHAPTER

17

Implant Overdentures

Alan G.T. Payne, George Zarb

Several compelling conclusions can be drawn from earlier chapters.

- Treatment outcomes with complete dentures depend on dentist-mediated and patient-mediated considerations. The former include clinical judgment and technical skills combined with expert laboratory technological support. The latter are defined by each individual patient's adaptive traits, systemic and local health considerations, and morphological characteristics.
- An adaptive denture experience is the frequently achieved treatment goal when complete dentures are made. However, an ongoing long-term continuum of adaptation is unpredictable, because of inevitable time-dependent anatomical and physiological changes. These include severe residual ridge reduction, an increased mucosal vulnerability, reduced salivary flow, and compromised motor skills. Nonetheless, clinical experience suggests that time-dependent denture-wearing problems can be frequently solved by making new optimized dentures for these patients.
- The older preprosthetic surgical techniques prescribed for maladaptive denture patients sought to enlarge the denture-bearing area via sulcus-deepening procedures, ridge augmentation, or both. The approach failed to yield beneficial results that were predictable, long-term, and without adverse consequences.
- Overdentures supported by natural tooth roots have been a long-standing and integral part of treatment planning for potentially edentulous patients. Regrettably, their short-term and long-term treatment outcomes are unpredictable because of caries and periodontal disease affecting the tooth root abutments.
- The introduction of the preprosthetic osseointegration technique ushered in a new era of versatile, predictable, and virtual morbidity-free fixed prosthodontic treatment. This significantly enhanced the quality of life of edentulous patients although associated costs precluded routine fixed full-arch prescriptions. However, extrapolation of the merits of the traditional overdenture technique, coupled with a reduced number of prescribed implants, quickly led to a more cost-effective version of implant-supported prostheses—the implant overdenture.
- Overdentures supported by "ankylotic-like" osseointegrated implant abutments demonstrate a positive influence on adjacent periimplant bone levels. There also appears to be some sensorimotor feedback that seems to also facilitate the overall functional experience with implant abutments under overdentures. This observation has now been supplemented with studies on patient satisfaction with improved masticatory function, bite forces, and chewing activity.

It is therefore tempting for dentists to also conclude that optimal prosthodontic management of most edentulous patients, even those without a maladaptive denture-wearing experience, should be implant-supported prostheses. Moreover, fiscal realities in the context of aging populations with fixed incomes, as well as socioeconomic realities in underdeveloped countries, demand a more financially accessible approach while offering similar advantages. This chapter describes the application of the implant overdenture protocol as a routine measure for managing the edentulous predicament by enhancing a complete denture's retention and stability.

GENERAL OVERDENTURE TREATMENT CONSIDERATIONS

When planning implant overdenture treatment, the following considerations should be noted:

- Mandibular overdentures have been extraordinarily successful irrespective of the diversity of residual ridge morphologies encountered. However, patterns of resorption in the moderate to severely resorbed maxilla present greater treatment challenges when planning maxillary overdentures.
- Although the diversity of commercially available attachment systems for implant overdentures differs slightly from those for natural tooth/root abutments for overdentures, the prosthodontic role of these attachment systems is similar.
- Implant abutment availability that ensures denture retention and stability should not be relied on to exclusively compensate for technically or functionally

inadequate dentures. Therefore the need for traditional and optimal complete denture fabrication techniques should still be followed.

- Esthetic denture design should not be compromised by the planned location of implants and their connection to attachment systems. Consequently, it is difficult to accomplish routine esthetic results with maxillary full-arch fixed implant prostheses, especially in the maxilla, when moderate residual ridge resorption has occurred. On the other hand, overall esthetic objectives can be addressed and achieved with greater ease by using the overdenture technique.
- Very close cooperation is necessary between surgical and prosthodontic planning and actual treatment to maximize the merits of the placement of implants to support overdentures.

INCLUSION AND EXCLUSION CRITERIA

Implant treatment decisions must be made for each patient according to their individual circumstances. The major inclusion criteria underscore the quasi-universal patient eligibility for the method (Box 17-1). Age itself is not an exclusion criterion; however, age-related factors may frequently influence treatment planning in elderly patients. Common challenges encountered include communication difficulties (e.g., compromised hearing and cognitive skills) with consequent lack of cooperation, the likely need for short appointments, special attention to presurgical measures such as general health status and information, the oral hygiene state, and home care provision. Poor general health is often found in elderly patients with consequent deterioration in biological health that is far beyond their chronological age. Medical consultation is frequently required and mandatory for all systemically compromised patients. The patient's family physician should be routinely consulted for these patients and any suspicion of risk or unclear information is revealed.

Problems with wearing complete dentures or adaptation to new ones are multifactorial and include age-related considerations. Patient selection criteria must therefore be established with respect to a broad range of local and general aspects. Clinical experience supports specific exclusion criteria (Box 17-2) but also reveals that patients with a history of cardiovascular disease, osteoporosis, and certain endocrine disorders (e.g., diabetes) are still able to undergo a successful implant operation as long as their systemic condition is not a brittle one. Surgical treatment should only be carried out when the patient's health status allows it and when a patient feels well enough and able to undergo the procedure.

Box 17-1 Inclusion Criteria for Implant Prosthodontic Treatment

- Patient desire for implant treatment
- Systemic health status, which permits a minor surgical procedure
- Sufficient bone quantity to accommodate prescribed implant dimensions
- Patient willingness and ability to maintain oral health status

PRESURGICAL EVALUATION AND TREATMENT PLANNING

The treatment planning protocol is identical for all edentulous patients and is a result of clinical and radiographic assessments that yield the information contained in Box 17-3. The clinical oral assessment provides information about shape, width, and height of the residual ridges and

Box 17-2 Exclusion Criteria for Implant Prosthodontic Treatment

- Patient's current prosthetic experience is an adaptive one
- Residual ridge dimensions do not accommodate preferred implant dimensions
- Communication with patient is not possible because of his or her compromised cognitive skills
- Patient has a history of substance abuse
- General health conditions preclude a minor surgical intervention
- Local anesthesia with a vasoconstrictor is contraindicated
- Immunosuppressive therapy, prolonged intake of antibiotics or corticosteroids, or brittle metabolic disease history

Box 17-3 Specific Objectives of Treatment Planning for a Patient with Implant-Supported Overdentures

- To determine the optimum location and number of implants in the context of the morphological aspects of the residual ridge
- To design a favorable distribution for occlusal stresses on the implants and the prostheses-bearing tissues
- To avoid discrepancies among the design of the dentures, the implants' location, and the dentures' attachment systems
- To ensure an optimal esthetic result and hygiene protocol

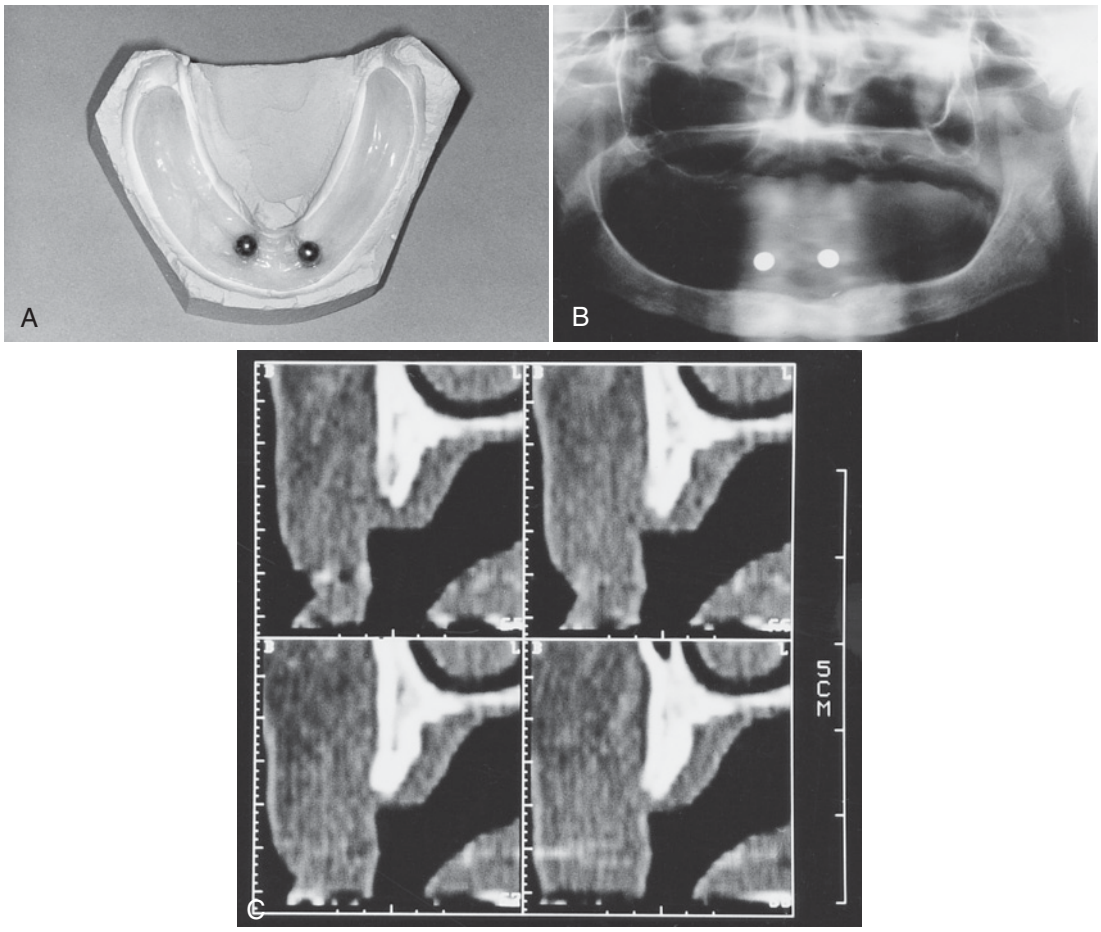


Figure 17-1 Correct imaging of potential host bone sites requires a mix of radiographs, which can be rendered more accurate by using a template with metallic markers of known dimensions **(A).** These markers will show up on a frontal **(B)** or sagittal image and allow for measurement adjustments in bone height or width. Required sagittal views of anterior edentulous zones are provided by means of cephalometric films, computed tomograms, or cone-beam radiography **(C).**

soft tissue conditions. Horizontal and vertical relationships of the residual ridges are examined, and available space for the proposed implants and attachment systems is assessed. Most edentulous patients who are treated with implants frequently show advanced residual ridge reduction without a wide band of attached mucosa. This does not seem to adversely affect the soft tissue health around implants; hence, gingival-mucosal grafting procedures are rarely prescribed.

Panoramic radiographs are made to overview required bone dimensions, to "scout" anatomical structures, to discover possible pathological findings, and to obtain information on bone quality (density) and quantity. Since panoramic films are not entirely reliable, additional radiographic imaging is usually requested for the maxilla. Simple templates with metallic markers of known diameter may be used to measure the available bone height on panoramic radiographs. They also predetermine a favorable location of the implants with respect to the topography of the residual ridge and adjacent anatomical landmarks, such as the mandibular nerve or the maxillary sinus (Fig. 17-1). Cephalometric radiographs can provide information about faciolingual dimensions, plus the lingual aspect of the residual mandibular bone and the shape of the maxillary ridge. Tomographic or cone-beam images are not necessarily used for mandibular interforaminal implant placement; however, they are indicated for determining maxillary implant placement.

Examination of patients' existing complete dentures helps the dentist decide whether they are adequate for temporary use during the postsurgical healing phase. New or optimized dentures can be made before surgery if stability of old dentures cannot be achieved by minor routine adjustments or modifications. Old dentures also are examined regarding their esthetic merits, plus the presence of loss of vertical dimension of occlusion. Consideration is given to the type of planned surgical approach, implant system selection, and loading protocol because components such as transmucosal healing abutments may be used, and they

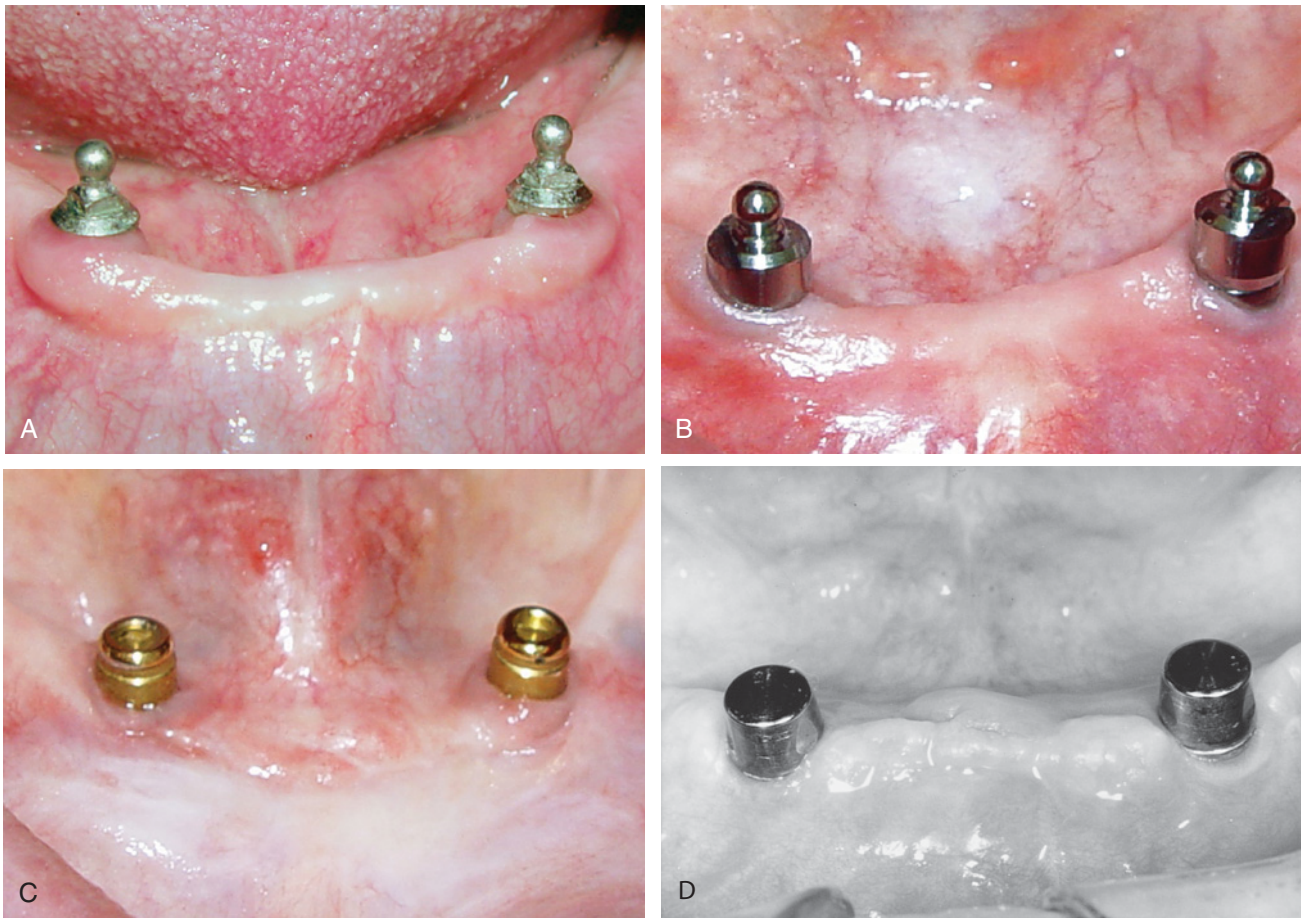


Figure 17-2 Mandibular overdentures have been shown to perform well when supported by only two implants. These prostheses are implant/ridge supported and can be so designed when implants are placed around 22 to 27 mm apart between the mental foramina. **A** to **C,** Freestanding or unsplinted design using ball abutments or magnets **(D).**

influence decisions on the option of using old dentures during the healing period.

The number and distribution of implants is influenced by residual jaw shape and planned variations of mucosal-and-implant support or exclusive implant support. The following two planning concerns of prosthodontic treatment for implant overdentures must be considered:

1. Number of implants prescribed and their location
2. Preferred denture retention devices—the attachment systems

Current and most frequently prescribed treatment options for mandibular overdentures (usually opposing complete maxillary dentures) involve using either two (sometimes more) unsplinted implants with a selected attachment method from the diverse systems available (Fig. 17-2) or bars that connect and splint two or more implants via their abutments (Fig. 17-3). When the anterior mandibular ridge



Figure 17-3 Use of a connecting bar splints two implants and allows for rotation of the prosthesis around the interimplant axis. This can be achieved if the anterior residual ridge shape is only slightly curved and parallel to the arbitrarily determined hinge axis. The functional result simulates the effect of a class I Kennedy removable partial denture (RPD).

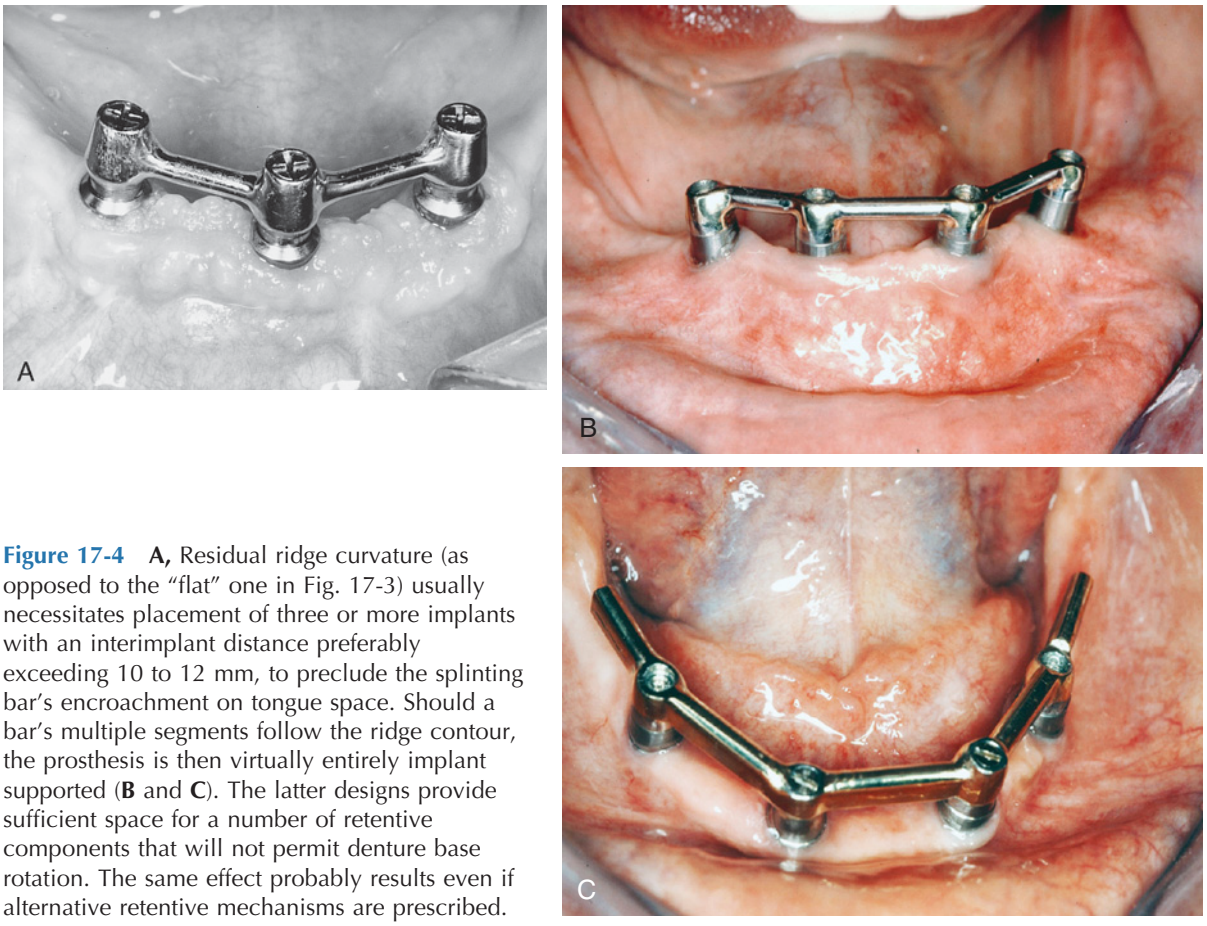


Figure 17-4 **A,** Residual ridge curvature (as opposed to the "flat" one in Fig. 17-3) usually necessitates placement of three or more implants with an interimplant distance preferably exceeding 10 to 12 mm, to preclude the splinting bar's encroachment on tongue space. Should a bar's multiple segments follow the ridge contour, the prosthesis is then virtually entirely implant supported (**B** and **C**). The latter designs provide sufficient space for a number of retentive components that will not permit denture base rotation. The same effect probably results even if alternative retentive mechanisms are prescribed.

shows a slight curvature or an ovoid shape, a bar can splint two implants on its shortest distance and preferably parallel to the patient's arbitrary hinge axis (Fig. 17-4). The interimplant distance should exceed 10 to 12 mm to provide sufficient space to accommodate retentive components. With advanced mandibular residual ridge resorption or a pronounced curvature (a U-shape) of the mandibular ridge, three or preferably four implants can be prescribed. Short implants less than 10 mm in length also can be used in the anterior mandible as per reduced morphological dictates. Reducing the number of implant abutments further for selected patients (especially elderly ones) with a single midline implant to retain a mandibular overdenture is also possible. This is currently regarded as the minimum surgical intervention needed to obtain the benefit of implant overdentures (Fig. 17-5).

The recommended treatment option for maxillary overdentures (usually opposing a natural dentition or a restored one) is commonly four to six implants and infrequently connected using a bar. In maxillary ridges, short bar segments connecting multiple implants are suggested with a segmented bar more likely to follow the ridge without encroaching on the palatal space (Fig. 17-6). Implant length should preferably be 10 mm or longer, and several implants should be prescribed when resorbed host bone sites preclude placement of 10 mm or longer fixtures. Reducing the proposed number of implants to retain maxillary overdentures is not recommended.

SURGICAL PROTOCOL AND THE OSSEOINTEGRATION PHASE

The surgical procedure is particularly well documented and seeks to place implants into predetermined host sites addressing prosthodontic design objectives. A surgical template or guide is recommended to ensure optimal implant location and alignment. This is facilitated by duplicating the previous denture and trimming it as needed. The patient's informed consent is obtained, and appropriate premedication is prescribed. The patient's operation is carried out under local anesthesia as atraumatically as possible. In the mandible, dense cortical bone frequently encloses a tightly structural cancellous structure. In the maxilla, loosely structured trabecular or cancellous bone without a dense cortical layer is often encountered. As a result, the implants are usually self-tapped into such bone of compromised quality. The postoperative phase is almost always

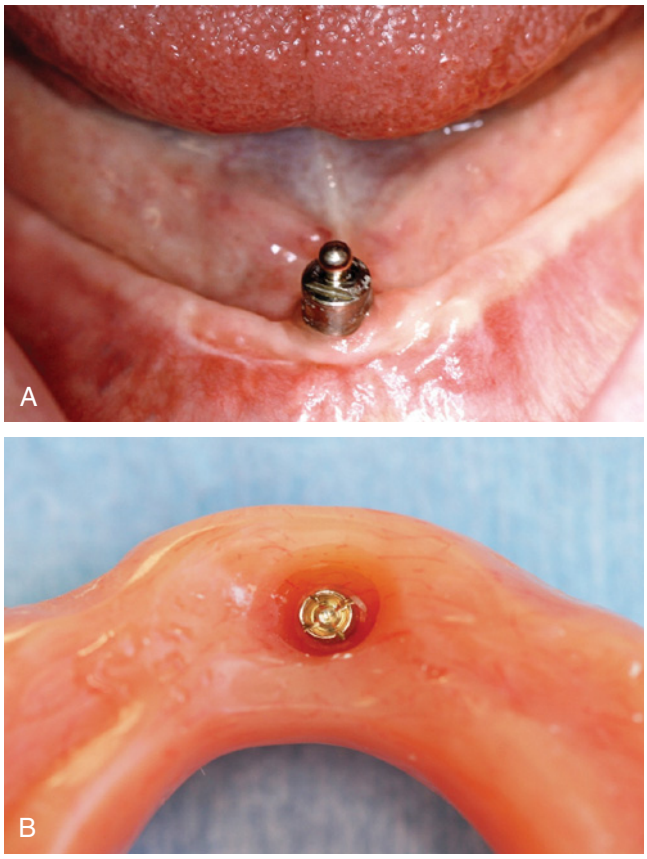


Figure 17-5 **A** and **B,** Application of a mandibular midline implant to support an overdenture.

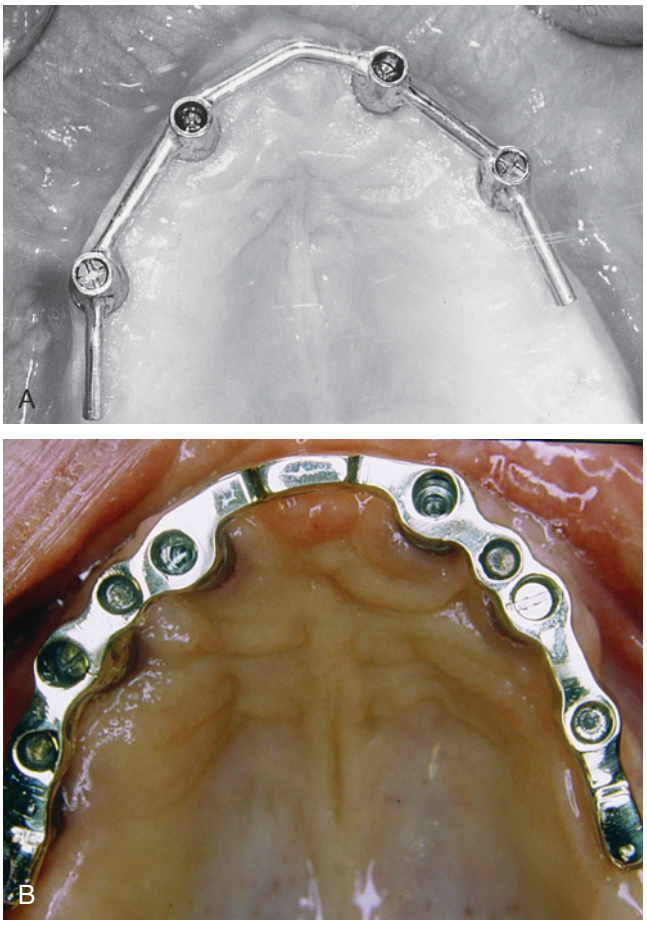


Figure 17-6 **A,** The maxilla's ridge contour is reflected in a segmented bar soldered to four implant abutments. **B,** Rigid splinting of multiple implants using a cast milled bar. Retentive clips or attachments can engage any or all of the available segments, ensuring good retention, optimal prosthetic teeth placement, and nonrestriction of tongue space.

uneventful and is ensured by means of standard analgesia medication plus use of postoperative ice packs and chlorhexidine mouth rinses.

Whenever a two-stage surgical approach is performed (a particularly prudent consideration for the maxilla), the denture is provisionally refitted with a soft liner either right away, or after a few days, depending on the wound healing process supplemented with resorbable sutures. With the one-stage surgical approach, the implants should be protected from contact with the temporary relined denture base, and therefore the dentures are generously relieved overlying the implant before the soft liner is placed. The latter should be changed at regular intervals and patients are instructed about careful hygienic procedures with small soft brushes and the use of a chlorhexidine mouthwash to facilitate plaque removal.

A healing period of 3 to 4 months for mandibular implants and 6 months for maxillary implants (conventional loading) has been traditionally observed—a protocol supported by long-term outcome studies. A longer interval is prescribed for compromised bone quality sites because published research suggests that the healing process is a very individual response that may be accelerated or delayed in different sites in different patients. Evidence suggests that the healing interval also may be abbreviated to permit either an early loading or immediate loading protocol for mandibular overdentures in selected cases (see Chapter 22). Caution is recommended for a similar approach with maxillary overdentures, given the absence of long-term evidence regarding the effectiveness of such an approach.

PROSTHODONTIC PROTOCOL

GUIDELINES FOR SELECTING ATTACHMENT SYSTEMS

Attachment systems for implant overdentures consist of two parts: the matrix being the receptacle component, and a corresponding patrix that fits closely within the matrix, either mechanically or with a friction fit. One part of the attachment system is usually connected to the implant and the other is incorporated within the undersurface of the overdenture. The patrix designs take the form of a

Box 17-4 Prosthodontic Approaches and Philosophies Used for Implant Overdentures

Single Elements (unsplinted)
- Single ball abutments (stress-breaking mechanism)
- Single magnet abutments (stress-breaking mechanism)
- Individually cast telescopic copings (rigid mechanism)

Connected Elements (splinted)
- Egg-shaped Dolder bar (stress-breaking mechanism)
- Round clip bar (stress-breaking mechanism)
- U-shaped bar (rigid)
- Customized precision-milled bars (rigid)

connecting bar or bars or freestanding ball/magnetic abutments. The matrix designs are adjustable and/or replaceable; can be mechanical, friction fit, or magnetic; and usually take the form of clips for bars. They have metal lamellae, plastic/nylon cap springs, or rubber O-rings for ball abutments and keepers or retainers for magnetic abutments. The overwhelming selection of attachment systems available today invariably leads to dentists selecting a retentive mechanism based on personal experience and patient considerations such as digital dexterity.

Considerations influencing the choice of attachment system include: (1) number of supporting implants and their distribution over the ridge, (2) type and size of ball abutments or the bars, (3) length of the bar segments, (4) number of matrices, and (5) degree of residual ridge resorption. Much empirical discussion exists regarding the benefits of different prosthodontic approaches and philosophies (resilient versus rigid) (Box 17-4). The resilient retention mechanism is widely recommended for anchorage of overdentures to implants, based on the assumption that this will protect implants from overload. In vivo research measurements of patients with two mandibular implants supporting an overdenture do not reveal a preference of one type of anchorage device or retention mechanism over another. They are all arguably equally efficient. A popular belief among dentists is that bars may contribute to load sharing.

Indications for Ball or Magnetic Attachments

Ball or magnetic attachments offer an easy way to retain implant overdentures and are frequently recommended when implants are placed underneath a patient's presently worn dentures, that is, ones that do not have to be remade. Denture-wearing problems of elderly patients with impaired manual dexterity also may be readily resolved using this approach. They should not be used to compensate for unfavorable and nonparallel alignment of the implants. Examples of matrices of some attachment systems are shown in Fig. 17-7 (see patrices in Figs. 17-2 and 17-3).

Indications for Bar Attachments

These are routinely recommended for maxillary overdentures, atrophic residual ridges in the mandible, and mandibles with more than two implants due to pronounced ridge curvature. The bars can be soldered, cast, or made using milled precision bars as part of an attachment system. Short distal extensions from rigid bars can contribute to stabilization and prevent horizontal shifting of the overdenture. Because splinted multiple implants with a bar usually are prescribed for the maxilla, a horseshoe design is possible (Fig. 17-8). As a consequence, this type of maxillary overdenture will resemble a fixed full-arch prosthesis with regard to stability and function. It is therefore understandable that this may not be regarded as a realistic and economic alternative to a tooth-supported overdenture or complete denture, as is the case with mandibular overdentures supported by only two implants.

IMPLANT OVERDENTURE DESIGN

The design and fabrication of implant overdentures follow previously described principles of fabricating complete dentures as described in Part IV. Stability and retention of complete dentures are enhanced by provision of a well-fitting denture base and properly extended flanges. However, should a patient object to prosthesis bulk, it is reasonable to reduce the denture's peripheries or palatal coverage because of the prosthesis' relative immobility. Relatively easy replacement of lost soft tissue and restoration of facial support are compensated for by the denture base's design and the established vertical dimension of occlusion.

The arrangement of anterior teeth follows basic guidelines as determined by facial esthetic needs, whereas the arrangement of posterior teeth contributes to retention and stability of the dentures. Individual patient preferences frequently can be fulfilled, but anterior teeth positions should not interfere with the circumoral musculature. It is presumed that a stable occlusal scheme (see Chapter 10) is likely to contribute to the protection of implants from overloading.

CLINICAL AND LABORATORY PROCEDURES

Ball or magnetic abutments facilitate simple procedures, as opposed to making a bar. Preliminary impressions are made with alginate in metal stock trays. The custom acrylic resin trays are made either with space relief using ball/magnetic abutments or with openings accommodating transfer copings placed on the implants with the bar design. The final impression is made, it is removed from the mouth, and

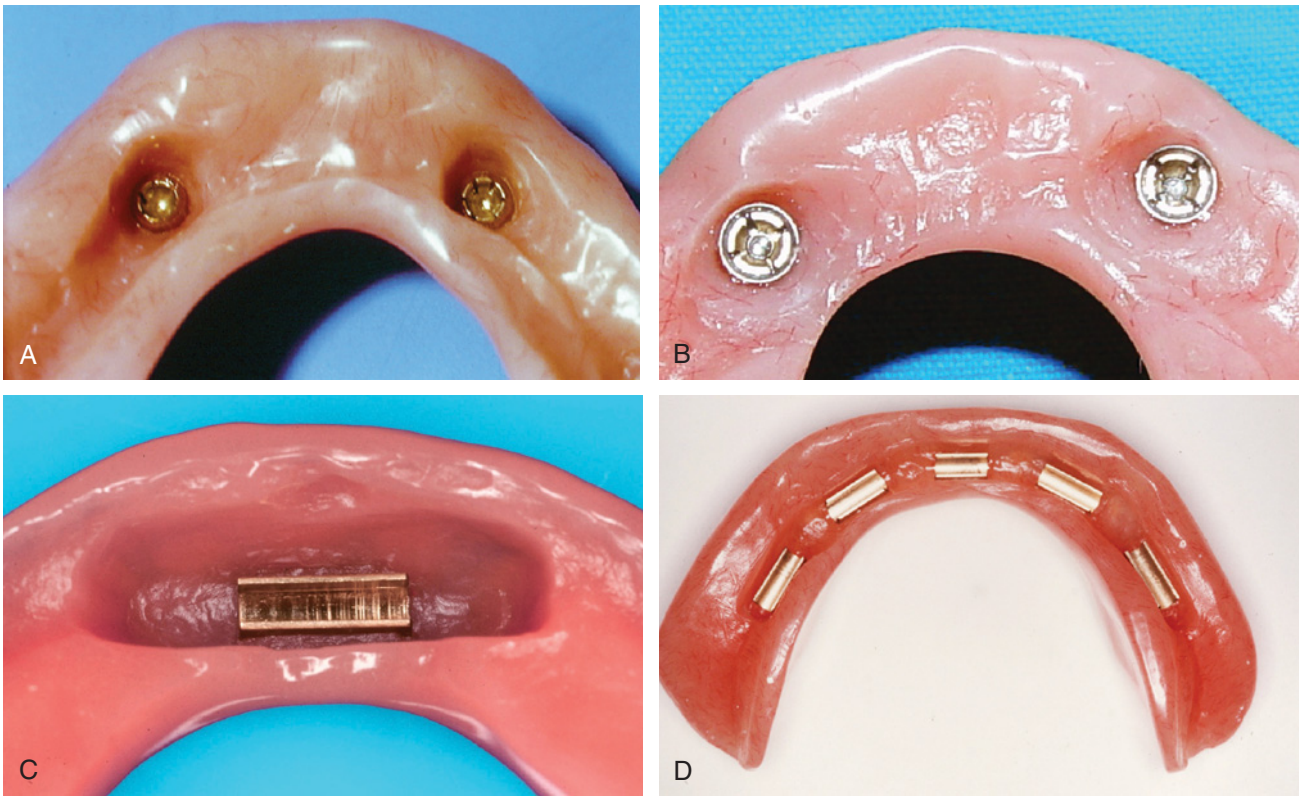


Figure 17-7 **A** to **D,** Numerous attachment matrices have been commercially produced in an attempt to enhance or diversify claims for optimal implant/prosthesis retention. These methods are backed by strong anecdotal support.

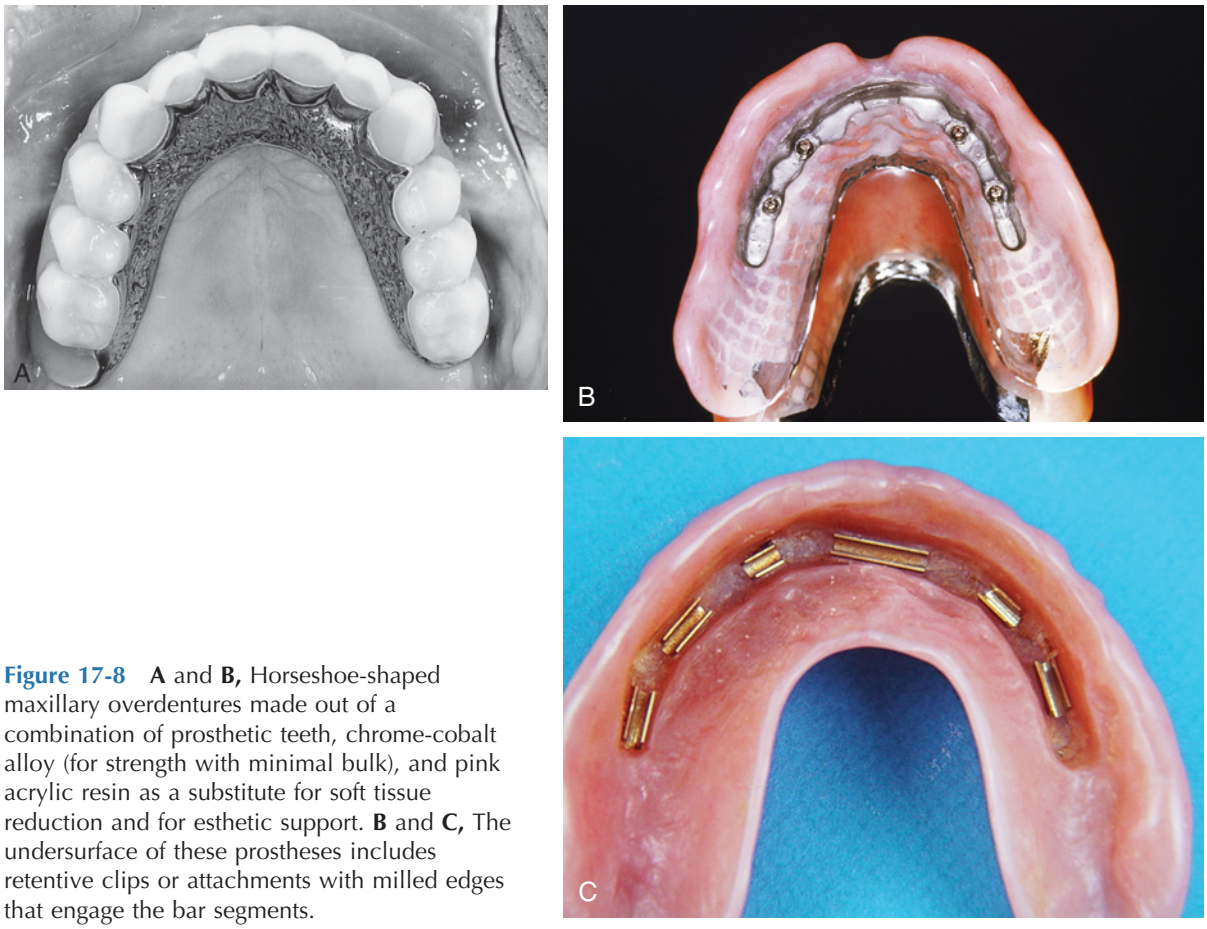


Figure 17-8 **A** and **B,** Horseshoe-shaped maxillary overdentures made out of a combination of prosthetic teeth, chrome-cobalt alloy (for strength with minimal bulk), and pink acrylic resin as a substitute for soft tissue reduction and for esthetic support. **B** and **C,** The undersurface of these prostheses includes retentive clips or attachments with milled edges that engage the bar segments.

laboratory replicas are placed directly into the impression surface for ball or magnetic abutments or connected to the transfer copings for a bar design. The master cast is poured with the laboratory replicas in place. Whenever a bar is used, the bar (1) follows the shape of the ridge in straight segments, (2) respects the position of the prosthetic teeth, and (3) provides access for oral hygiene procedures.

The subsequent clinical/laboratory protocol is identical to that used for complete denture fabrication. The exception is the inclusion of the selected matrices directly in the undersurface of the overdenture base during the laboratory processing procedures. Some clinicians prefer to use a cobalt-chromium framework embedded in the acrylic resin denture base; this appears to be a subjective decision, although it has economic implications (see Fig. 17-8). The matrices for bar designs (retentive clips) are processed in the acrylic resin denture base. The same orientation index is used to cast a metal framework after final soldering of the bar. The bar is soldered to the prosthetic copings and tried in the mouth. Matrices should not be soldered to the metal framework. They are retained in the denture base with acrylic resin to facilitate future changes or repairs. Step-by-step clinical and laboratory procedures for fabricating the implant overdenture are shown in Box 17-5.

MAINTENANCE

The objective of regular recalls for patients with overdentures is twofold: (1) to check the overdenture for minor denture adjustments, retention, stability, occlusal adjustments, and maintenance of the attachment system, and (2) to monitor implant osseointegration with marginal bone loss and the health of the oral and periimplant tissues. Both matrix activation and replacement are common events during the first year of service. Replacement of denture teeth, relining, or remaking of the implant overdenture together with wear and tear of the ball abutments or connecting bars (patrices) become prevalent over time. The type of attachment system used can influence the frequency of prosthodontic maintenance events required.

The cleaning of implants and overdentures is easier when compared with fixed full-arch prostheses (Fig. 17-9). The majority of patients with overdentures who are in special need of oral health care are frequently elderly because they tend to have to cope with impaired manual skills and reduced visual capacity. They are likely to have difficulties in following cleaning instructions and therefore rely on their care providers for professional assistance. They have to be taught individual hygienic procedures that best correspond to their abilities. The wearing of overdentures certainly enhances plaque accumulation and risk of inflammatory soft tissue reactions, but it is not as ominous a concern where implant abutments are used. Periimplant tissues do not appear to be as vulnerable to plaque by-products as periodontal tissues are, yet a variety of nuisance type gingival responses may develop and can be avoided with good hygiene protocol. Asymptomatic growth of hyperplastic soft tissue around implants and particularly underneath bars is common and usually rectified by a program of vigorous massage.

Box 17-5 Step-by-Step Prosthodontic Procedures

One
- Preliminary impression with irreversible hydrocolloid
  Laboratory: custom trays closed with space relief (ball abutments) or with openings over implants (bar design)

Two
- Abutment components placed
- Mounting of transfer copings (bar design only)
- Definitive impression with closed custom tray (ball abutments) or open custom tray (bar design)
  Laboratory: master cast with implant analogues, wax occlusion rims

Three
- Jaw relation records
- Tooth selection
  Laboratory: mounting the casts on the articulator, preliminary tooth setup

Four
- Verification of occlusal records
- Esthetic and functional assessment of tooth setup with the patient
- Indexing of denture tooth position (bar design only)
  Laboratory: corrections as determined at try-in appointment; bar fabrication

Five
- Complete try-in, obtain consent of the patient
- Try-in of bar assembly, correction of casting if a passive fit is not obtained
  Laboratory: final corrections, preparation for processing: assembly of attachment system components
- Processing the denture, occlusal equilibration on articulator to rectify processing errors

Six
- Delivery of dentures
- Instruction about insertion and removal of the implant overdenture
- Cleaning instructions for implants, attachment systems, dentures
- Information about and enrollment in the maintenance care program
- Baseline radiographs for monitoring marginal bone changes (optional)

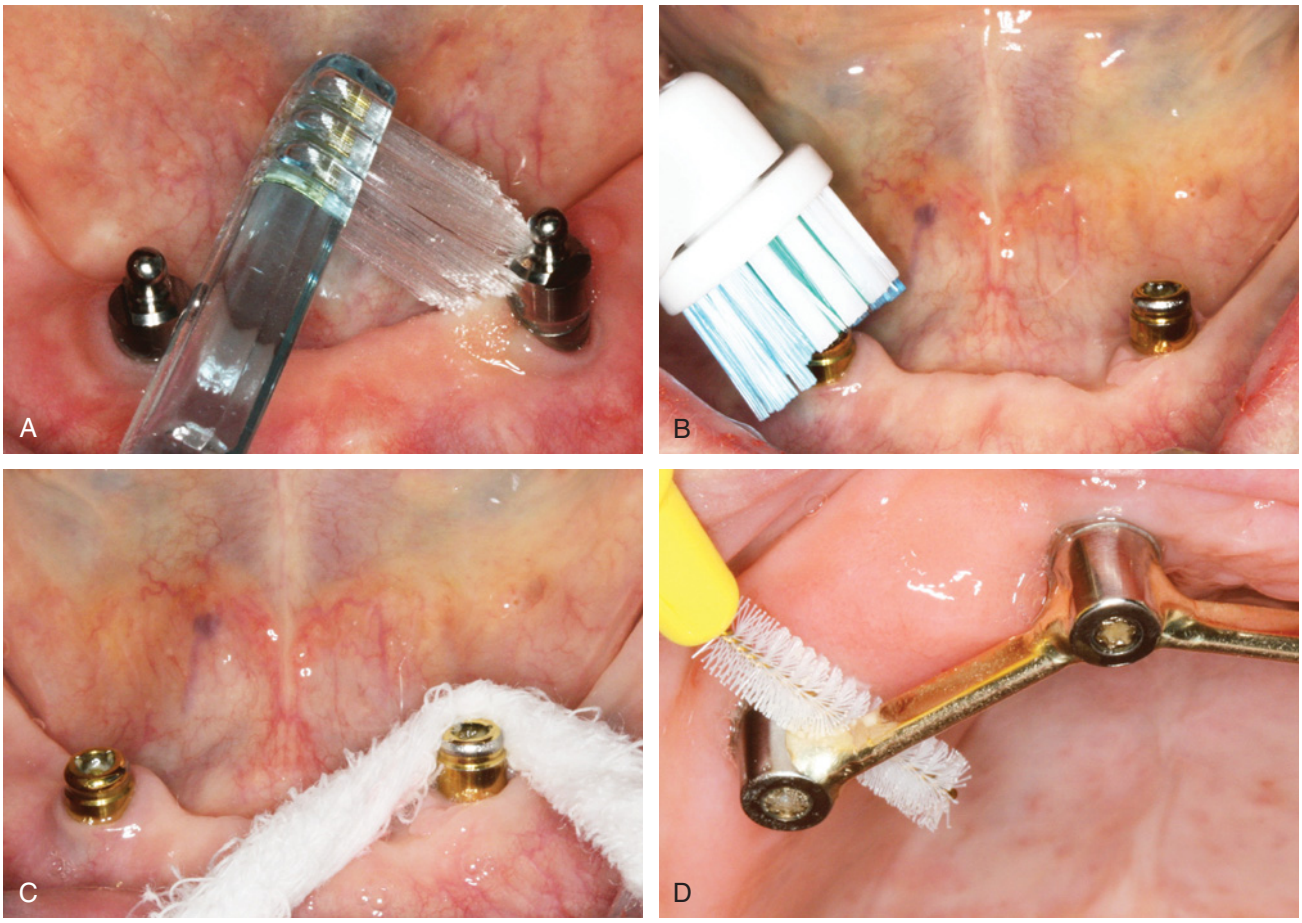


Figure 17-9 **A** to **D,** Popular manual or electric adjuncts for ensuring continued soft tissue health include brushing and stimulating periimplant tissues. The objective is plaque- and deposit-free implant components.

Bibliography

Allen PF, McMillian A: Food selections and perceptions of chewing ability following provision of implant and conventional prostheses to complete denture wearers, *Clin Oral Implants Res* 12:320-326, 2002.

Attard NJ, Zarb GA: Long-term treatment outcomes in edentulous patients with implant overdentures: the Toronto study, *Int J Prosthodont* 17:425-433, 2004.

Ceruti P, Bryant SR, Lee JH, et al: Magnet-retained implant-supported overdentures: review and 1-year clinical report, *J Can Dent Assoc* 76:a52, 2010.

Cune M, Burgers M, van Kampen F, et al: Mandibular overdentures retained by two implants. 10 year results from a cross-over trial comparing ball-socket and clip-attachments, *Int J Prosthodont* 23:310-317, 2010.

Meijer HJ, Raghoebar GM, Batenburg RH, et al: Mandibular overdentures supported by two or four endosseous implants: a 10-year clinical trial, *Clin Oral Implants Res* 20:722-728, 2009.

Ma S, Payne AGT, Tawse-Smith A, et al: Marginal bone loss with mandibular two-implant overdentures using different loading protocols and attachment systems: 10-year outcomes, *Int J Prosthodont* 23:321-332, 2010.

Merickse-Stern RD, Taylor TD, Belser U: Management of the edentulous patient, *Clin Oral Implants Res* 11(Suppl): 108-125, 2000.

Naert I, Alsaadi G, van Steenberghe D, et al: A 10-year randomized clinical trial on the influence of splinted and unsplinted oral implants retaining mandibular overdentures: peri-implant outcome, *Int J Oral Maxillofac Implants* 19:695-702, 2004.

Sadowsky S: Treatment considerations for maxillary overdentures: a systematic review, *J Prosthet Dent* 97:340-348, 2007.

van Kampen FMC, van der Bilt A, Fontijn-TeKamp FA, et al: Masticatory function with implant-supported overdentures, *J Dent Res* 83:708-711, 2004.

Walton JN, Glick N, MacEntee MI: A randomized clinical trial comparing patient satisfaction and prosthetic outcomes with mandibular overdentures retained by one or two implants, *Int J Prosthodont* 22: 331-339, 2009.

CHAPTER

18

Fixed Full Arch Implant-Supported Prostheses for the Edentulous Patient

Thomas J. Salinas, Sreenivas Koka

As emphasized throughout this text, edentulous patients seek treatment for functional and esthetic improvement. It has been reported that the incidence of complete edentulism is declining; however, it is also true that numerous adult and elderly patients continue to require management of their edentulous predicament. Success when treating edentulous patients with complete dentures is influenced by many variables, including patients' pretreatment expectations, satisfaction with their dental care, and mental health (see Chapters 1 and 5).[3] However, some individuals are maladaptive in their ability to tolerate such treatment and might require a more advanced technique. The advent of osseointegration has vastly improved outcomes related to treating edentulous patients because it has provided for the management of edentulism to extend beyond that previously attainable by complete dentures. Increased stability and retention of prostheses can be achieved by one of two means, either an implant-retained removable overdenture or an implant-supported fixed prosthesis. This chapter seeks to introduce the reader to the pertinent factors of clinical decision making in the treatment of edentulism with an implant-supported fixed prosthesis.

PATIENT SELECTION

Patients who struggle to adapt sufficiently to complete dentures may experience severely compromised quality of life as reflected by diminished masticatory function, significant discomfort (pain), and a loss of social confidence and self-esteem. The promise of rehabilitation in one or more of these areas is appealing, and patients who opt for the implant-supported fixed option are likely to experience meaningful improvement. Not all patients are best suited to such treatment, and a number of important factors must be considered before implant-supported fixed prosthesis therapy is undertaken.

A patient who has adequate volume of bone to support successful osseointegration of sufficiently long implants offers an excellent prognosis. However, the patient's healing capacity must be assessed preoperatively to ensure that no conditions exist that might impact on the host response. This assessment would necessarily be part of the meticulous diagnostic phase of treatment that reconciles patient wishes with their medical and dental histories and their current condition. In addition, diagnostic radiographic imaging is also necessary. Experienced surgeons will usually need a dental panoramic film and occasionally more advanced imaging in the form of cone beam computed tomography (CBCT) scans. These provide a more complete view of the maxillofacial skeleton and are very helpful when questions of bone volume and the positions of key structures are not apparent from the panoramic film. The additional radiation of the patient and extra cost, however, dictate that this should only be done when clinically necessary. In addition, diagnostic casts and a diagnostic tooth arrangement also may be required to assess whether patient expectations can be met within the clinical restraints. Clearly, the possible need for any form of bone augmentation can be better determined with a diagnostic protocol that captures all necessary information.

The completed diagnostic procedures will permit a final decision as to whether treatment with a fixed prosthesis is appropriate. Also, key decisions regarding treatment details can be made. These will include the probability that patient expectations will be met, the likely improvement in the performance of the prostheses, and the patient's understanding of the treatment procedures. In addition, the following factors also must be considered: the number of implants to be used, their macrodesign (geometry) and microdesign (surface characteristics), and their ideal length; the need for site modification before or concurrent with implant placement; the choice of provisional prosthesis (if indicated); the suitability of immediate loading of the implants; and the predicted ability of the host tissues to establish osseointegration in a sufficiently short time frame and to support its long-term maintenance. Finally the motivation level of the patient regarding oral hygiene measures

Box 18-1 Key Factors Associated with Long-Term Implant Success and Survival

Patient expectations
Number of implants
Design of implants (macrodesign and microdesign) and implant length
Site selection and augmentation
Provisional prosthesis and immediate loading
Host response
Patient motivation

and ongoing maintenance must be evaluated carefully before embarking on what will be a highly invasive and extensive course of treatment that by its nature carries some degree of risk (Box 18-1). These considerations are discussed in more detail below.

- Patients' expectations. Assessing the patient's expectations and determining the degree to which these can or will be met is the single most important step on the care pathway to the desired destination: a satisfied patient. Unfortunately, the accurate determination of the patient's expectations is often given low priority in the diagnostic phase. Taking the time necessary to build rapport with a patient is vital if the psychosocial reasons that are the impetus for most patients to seek treatment are to be satisfactorily addressed. When treatment is complete, a technically superb outcome that does not address typical issues of the patient's self-esteem or self-confidence will not lead to the desired answer to that most important of questions: "Would you undertake this treatment again?" (see Chapter 5).
- Number of implants. Although expert opinions have suggested a minimum number of implants for each arch to support a fixed prosthesis, there is little evidence to support a notion that, with current implant designs and surfaces, the maxilla requires more implants than the mandible. Indeed, it is more likely that the position and length of the implants can overcome a deficiency in absolute number. Nevertheless, clinical experience suggests that fixed prostheses in either arch can be successfully supported by as few as four implants, provided that their positioning permits minimal cantilever extensions.
- Macrodesign, microdesign, and implant length. The threaded screw macrodesign has produced excellent long-term results with numerous 20-year studies attesting to the durability of the host response. Both external and internal connections between the implant body and connecting components are also very successful and clearly possess appropriate properties for supporting a prosthesis with a low complication rate. The microdesign of implants focuses predominantly on modulating the implant surface by either physical and/or chemical treatments. These can enhance the host response and overcome the problems encountered in some situations with machined-surface commercially pure titanium implants. Recent research indicates that while devices with such surfaces were more susceptible to failure when the implants were short (<10 mm), placed in maxillary bone, or used in smokers, none of these effects are evident to the same degree when a suitably microdesigned surface is used.
- Site modification. This area is addressed elsewhere in this text (see Chapter 23). However, from a prosthesis design perspective, bone augmentation may be necessary both to create the volume of tissues necessary to accommodate the implant and to provide the desired esthetic outcome as it relates to tooth position, lip support, and facial contour.
- Choice of provisional prosthesis and immediate loading. Patient concerns will dictate the need for and type of provisional prosthesis. Some patients will be satisfied with no provisional prosthesis, some with a removable provisional or interim appliance, and some only with a fixed provisional prosthesis. Patients' hopes and expectations pertaining to esthetics, comfort, and function drive the ultimate decision with regard both to the need for a provisional prosthesis and its type. This also has been influenced by good intermediate term (5 to 10 years) results of immediately loaded implants, which have shown fixed provisionalization to be a predictable and safe clinical procedure if multiple implants with sufficient primary stability are present, and has increased patient acceptance of implant-supported therapy. Clinical evidence indicates that immediately loaded single implants have a significantly higher failure rate,[4] while implants that do not exhibit good primary stability are also at greater risk for failure.
- The host response. The host-implant interface is far more greatly affected by the host than it is by the implant design. Host variability with regard to all aspects of wound healing, initial bone formation, and bone maturation is the primary reason why implants do not become integrated or fail to remain integrated in the long term. Whereas the processes of wound healing and woven bone formation can be considered in the context of the "promotion" of osseointegration, should this occur successfully, challenges to the "protection" and "perpetuation" of osseointegration will remain during the lifetime of the host-implant interaction. The host's ability to provide an environment (soft and hard tissues) that can satisfactorily adapt to the challenges of occlusal function, soft tissue forces, and bacterial challenge is paramount to long-term retention of an implant. The inability of the host to provide such an environment leads to a state of compromise where the interface





Figure 18-1 All-ceramic mandibular prosthesis **(A)** constructed in two segments **(B)** to permit a presumed independent movement of the left and right sides of the mandible.

will break down, perhaps episodically, until a point is reached where the implant can no longer survive.

- Patient motivation. Scrupulous oral hygiene measures are vital to ensuring soft tissue health adjacent to implant-supported or implant-retained restorations. Patients who do not demonstrate sufficiently diligent oral hygiene practices are prone to periimplant mucositis (soft tissue inflammation) with ensuing erythema, swelling, and bleeding upon gentle probing. Providing patients with thorough instructions regarding oral hygiene measures is important and a mandatory part of therapy. Patients also should be educated in the importance of presenting for regular maintenance visits to permit clinical and, where indicated, radiographic evaluations. The duration between maintenance visits should be determined on an individual basis and also predicated upon the type of prosthesis.

CONSIDERATIONS SPECIFIC TO THE EDENTULOUS MANDIBLE

Treatment planning for the edentulous mandible could range from providing the patient with simple anchorage for a complete denture, thus maintaining its stability, to provision of a fixed prosthesis that relies entirely on implant support.[5,6] In these cases, surgical placement of between four and six implants in the anterior mandible and limited distal cantilevered extensions to the posterior mandible has been a model that has been shown in long-term studies to be very successful.[7,8] The maximum desirable cantilever extension has been estimated to be approximately 1.5 times the maximum anterior posterior distance between the implants supporting the prosthesis.[9,10] It is therefore imperative to maximize this distance. Attention directed to angulating the posterior implants distally may help maximize this dimension because no difference in long-term success has been noted between implants placed perpendicular to the occlusal plane and those that are angulated.[11] The biomechanical needs of a particular patient also may require the elimination of cantilevering and the placing of several implants in the posterior mandible if alveolar volume permits. In these cases, consideration should be given to mandibular flexure and designing the prosthesis into segments permitting independent movement of the two halves of the jaw[12,13] (Fig. 18-1).

IMMEDIATE LOAD REHABILITATION OF THE EDENTULOUS MANDIBLE

Successful treatment of the edentulous mandible using multiple immediately loaded implants has been documented and has similar patient selection criteria to those for a two-implant overdenture.[14,15] The use of a conversion prosthesis has been described[16-18] and can facilitate short-term function while awaiting the final restorative phase (Fig. 18-2). Splinting of multiple implants immobilizes them and discourages micromovement between implants, which it has been postulated may disturb the osseointegration process. At the same time, the need for soft tissue support, which is required for a removable prosthesis, is eliminated, facilitating patient compliance and comfort during the interim period. Current reviews of the literature indicate that treatment with immediately loaded implants in the anterior mandible has favorable outcomes and can be safely accomplished within the parameters discussed above. Methods of providing treatment with an immediately load fixed prosthesis follows.

Step-by-Step Procedures

1. The clinical and radiographic evaluation had led to a diagnosis, which helped to determine a treatment plan for this patient (see Fig. 18-2, *A* and *B*). Following

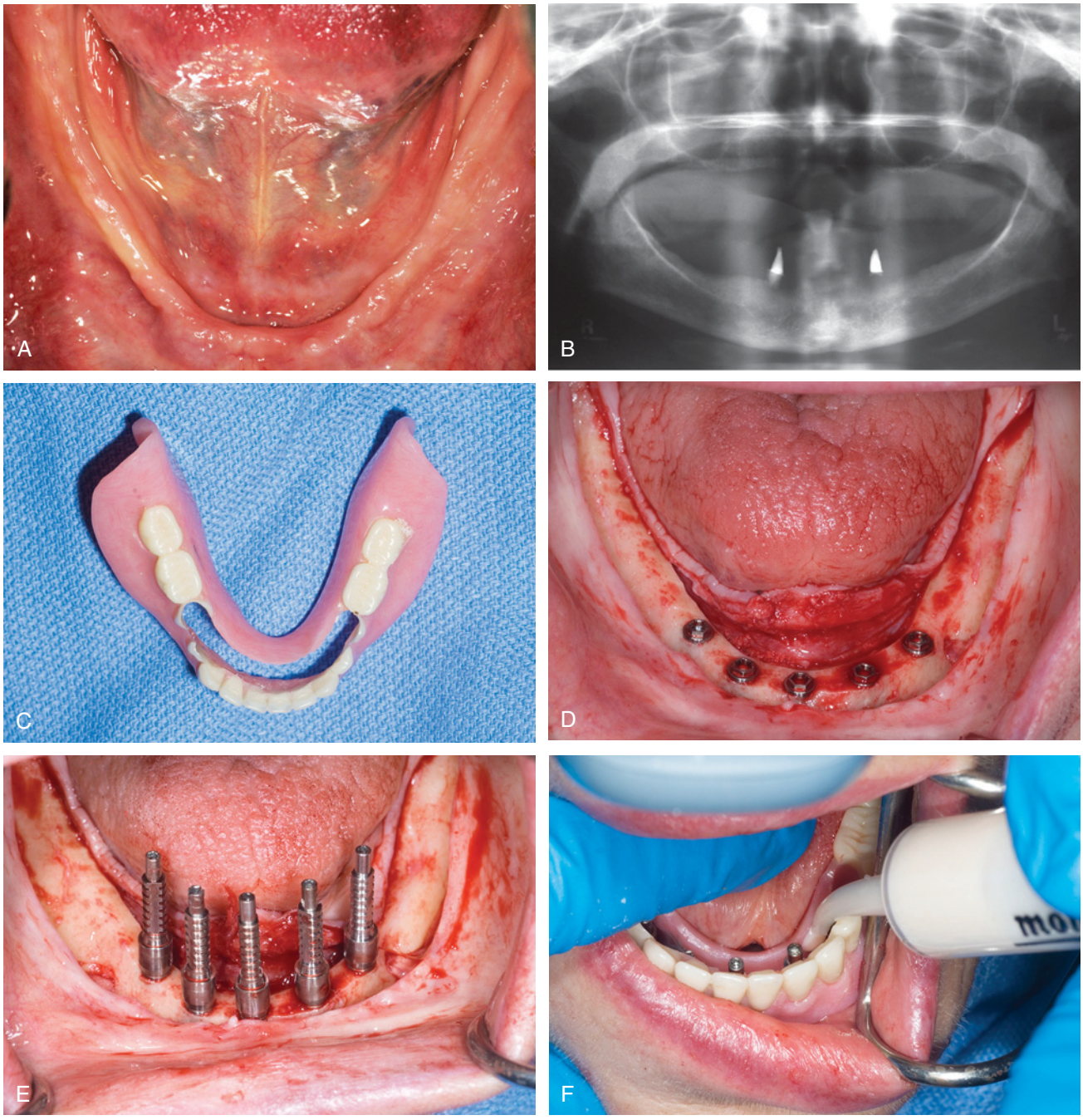


Figure 18-2 Edentulous patient planned for mandibular osseointegrated fixed complete prosthesis. **A,** Occlusal view of mandible. **B,** Panoramic radiograph with radiographic markers for location of mental foramina. **C,** Modification of complete denture to act as surgical guide. **D,** Surgical placement of five endosseous implants. **E,** Attachment of abutments and provisional copings to implants. **F,** Relation of prosthesis to copings using autopolymerizing acrylic resin.

Continued

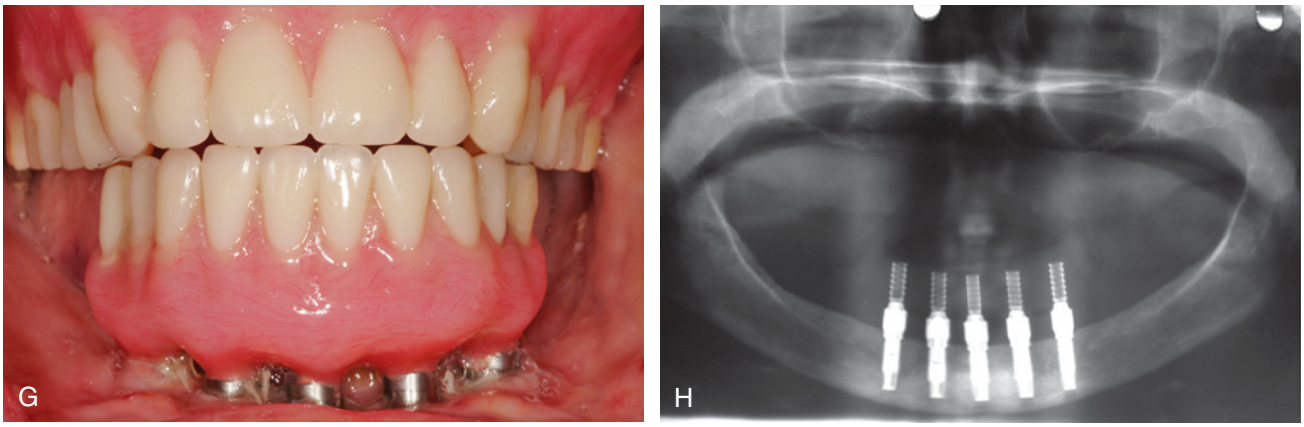


Figure 18-2, cont'd **G,** Insertion of conversion prosthesis within 24 hours. **H,** Radiographic survey of provisional prosthesis in place.

provision of conventional maxillary and mandibular complete dentures, the patient desired a fixed prosthesis in the lower jaw. This required placement of a number of implants in the anterior mandible to support a fixed complete denture.

2. In cases where the maxilla will be restored with a conventional complete denture, it is suggested that four to six implants be placed in the interforaminal area. Optimal placing of the implants is facilitated by using the patient's lower denture, or a duplicate, as a surgical guide. This should be perforated with a slot following the curve of the arch between the premolar regions, thus delineating the space available for implant placement (see Fig. 18-2, *C*).
3. After placement of the dental implants their stability should be assessed. A final insertion torque of 35 Ncm may be considered to confirm their suitability for immediate loading, although the current research evidence for this is far from robust (see Fig. 18-2, *D*). Restorative components (temporary titanium cylinders) with guide pins are then secured to the implants (see Fig. 18-2, *E*). During this procedure a sheet of rubber dam material should be placed over the assembly to isolate and protect the surgical site.
4. The prosthesis is placed over the assembly and related to the components with either a rigid material (autopolymerizing acrylic resin) or an elastomeric material introduced with a syringe (see Fig. 18-2, *F*). The patient is then directed to close against the opposing arch until the relating material is set. The assembly is then carefully detached by unscrewing the guide pins and retrieved from the mouth.
5. Laboratory implant/abutment analogs are related carefully to the prosthetic cylinders with care being taken to avoid displacing the components. This is then immersed in low expansion stone to act as a verification index. Flanges and cantilever extensions are then removed to create a convex intaglio surface facilitating hygiene procedures.
6. The prosthesis is then attached to the implants within 24 to 48 hours before any swelling occurs, which is often prevalent within the first 72 hours (see Fig. 18-2, *G* and *H*). This placement time is also critical so as to effectively splint the implants, discouraging any micromovement in advance of the critical period of osseointegration. Controlled occlusal forces are established by furnishing the opposing prosthesis with maximum occlusal contact and prescription of a relatively soft diet for 90 days. After this time, construction of the definitive prosthesis can take place.

The successful use of implants for immediate anchorage of prostheses when treating mandibular edentulism has been documented in the short term,[19] while others[20,21] have reported that this treatment modality is successful and has few requirements.

Implant placement in these cases should allow the body of the implant to be completely surrounded by bone with stabilization equated to an insertion torque of at least 25 Ncm.[22] It is the authors' experience that a placement torque of at least 35 Ncm will permit stable manipulation of these components during the immediate load treatment phase. An alternative measure of implant stability is the implant stability quotient (ISQ), which can be determined by analysis of the implant's resonance frequency. To use immediate loading, the ISQ has been recommended to be at least 60. However, the considerable variations in findings and recommendations regarding their validity make it difficult to currently justify the routine clinical use of the technique. In the original Brånemark protocol, the goal was to achieve optimal stability using bicortical stabilization. Currently, this concept is emphasized less than maximum bony engagement, with healthy bone completely surrounding the implant. Treatment with implant-retained removable prostheses is often particularly effective for patients with edentulous mandibles, depending on their expectations, anatomic limitations, and a desire for reduced maintenance.

THE EDENTULOUS MAXILLA

Decisions concerning treatment planning for an edentulous maxilla often are first approached from the viewpoint of the patient's needs and expectations. The configuration of the maxilla should favorably contribute to the stability of a complete denture by having a well-defined ridge, favorable palatal vault form, favorable maxillomandibular relationship, distinct tuberosity formation, and prominent anterior labial and buccal vestibules.[23] In some circumstances, the clinical experiences of the patient restored with a maxillary complete denture may warrant consideration of implant-assisted restorations. In these situations, a complete analysis of the esthetic, phonetic, and occlusal factors is imperative so as to develop a carefully conceived treatment plan for the patient.[24]

The choice of using a fixed or removable restoration for the patient should be based partly on the clinical assessment of the patient's speaking space with a diagnostic tooth arrangement. Other important factors are lip posture and tooth display when the lips are at rest,[25,26] while lingual-alveolar consonant production and labiodental sounds also may dictate the use of a removable rather than a fixed restoration. For implant-supported restorations, assessment of the remaining alveolar bone in the edentulous maxilla will determine the feasibility of placing seven to eight implants for a complete arch implant-stabilized fixed restoration. Implants should be equally distributed around the arch to form a five-sided polygon, so that multiple force vectors can be resisted.[27] Because sinus enlargement is a common sequela of tooth extraction, it is often necessary to limit implant placement to the anterior maxilla, typically from the first or second premolar regions anteriorly. Alternatively it may be possible to augment the maxillary sinuses with bone or a bone substitute to enable a wider distribution of the implants. Bone augmentation of the maxillary sinuses has been well documented and is effective in enabling implant placement in the posterior maxilla[28-30] (Fig. 18-3, *A* to *G*).

The available interarch distance may have some bearing on the choices of materials and superstructure design. This dimension may be limited to less than 10 mm for which the use of porcelain fused to metal design may be indicated.

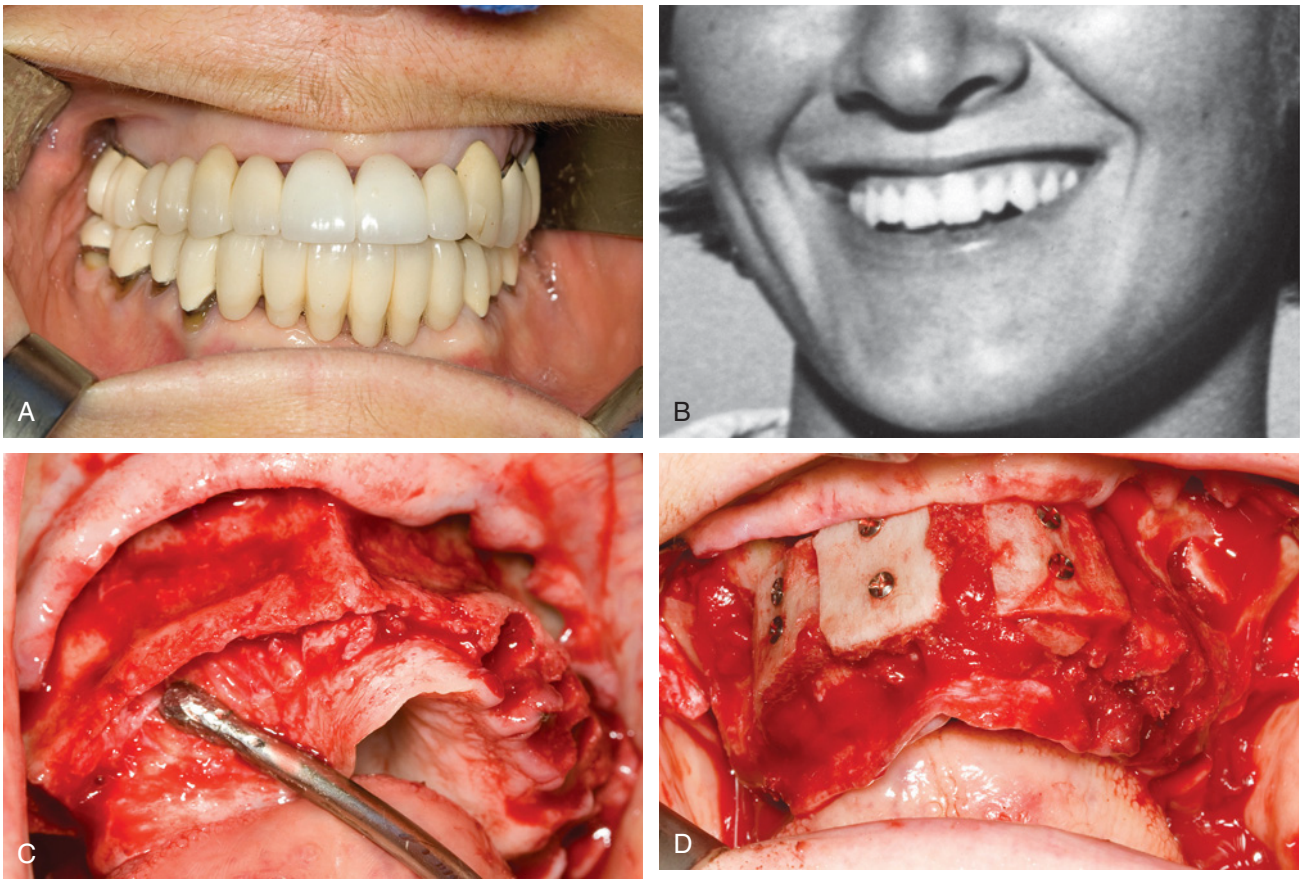


Figure 18-3 Atrophic maxilla secondary to a motor vehicle accident some 25 years before presentation. **A,** Failing maxillary fixed prosthesis. **B,** Photograph from before the accident reveals the smile line. **C,** Reflection of soft tissues revealing atrophic nature of residual alveolar ridge. **D,** Veneer grafting and sinus augmentation with iliac cortex and marrow.

Continued









Figure 18-3, cont'd **E,** Dental implants placed into surgically preferred recipient sites. Rehabilitation of patient with a cement-retained ceramometal prosthesis. **F,** Multiple implant-retained parallel abutments in maxilla. **G,** Intaglio surface of maxillary ceramometal fixed prosthesis. **H,** Frontal view of prosthesis before insertion.

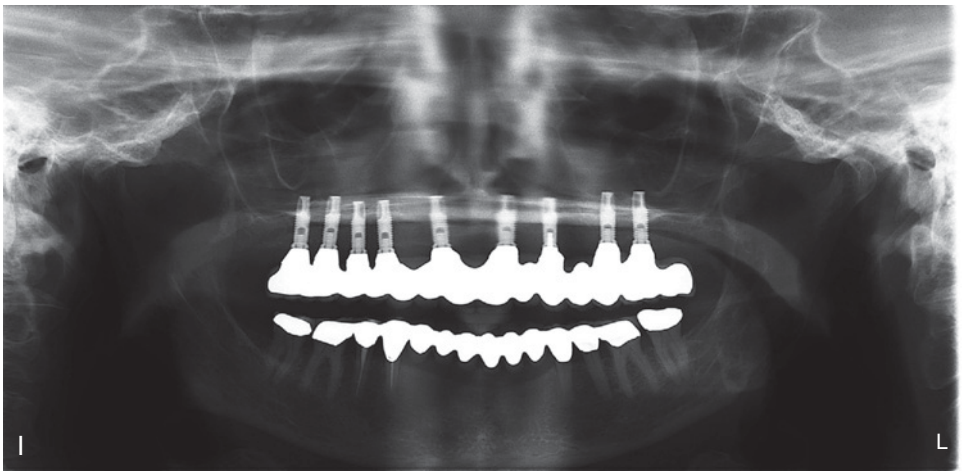






Figure 18-3, cont'd **I,** Try-in of abutments and prosthesis illustrated on panoramic radiograph. **J** and **K,** Frontal views of prosthesis from intraoral and extraoral perspectives.





Figure 18-4 Edentulous patient planned for fixed implant-supported prostheses. **A** to **C,** Provisional prostheses demonstrating constrained interarch distance after esthetic and functional verification.

Other indications for the choice of such designs include opposing porcelain surfaces and where an increased occlusal wear potential exists (Fig. 18-3, *H* to *K*).

Some evidence has challenged the notion of minimum implant numbers to form this polygonal approach with as few as four strategically placed implants being proposed in the edentulous maxilla (Fig. 18-4).

The use of remote anchorage or tilted implants has been demonstrated to have a comparable degree of success to orthogonally placed implants.[31-33]

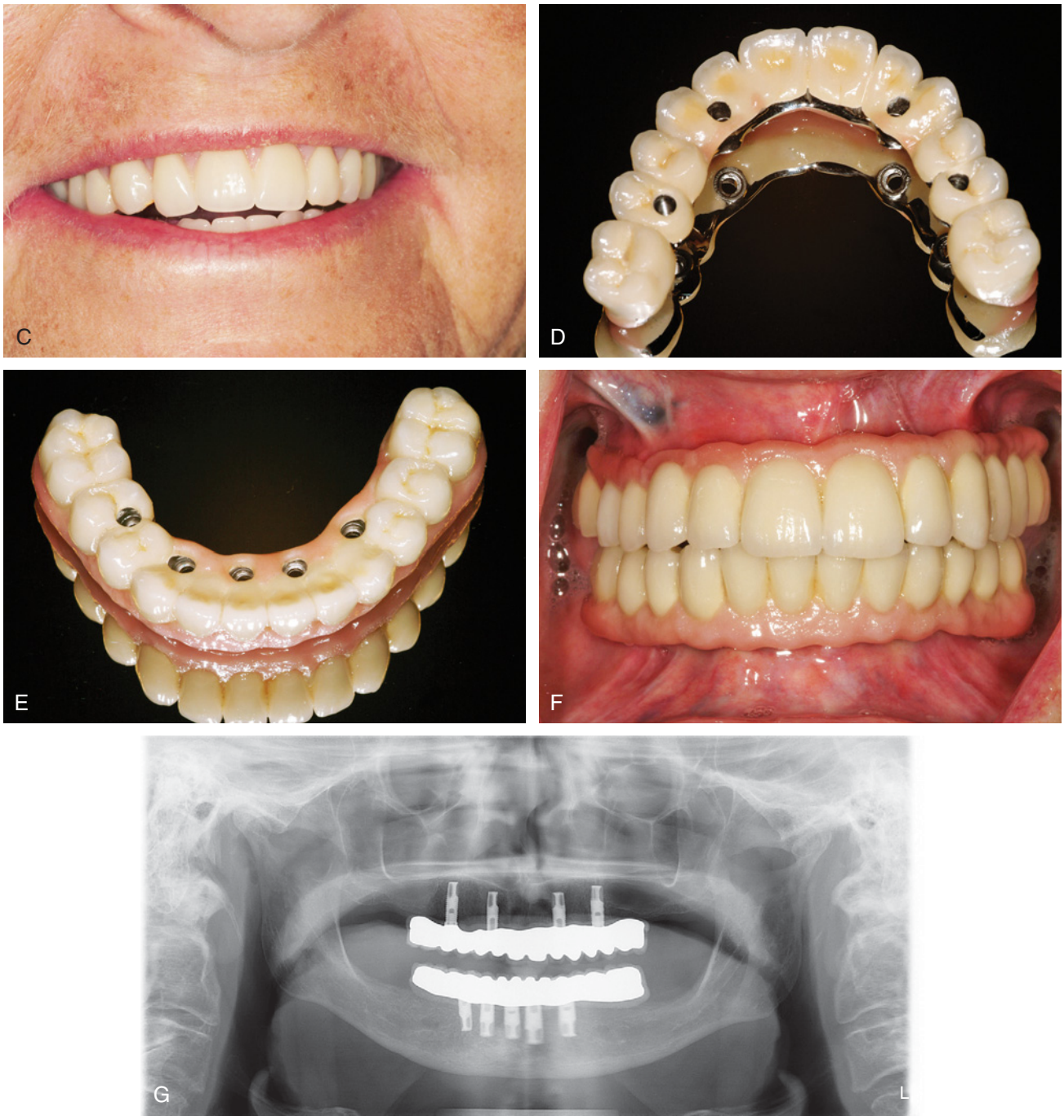


Figure 18-4, cont'd **D** and **E,** Occlusal views of screw-retained ceramometal prostheses with strategic placement of maxillary implants for maximum force distribution. **F,** Frontal occlusal view of prostheses. **G,** Panoramic radiograph illustrating completed treatment.

SUMMARY

The edentulous patient may be treated with implant-supported fixed prostheses after a full assessment, including the patient's expectations, interocclusal relationships, alveolar bone volume, and host factors. The surgical approach can be supported by 3-dimensional radiographic analyses planned on the basis of whether full or shortened dental arches are to be used. Patient-specific requirements for determining individual design requirements are often best based on patient experience with provisional restorations. The reader is encouraged to seek additional information on surgical and prosthodontic approaches for specific needs relative to restoring edentulous patients with a fixed dental prosthesis before undertaking such procedures.

References

1. Douglass CW, Shih A, et al: Will there be a need for complete dentures in the United States in 2020? *J Prosthet Dent* 87(1):5-8, 2002.
2. Chattopadhyay A, Arevalo O, et al: Kentucky's oral health indicators and progress towards Healthy People 2010 objectives, *J Ky Med Assoc* 106(4):165-174, 2002.
3. Diehl RL, Foerster U, et al: Factors associated with successful denture therapy, *J Prosthodont* 5(2):84-90, 1996.
4. Atieh MA, Atieh AH, Payne AG, et al: Immediate loading with single implant crowns: a systematic review and meta-analysis, *Int J Prosthodont* 22(4): 378-387, 2009.
5. Feine JS, Carlsson GE, et al: The McGill consensus statement on overdentures. Mandibular two-implant overdentures as first choice standard of care for edentulous patients, *Gerodontology* 19(1):3-4, 2002.
6. Carpentieri J: Treatment options for the edentulous mandible: clinical application of the two-implant overdenture, *Pract Proced Aesthet Dent* 16(2):105-112, 2004; quiz 114.
7. Zarb GA, Schmitt A: The longitudinal clinical effectiveness of osseointegrated dental implants: the Toronto Study. Part II: The prosthetic results, *J Prosthet Dent* 64(1):53-61, 1990.
8. Brånemark PI, Svensson B, et al: Ten-year survival rates of fixed prostheses on four or six implants ad modum Brånemark in full edentulism, *Clin Oral Implants Res* 6(4):227-231, 1995.
9. McAlarney ME, Stavropoulos DN: Determination of cantilever length-anterior-posterior spread ratio assuming failure criteria to be the compromise of the prosthesis retaining screw-prosthesis joint, *Int J Oral Maxillofac Implants* 11(3):331-339, 1996.
10. McAlarney ME, Stavropoulos DN: Theoretical cantilever lengths versus clinical variables in fifty-five clinical cases, *J Prosthet Dent* 83(3):332-343, 2000.
11. Krekmanov L, Kahn M, et al: Tilting of posterior mandibular and maxillary implants for improved prosthesis support, *Int J Oral Maxillofac Implants* 15(3):405-414, 2000.
12. Hobkirk JA, Wiskott HW, Working Group 1: Biomechanical aspects of oral implants. Consensus report of Working Group 1, *Clin Oral Implants Res* (Suppl)2:52-54, 2006.
13. El-Sheikh AM, Abdel-Latif HH, Howell PG, et al: Midline mandibular deformation during nonmasticatory functional movements in edentulous subjects with dental implants, *Int J Oral Maxillofac Implants* 22(2):243-248, 2007.
14. Gallucci GO, Bernard JP, et al: Immediate loading with fixed screw-retained provisional restorations in edentulous jaws: the pickup technique, *Int J Oral Maxillofac Implants* 19(4):524-533, 2004.
15. Balshi SF, Wolfinger GJ, et al: A prospective study of immediate functional loading, following the Teeth in a Day protocol: a case series of 55 consecutive edentulous maxillas, *Clin Implant Dent Relat Res* 7(1):24-31, 2005.
16. Winkelman RD, Fox NF: Conversion of a conventional crown and bridge prosthesis to an implant supported restoration, *Trends Tech Contemp Dent Lab* 10(6): 51-55, 1993.
17. Balshi TJ: Improve transition with an implant conversion prosthesis for the edentulous arch, *Dent Implantol Update* 5(9):65-69, 1994.
18. Balshi TJ, Wolfinger GJ: Conversion prosthesis: a transitional fixed implant-supported prosthesis for an edentulous arch—a technical note, *Int J Oral Maxillofac Implants* 11(1):106-111, 1996.
19. Payne AG, Tawse-Smith A, et al: One-year prospective evaluation of the early loading of unsplinted conical Branemark fixtures with mandibular overdentures immediately following surgery, *Clin Implant Dent Relat Res* 3(1):9-19, 2001.
20. Randow K, Ericsson I, et al: Immediate functional loading of Branemark dental implants. An 18-month clinical follow-up study, *Clin Oral Implants Res* 10(1): 8-15, 1999.
21. Engelke W, Decco OA, et al: Immediate occlusal loading of freestanding implants using cortical satellite implants: preliminary report of a prospective study, *Implant Dent* 14(1):50-57, 2005.
22. Degidi M, Piattelli A, et al: Clinical outcome of 802 immediately loaded 2-stage submerged implants with a new grit-blasted and acid-etched surface: 12-month follow-up, *Int J Oral Maxillofac Implants* 21(5):763-768, 2006.
23. McGarry TJ, Nimmo A, et al: Classification system for complete edentulism, *Dent Today* 20(10):90-95, 2001.
24. Jivraj S, Chee W, et al: Treatment planning of the edentulous maxilla, *Br Dent J* 201(5):261-279, 2006; quiz 304.
25. Ellis E III, McFadden D: The value of a diagnostic setup for full fixed maxillary implant prosthetics, *J Oral Maxillofac Surg* 65(9):1764-1771, 2007.
26. Bedrossian E, Sullivan RM, et al: Fixed-prosthetic implant restoration of the edentulous maxilla: a systematic pretreatment evaluation method, *J Oral Maxillofac Surg* 66(1):112-122, 2008.
27. Misch C: *Dental implant prosthetics*, St. Louis, 2005, Mosby Inc.
28. Boyne PJ, James RA: Grafting of the maxillary sinus floor with autogenous marrow and bone, *J Oral Surg* 38(8):613-616, 1980.
29. Tong DC, Rioux K, et al: A review of survival rates for implants placed in grafted maxillary sinuses using meta-analysis, *Int J Oral Maxillofac Implants* 13(2): 175-182, 1998.
30. Wallace SS, Froum SJ, et al: Effect of maxillary sinus augmentation on the survival of endosseous dental implants. A systematic review, *Ann Periodontol* 8(1): 328-343, 2003.

31. Malo P, Rangert B, et al: All-on-4 immediate-function concept with Brånemark system implants for completely edentulous maxillae: a 1-year retrospective clinical study, *Clin Implant Dent Relat Res* 7(Suppl 1):S88-S94, 2005.
32. Malo P, Nobre Mde A, et al: A pilot study of complete edentulous rehabilitation with immediate function using a new implant design: case series, *Clin Implant Dent Relat Res* 8(4):223-232, 2006.
33. Zarb G, Albrektsson T, Baker G, et al: Surgical considerations in osseointegration: on continuing synergies in surgery, prosthodontics, biomaterials, Carol Stream, Chicago, 2008, Quintessence.

CHAPTER 19

Maxillofacial Prosthodontics for the Edentulous Patient

Rhonda F. Jacob, Ting-Ling Chang

FORM AND FUNCTION

Maxillofacial prosthodontics focuses on optimizing the rudimentary functions of speech and swallowing. These functions are disrupted because of congenital, organic, traumatic, or surgical abnormalities involving the oral cavity and related anatomic structures. Depending on the etiology and severity of the abnormality, the multidisciplinary team will create treatment plans that consider a combination of interventions and timing of the interventions, sequelae and benefits of treatment, accompanying comorbidities, and the patient's psychosocial issues. The dentist who understands the commonalities of maxillofacial prosthodontic needs and procedures, despite different medical etiologies, is a valuable team member. Modifying routine dental procedures, the dentist creates static prostheses to fill voids created by missing tissues or to approximate organs with suboptimal function. Although the health care provider often considers rehabilitation of these rudimentary functions as the primary goal, restoration of normal esthetics and mastication is of no less importance to the patient. These prostheses can be critical requirements to improve quality of life for individuals whose rehabilitation will be a lifelong proposition. Normal function may not be achieved, but optimal function should always be attained, and normalcy should always be sought.

ANATOMIC AND PHYSIOLOGIC CONSIDERATIONS: NORMAL FUNCTION

The superior aspect of the oral cavity includes the hard and soft palate. As the beginning of the upper aerodigestive tract, the oral cavity serves to move air for speech and respiration and food and liquids for nutrition. The hard palate is the static "roof" of the oral cavity and the "floor" of the nasal cavity and maxillary sinuses. It serves to separate the oral cavity from the nasal cavity as required for speech, respiration, and swallowing. The soft palate is a dynamic separator of the oral cavity and nasal cavity.

During respiration, an individual either inspires or expires through the nose or the mouth, but never both simultaneously. During expiration, air passes from the lungs, through the pharynx, and then through the oropharynx. Either the air then passes behind the soft palate into the nasopharynx, the nasal cavity, and out the nose, or the soft palate elevates to block the nasopharynx and the air passes out the oral cavity. During inspiration, the air passes in the opposite direction, through either the nasal cavity or the oral cavity.

For appropriate separation of these cavities during speech, respiration, and swallowing, the soft palate elevates in the middle third to separate the oropharynx and nasopharynx. The soft palate musculature extends from the pharynx at the level of the palate, inferiorly to the tonsillar area. The right and left muscles of the soft palate attach to the distal aspect of the hard palate and then intermingle on the entire midline length of the soft palate, forming an aponeurosis. Simultaneous contraction of these bilateral muscles causes the midline elevation of the soft palate. As the soft palate elevates, the pharyngeal wall simultaneously moves anteriorly and medially at the level of the soft palate elevation, which is in line with the plane of the hard palate and the atlas of C1. The sphincter formed by the soft palate and pharyngeal wall tightly closes and prevents any passage of liquid or food into the nasopharynx during deglutition. During phonation, the soft palate also elevates, and the pharyngeal wall moves anteriorly and medially; however, the movement of both structures is usually less dramatic than the sphincteric movement that occurs in swallowing. These functional movements of the soft palate and pharyngeal walls during speech and swallowing are called *velopharyngeal closure* (Fig. 19-1). In the English language, there are very few sounds that require air to travel from the oral cavity, behind the soft palate, and escape from the nose. These "nasal sounds" are *n*, *m*, and *ng* and resonate in the nasal cavity before exiting the nose. All "oral sounds" require that air be impounded in the oral cavity by the elevation of the soft palate and closure of the pharyngeal walls.

The inferior aspect of the oral cavity includes the tongue, muscles, and tissues of the floor of mouth, and the

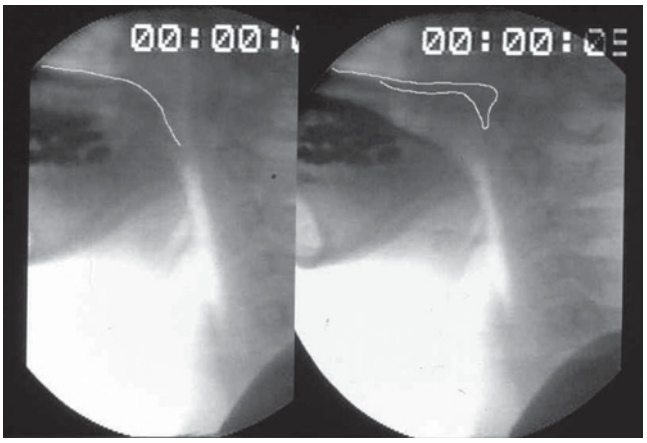


Figure 19-1 These lateral videofluoroscopic frames show the "at-rest" position of the soft palate *(left)* that postures against the base of the tongue and leaves the nasopharynx open for respiration. During swallowing *(right),* the soft palate sharply elevates as the pharyngeal wall (superior constrictor muscle) constricts, thereby forming a sphincter that separates the nasopharynx and oropharynx.

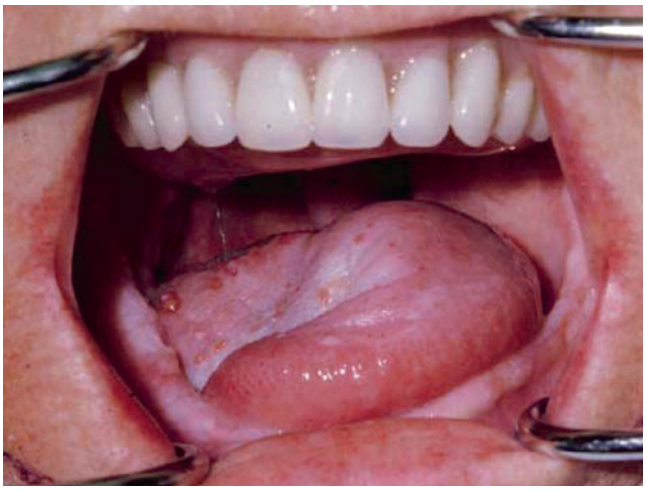


Figure 19-2 Patient with partial glossectomy defect closed primarily. Tongue mobility was deficient. It is not possible for the patient to move the tongue or any food bolus laterally onto the occlusal surfaces of the teeth.

mandible. These inferior structures act in concert during speech. The tongue acts as the primary articulator. Airflow and the sounds emanating from the larynx are modulated through specific sites of contact and approximation of the tongue with the hard palate, the soft/hard palate junction, and the dentition. Accurate and rapid tongue movements are required for intelligible articulation.

During mastication, the tongue and cheeks constantly move the food bolus onto the occlusal surfaces. The tongue finally forms the food into a mass and pushes the mass posteriorly against the hard and soft palate and into the oropharynx. As the bolus passes, the sensory nerves in the tonsillar area begin the reflexive portion of the swallow where the airway closes and the esophagus opens. The soft palate simultaneously elevates as the pharynx squeezes. The pharyngeal squeeze pushes the food into the esophagus. On average, this push of the bolus from the posterior oral cavity into the esophagus takes 2 minutes.

FUNCTIONAL DEFICITS OF SPEECH AND SWALLOWING

There are a myriad of functional and chronologic interactions in the oral cavity, nasal cavity, nasopharynx, and oropharynx that influence speech and swallowing. Disruption of any of these interactions can lead to deficits in speech and swallowing. These disruptions result from congenital malformations, central nervous system trauma, or surgery. They are seen as tissue loss, muscular denervation, or both. The most common congenital deficit is a cleft palate, seen as missing tissue in the hard and/or soft palate. Central nervous system deficits result from head injuries and cerebrovascular accidents. Tissues remain intact but are centrally denervated. Surgery for neoplastic disease results in tissue loss and local denervation; in addition, closure of the surgical site often tethers remaining tissues and restricts their movement.

When a patient has disruption of *velopharyngeal closure* or defects in the hard palate, air escapes inappropriately from the nose in nonnasal speech sounds. The patient is said to have *hypernasal speech*. As the volume of air that inappropriately escapes from the nose increases, the patient becomes more hypernasal until his or her speech becomes unintelligible. During swallowing, these same functional defects allow reflux of food and liquids into the nasal cavity. In the case of *velopharyngeal inadequacy*, dysfunction of the pharynx or soft palate may be the cause. When the soft palate is partially resected, the bilateral synchronous movement of the right and left muscles is disturbed. Unilateral soft palate function will not close the sphincter. Limited movement of any of the walls of the pharynx will not close the sphincter. Lack of adequate movement of the pharynx or the soft palate may result from surgical resection of these structures, causing lack of tissue, surgical scarring, or denervation of muscles. Head trauma or stroke can centrally denervate the soft palate or pharynx.

When the tongue or its contiguous structures in the inferior aspect of the oral cavity are resected, tissue loss, denervation of tongue muscles, or tethering of the tongue from surgical closure of the floor of the mouth inhibits the appropriate tongue-palate contact necessary for articulation. Loss of lateralization of the tongue inhibits movement of the food bolus onto the teeth, and mastication is impaired (Fig. 19-2). Loss of elevation and "curling" of the tongue will inhibit moving the food bolus into the oropharynx to initiate the swallow.

PROSTHETIC CONSIDERATIONS FOR EDENTULOUS MAXILLOFACIAL PROSTHESIS

When patients have disruption of the rudimentary functions of speech and swallowing, as previously described, various intraoral prostheses are made to compensate for loss of function. There are particular prosthetic considerations that are universal for edentulous maxillofacial prostheses, and these will be addressed before individual prostheses are discussed.

FACIAL FORM

Patients who have received trauma or surgical resection for neoplastic disease to the face or oral structures can be expected to have altered facial contours. This is due to scarring and tissue contracture, lack of bony support for the soft tissues of the face, and tissue edema. The patient and clinician should expect that it may take several months after an operation or trauma for the soft tissues to reach a final, stable position. These changes necessitate fabrication of interim prostheses and repeated prosthesis adjustments to conform to soft tissue changes. Constant wearing of an interim prosthesis may slightly decrease or slow tissue contraction and collapse; however, because of a lack of dental retention in an edentulous removable prosthesis, contracture of tissues leads to prosthesis overextension and dislodgement of the prosthesis. When making an intraoral prosthesis, the clinician is very cognizant of the need to support the lips and cheeks, but soft tissue support and esthetics may be compromised in order to achieve prosthesis retention and stability.

LOSS OF VERTICAL OPENING AND ALTERED MANDIBULAR MOVEMENTS

Surgical resection, or trauma to oral cavity structures, can lead to loss of vertical opening of the mandible and altered mandibular range of motion. When there is surgical resection of the posterior aspect of the hard palate for neoplastic disease, the muscles of mastication are frequently detached from the maxilla or they are partially resected. This operation most often involves the medial and lateral pterygoid muscles at the attachment of the pterygoid plates. Trauma to the mandible in the area of the muscles of mastication also can damage the muscles. Trismus is the immediate result of muscular trauma, and the patient will have decreased vertical opening and range of motion of the mandible. As the area heals, the patient usually is recommended for manual mouth opening exercises and stretching to improve range of motion and vertical opening. As time progresses, the traumatic muscular injury may become fibrotic and scarred. Radiotherapy can further increase the severity of fibrosis. A decreased vertical opening often presents great challenges for oral hygiene, prosthetic treatment, and manipulation of a food bolus.

Partial resection of the posterior mandible removes the ipsilateral temporomandibular joint (TMJ) and the influence of the muscles of mastication that are detached from the resected mandible. This resection requires that the remaining mandible function on the opposing joint and muscles that support and move the remnant of the mandible. Unilateral joint and muscle control causes mandibular deviation and altered range of motion. The medial pull of the ipsilateral pterygoid muscles pulls the mandible toward the side of the resection. The muscles on the floor of the mouth that are attached to the remaining mandibular body rotate the chin inferiorly, causing loss of anterior vertical overlap. When the patient attempts to occlude, the mandibular body is positioned lingually to its appropriate position, and the anterior mandible is positioned inferiorly.

PROCESSED BASES

Processed bases have definite advantages in the patient with a maxillofacial prosthesis. Numerous soft tissue and bony undercuts exist after an oral cavity surgery or maxillectomy that may be used as prosthetic-retentive or bearing surfaces. When conventional record bases are made, the undercuts are blocked out to allow removal of the record bases from the master cast. Blocking out of these undercuts can result in lack of tissue contact of the record base with the periphery and the bearing surfaces within the surgical site (Fig. 19-3, *A* and *B*). Without bearing surface contact, the bases are unstable and nonretentive, thereby compromising correct placement of the midline and occlusal plane. The centric relation (CR) record may be grossly inaccurate. Using processed bases and denture adhesive in both the maxillary and mandibular prostheses will aid in achieving accurate records. Without correct and final peripheral extension of the base, it is difficult to set teeth in the appropriate buccal position, and it is not possible to discern how much additional lip and facial support may be gained from the teeth. Processed bases will allow the clinician to judge prosthesis retention and position of soft tissues supported by the base. At the try-in appointment, the patient and the clinician will be able to arrive at the optimal tooth position to consider esthetics, speech, retention, and stability of the prosthesis given the less than ideal postsurgical intraoral and extraoral tissue contours (Fig. 19-3, *C* and *D*).

BORDER MOLDING SOFT PALATE AND MAXILLARY DEFECTS

BORDER MOLDING THE VELOPHARYNGEAL AREA: PATIENT MOVEMENTS

Velopharyngeal closure can be reestablished with a properly contoured obturator if the residual portion of the velopharyngeal structure still exhibits some movement.

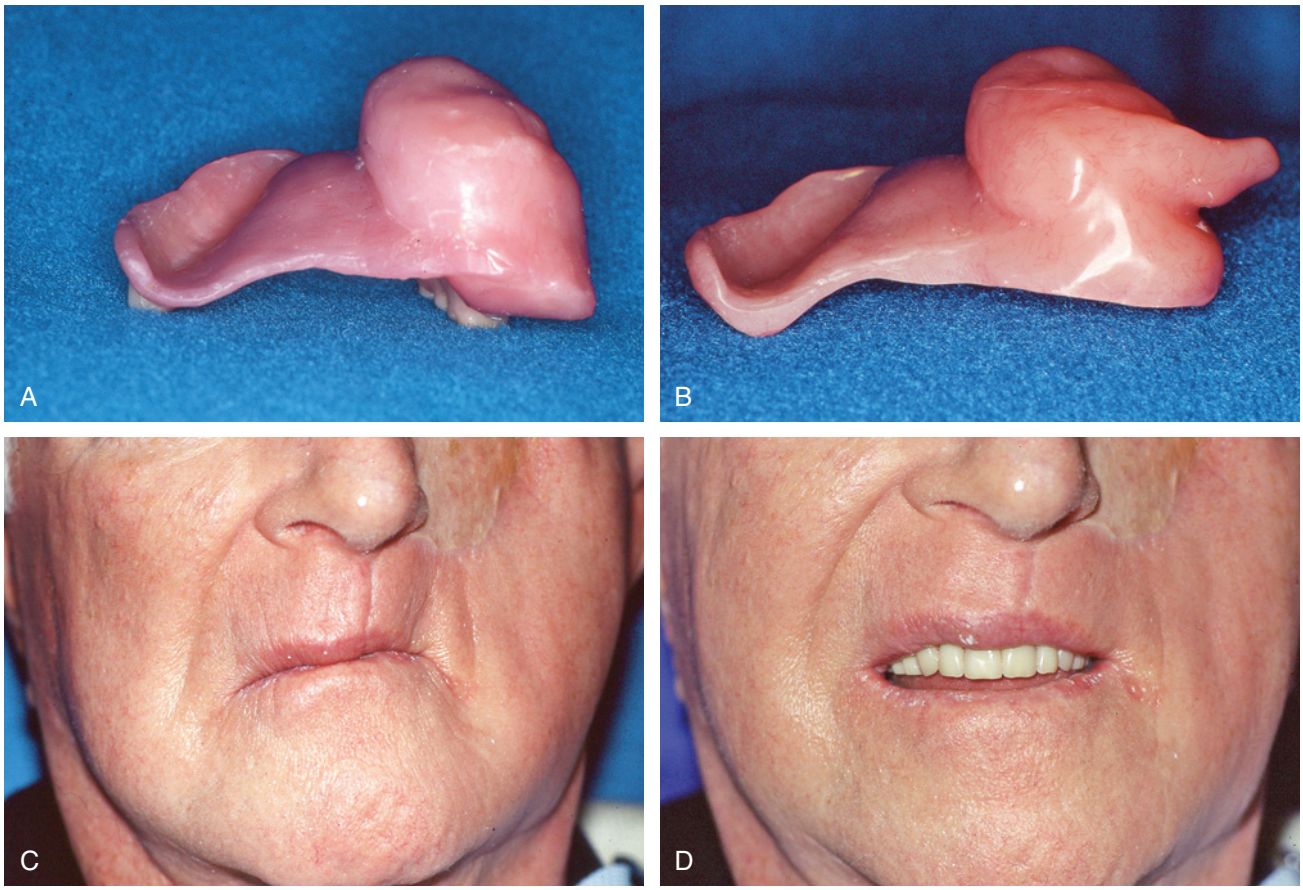


Figure 19-3 The conventional obturator trial base **(A)** has been blocked out at the peripheries of the maxillary resection to allow removal from the master cast. The processed base **(B)** made from the same master cast allows maximum tissue contact and stability for the arrangement of teeth and jaw relationship records. **C,** The patient's face is supported marginally with the maxillary edentulous obturator base and dentition but it is undercontoured to minimize the weight of the lip and face grossly unseating the prosthesis. **D,** Maximum retention can only be assessed with a processed base to optimize facial support at the try-in stage.

Physiological border molding of the velopharyngeal area to form the obturator segment is essential. Initial border molding with warm modeling compound material or viscous tissue conditioning material (Trusoft or Softone, Bosworth, Co., Skokie, IL) is placed incrementally around the periphery of the custom tray. The patient is instructed to swallow, speak, and perform posture movements: (1) open and close the mouth, (2) move the mandible from side to side, (3) turn the head from side to side, and (4) flex and extend the head.

When the border molding process of the obturator segment is complete, the patient is asked to speak, swallow, and breathe through the nostrils in order to test the formed obturator. If the position and contours of the obturators are satisfactory, all modeling compound is painted with a thin layer of impression wax for final impression, and the patient goes through the same functional movement, activating the velopharyngeal musculature as previously described. The wax can be tempered in hot water before placing it in the mouth to facilitate the flow during the intermittent soft tissue contact during swallowing and speech.

BORDER MOLDING PERIPHERIES OF MAXILLARY RESECTIONS AND HARD PALATE DEFECTS: PATIENT MOVEMENTS

The hard palate is a static structure. Border molding its bony margins requires no special patient movements. Border molding the posterior and lateral area of a maxillectomy requires that the patient go through head and mandible movements similar to border molding the velopharyngeal area. Mandibular movement has the greatest effect on the

lateral and posterolateral borders. Swallowing is important to move the cut edge of the soft palate at the posteromedial margin of the prosthesis.

TESTING THE PROSTHETIC "SEAL" BETWEEN THE ORAL CAVITY AND THE NASAL CAVITY

Drinking liquids is the usual test for prosthetic closure of an anatomic defect in the soft or hard palate. If the patient drinks in an upright position, water should not reflux into the nasal cavity. Placing the head downward will allow gravity to carry the liquid into the nasal cavity and the pharynx, and patients state that reflux is a particular problem when eating soup or drinking from a fountain. In both of these instances, the patient has the chin and head tucked. The patient needs to be informed and reminded to always keep the head upright when swallowing. It is unlikely that most patients will be able to drink from a straw, even though the "seal" may adequately stop reflux of liquids.

Listening to speech sounds is the usual way to test for appropriate separation of airflow from the oral cavity and nasal cavity. There are particular sounds that are very sensitive to airflow. To test for possible hypernasality, have the patient say the word "beat" with the prosthesis in position. Pinch the patient's nares closed with thumb and forefinger, and have him or her again say "beat." There should be no nasal air escape when saying this word, and there should be no difference in the sound of this word with or without the nares pinched together. If there is a difference in the sound of the word "beat," air is inappropriately escaping around the prosthesis periphery. Also, if the word "beat" sounds more like "meat," there is inappropriate air escape. Patients will report that they are misunderstood when using words that start with *b;* rather, the listener thinks that patients are using the letter *m*. To test for *hyponasality*, or lack of air escape through the nose on nasal sounds, have the patient say nasal consonant phonemes such as *m*. Nasal sounds use the nasal cavity as the primary resonating chamber. A phrase like, "Momma made lemon jam," is a good example. If the air is not allowed to escape from the oral cavity through the nose, the phrase will sound more like, "Bobba bade lebon jab." These are the speech sounds of a person with the common cold and indicate that air is not escaping through the nose as it should on nasal sounds. In this regard, the prosthesis may be too large or overextended; however, creating hyponasal speech with an obturator is uncommon. It is more likely that the obturator is satisfactory, but that the patient really is congested in the nasal passages. Unfortunately an ideal oral-nasal resonance balance may not be attainable in some patients. Good lateral and/or posterior pharyngeal wall movement is essential in order for the patient to properly control the oral-nasal flow. If the movement is very limited, speech intelligibility may be achieved but the restoration of normal speech with the obturator is compromised.

MAXILLARY OBTURATOR PROSTHESIS

An obturator prosthesis is required for patients with hard palate defects from a cleft palate, tumor resection, or facial trauma. Resections treat neoplasms that originate in the paranasal sinuses or superior aspect of the oral cavity. Hard palate defects cause disruption of articulation and airflow during speech production and allow nasal reflux during deglutition. The obturator prosthesis serves to restore continuity of the hard palate and separate the nasal cavity and maxillary sinus from the oral cavity.

The patient who undergoes maxillary resection is rehabilitated in three phases. Each phase requires an obturator prosthesis that supports the patient through various stages of healing. These three prostheses are immediate surgical obturator, interim obturator, and definitive obturator.

IMMEDIATE SURGICAL OBTURATOR PROSTHESIS

The surgical obturator serves some rudimentary goals: (1) to support the surgical packing placed in the resection cavity created by removal of the walls of the maxillary sinus and (2) to restore continuity of the hard palate. This prosthesis enables the patient to speak and swallow effectively after surgery. It also allows the patient to take oral nutrition immediately postoperatively and, if the swallowing mechanism is not disrupted by extensive surgery to the pharynx, precludes use of a nasogastric feeding tube. Speech is generally quite normal with the surgical obturator. This prosthesis will be in service for approximately 5 to 10 days.

The patient must have a presurgical dental examination to determine if there is nonsalvageable dentition or a need for preprosthetic surgery to remove epuli, reduce pendulous tuberosities, or relieve bony undercuts. Ideally, these procedures are performed concurrently with the tumor resection. The primary purpose of the cameo surface of the prosthesis is to restore normal palatal and alveolar form to facilitate postoperative speech and deglutition. The immediate surgical obturator for edentulous patients should be fabricated from a maxillary alginate impression much like an immediate denture record base. If the tumor mass changes the normal contours of the hard palate, the cast should be altered to restore appropriate palatal contour. The clinician should not attempt to delineate the exact posterior surgical margin on the soft palate, lateral surgical margins into the infratemporal fossa or pharynx, or superior margin into the sinus cavity. This limited "cast surgery" allows fabrication of only one prosthesis. Deliberate extension of an acrylic resin prosthesis beyond the confines of the oral cavity would likely be overextended and require major adjustments in the

operating room before it could be inserted. The immediate surgical obturator serves as a matrix on which the surgical packing can be placed and thus ensures close adaptation of the graft to the raw surface of the defect area. The packing placed superiorly into the surgical site will be supported by the immediate surgical obturator to accommodate any discrepancies between the surgical margins and the prosthesis borders.

The surgeon can greatly improve the tolerance of the obturator if the defect is lined with a partial thickness skin graft during the resection surgery, which is especially critical for edentulous patients. The keratinized skin graft surface is more resistant to abrasion than is respiratory mucosa and is a more favorable denture bearing and supporting surface. If any boney walls of the sinus remain, removing the sinus mucosa and resurfacing the bone with a skin graft allow these boney undercuts to be used to support and retain the obturator. When the boney sinus walls have been resected, the skin graft contracts at the cheek mucosal junction, finally creating a fibrous scar band over the next several weeks. The scar and facial movements should be incorporated in the obturator peripheral border impression allowing a border seal.

In edentulous patients, the immediate surgical obturators can be wired, sutured, or pinned to the alveolar ridge, vomer, zygomatic arches, and/or anterior nasal spine (Fig. 19-4). The mechanism to retain the immediate surgical obturator needs to be communicated with the surgeon. If circumzygomatic wiring is planned, retentive holes for zygomatic wires are placed bilaterally with a no. 8 round bur in the premolar area through the prosthesis flanges. For the prosthesis to be sutured in position, the same bur is used to drill multiple holes in the periphery of the anterior and lateral flanges. Removal of the bone screw and sutures is easily accomplished in an outpatient dental clinic setting. Removal of zygomatic wires may require local anesthesia. An existing well-fitting denture may be used as an immediate surgical obturator. However, the posterior dentition often causes trauma to the mandibular edentulous ridge immediately postoperatively. Usually occlusion is grossly inaccurate. An acrylic resin baseplate without dentition is the most accurate and an effective surgical obturator.

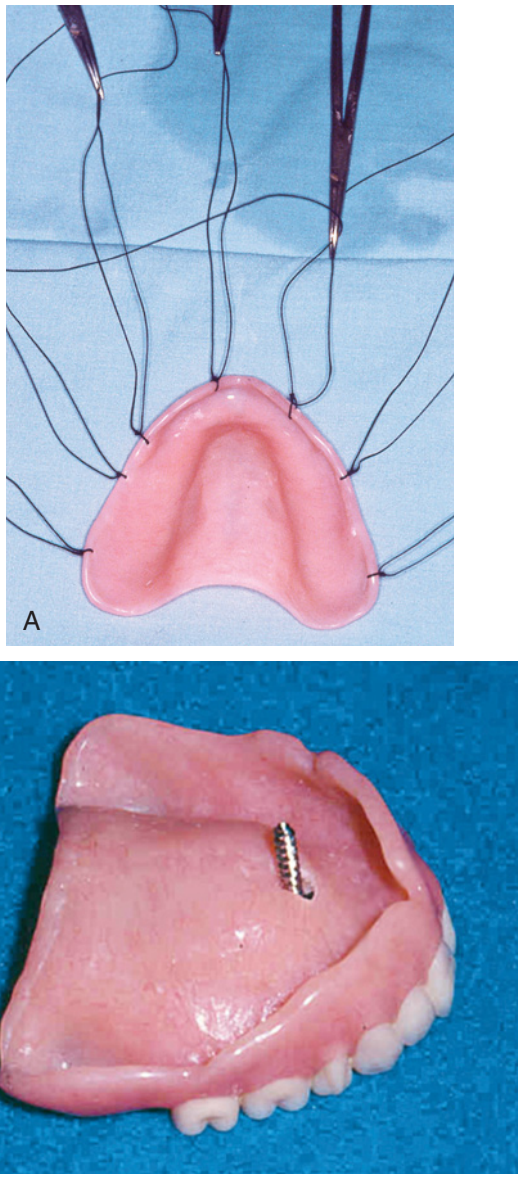


Figure 19-4 **A,** The 2-0 silk sutures are placed through the predrilled holes at the periphery of the obturator, knotted, and tagged with a hemostat before being placed into the mouth and sutured into the patient's vestibule. **B,** A palatal bone screw in the vomer can be used to retain an edentulous surgical obturator.

INTERIM OBTURATOR PROSTHESIS

The packing can be removed in 5 to 10 days; however, if the upper lip has been transected, the longer healing time is preferred. Ideally a maxillary edentulous impression was made preoperatively, and a resin baseplate obturator was made and used as the surgical obturator. The resin surgical obturator may be relined with tissue conditioning material on the remaining palate and in the maxillary defect. The entire baseplate can be used as the wax pattern, flasked, and processed with acrylic resin (Fig. 19-5). If necessary, a maxillary alginate impression may be made, but the added manipulation adds to the risk of breakdown of the lip suture line, with a permanent cleft forming in the vermilion border. Additional wax can be added on the stock impression tray in the defect area to provide support for the impression material or a viscous alginate material is used that carries into the maxillary defect. An acrylic resin baseplate can be made using this impression. Regardless of technique, the prosthesis should be delivered the same day as packing removal. Immediate delivery precludes the edematous changes that will occur within 24 hours after packing removal that negatively impact the fit of the prosthesis.

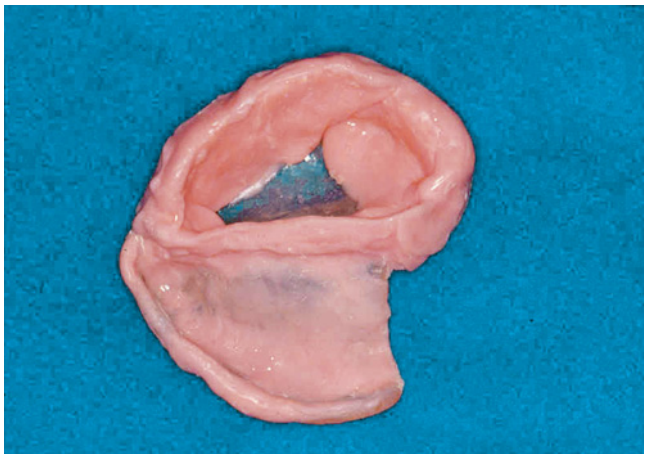


Figure 19-5 The baseplate surgical obturator can be modified at pack removal with an immediate impression of the palate, and then incremental additions of the tissue-conditioning material are made, processed to resin, and delivered the same day. *(Trusoft, Bosworth Co., Skokie, IL.)*



Figure 19-6 The acrylic resin interim obturator at follow-up. The defect area will be modified periodically with subtractions and additions of tissue conditioner material.

The prosthetic goals are to restore deglutition and speech by restoring palatal contours and separating the nasal cavity, maxillary sinus, and nasopharynx from the oral cavity. The patient and dentist understand that this prosthesis will be altered considerably as the patient heals and facial contours change. This prosthesis will be in service for approximately 2 to 6 months. A baseplate obturator without denture teeth can be used for the maxillary interim obturator in the edentulous patient. Retention is always a problem. The dentist should be certain that the border extensions and palatal tissue contact are ideal on the intact maxilla. Denture adhesives usually are required. Constant adjustments and relining are necessary because even slight border overextension in the edentulous maxillofacial prosthesis will unseat the prosthesis. Keeping the prosthesis obturator segment hollow in the defect site will decrease weight and aid retention.

The prosthesis is modified with an interim lining material to conform to the periphery of the surgical site. The defect portion should be kept hollow during the relining procedure to limit the weight of the prosthesis. The material is added to the periphery in incremental fashion during border molding while the patient is instructed to perform eccentric mandibular movements, speak, and swallow. An ideal material should have enough body to support itself during the initial impression procedure and for several weeks.

As the patient heals, the periphery of the surgical site will become smaller. The material should be reduced with a carbide bur and readapted with the addition of more liner (Fig. 19-6). The primary areas requiring readaptation are the posteromedial, posterolateral, and the anterior borders. It is more efficient to relieve the entire periphery and resurface the site than search for a specific area of pressure using pressure paste. The greater the volume of bone resected, the greater the amount of postsurgical soft tissue contracture and the more healing time before the surgical site is stable. As the tissue contracts, the prosthesis borders will be overextended, and the patient will have difficulty seating the prosthesis. The interim lining material borders should then be relieved and resurfaced. The patient may return, complaining that there is discomfort on the nonsurgical area of the maxilla or that the prosthesis is no longer retentive. Adjustments should not be made to the nonsurgical side of the prosthesis because the problem is likely to be tissue changes in the surgical area shifting the entire prosthesis. The prosthesis must be worn constantly, removed only for cleaning of the surgical site or prosthesis. If the patient removes the prosthesis nightly, the tissue changes will be rapid, and the patient will not be able to seat the prosthesis after only a few days. These contour changes are usually a combination of edema and tissue contracture.

When the surgical site is changing shape less rapidly (in approximately 1 to 2 months), the prosthesis can be flasked, replacing the surgical site interim lining material with acrylic resin. Maxillary anterior teeth may be added to the prosthesis to improve esthetics if the patient desires. For the prosthesis to be delivered in the same day, autopolymerizing resins are used. The dentist should not keep the prosthesis overnight; major tissue changes of the entire surgical border can occur, requiring relief of the periphery and another relining impression. Over time, slight tissue changes will continue, exemplified by increased nasal reflux and hypernasal speech. These slight changes usually occur at the medial posterior junction of the prosthesis and cut edge of the soft palate. These isolated areas can be addressed with



Figure 19-7 The patient's original denture has normal anatomical borders *(left);* however, the obturator prosthesis relined at 4 weeks after surgery *(right)* has markedly altered contours in the anterior of the prosthesis because of facial contracture. A tray extension over the soft palate into the pharynx was added to support an impression of the pharynx in function, which was necessary because the patient's velar movement was inadequate in the weeks after surgery (see Fig. 19-13).

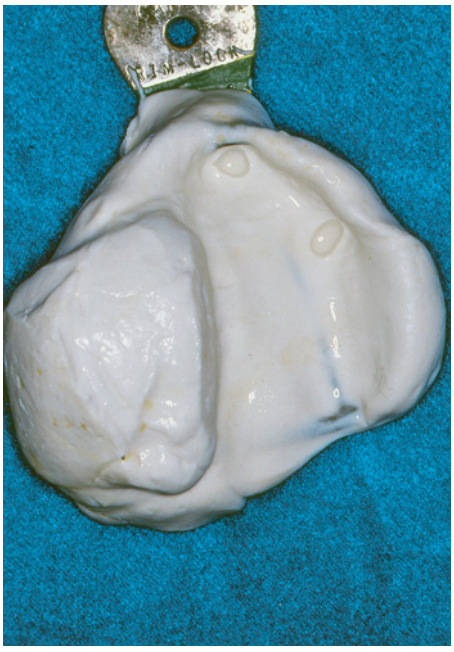


Figure 19-8 A viscous alginate carries into the maxillary defect allowing extension of the custom impression tray. *(Supergel, Bosworth Co., Skokie, IL.)*

tissue conditioning material, chairside autopolymerizing, or light cured resin as needed to correct speech and reflux.

For some edentulous patients with small or posterior resections, using a well-fitted existing maxillary denture as an interim obturator prosthesis can be considered. If the resection includes any of the premaxillary area, however, facial collapse is pronounced. The original border extension and the teeth will soon be overextended in a horizontal direction. The denture flange must be reduced, and the anterior teeth will need to be reset more palatally (Fig. 19-7). The posterior teeth also may require palatal repositioning, but the problem is most evident in the anterior area. In addition, repeated relining of the prosthesis, while attempting to maintain occlusion with a mandibular denture, is very difficult. For patient satisfaction, it may be necessary to remake the maxillary and mandibular prostheses or reset teeth more than once during the 2- to 3-month healing process. The patient must understand that mastication is rarely restored in the interim phase because of the constant transition of the tissues and fit of the dentures. These necessary modifications must be factored into the treatment plan and may be beyond the available time and finances of many patients; therefore a baseplate without teeth is a practical solution.

DEFINITIVE OBTURATOR PROSTHESIS

The definitive prosthesis is fabricated when tissue healing and contraction are complete. When irradiation follows surgery, resolution of radiation mucositis also is necessary. Proceeding with a definitive prosthesis before tissue contours are stable may require major adjustments that will involve changing tooth positions or gross adjustments to the prosthesis periphery. It may be 2 to 6 months postoperatively before the tissues are stable.

Preliminary impressions are made with irreversible hydrocolloid. It is desirable to capture the periphery and height of the surgical site in the preliminary impression so that maximum extension of the definitive impression tray is possible. Clinical blocking out of the defect is not necessary, unless the palatal defect is a small fistula. Modify the impression tray by adding wax or compound in the defect area to properly support the impression material. A large custom syringe can be used to inject the material into the defect or a viscous alginate may be used that carries into the defect without injection or tray modifications (Fig. 19-8).

Decreased vertical opening is often a problem in the patient undergoing a maxillectomy because of surgical trauma and fibrosis of the muscles of mastication in proximity to the maxillary resection. It may be difficult to carry impression material into the surgical defect because of the limited oral opening, but because of the lack of dentition, the clinician usually has enough access in the oral cavity despite the decreased opening.

A maxillary custom impression tray extended into the maxillary defect is recommended for the final impression. The custom tray should be fabricated with space relieved for compound and wax/impression material. Undercuts in the cast must be blocked out before making the tray. It is suggested that border molding and the elastic impression be completed initially on the unresected palate, alveolar ridge, and cut edge of the palate because this serves to stabilize

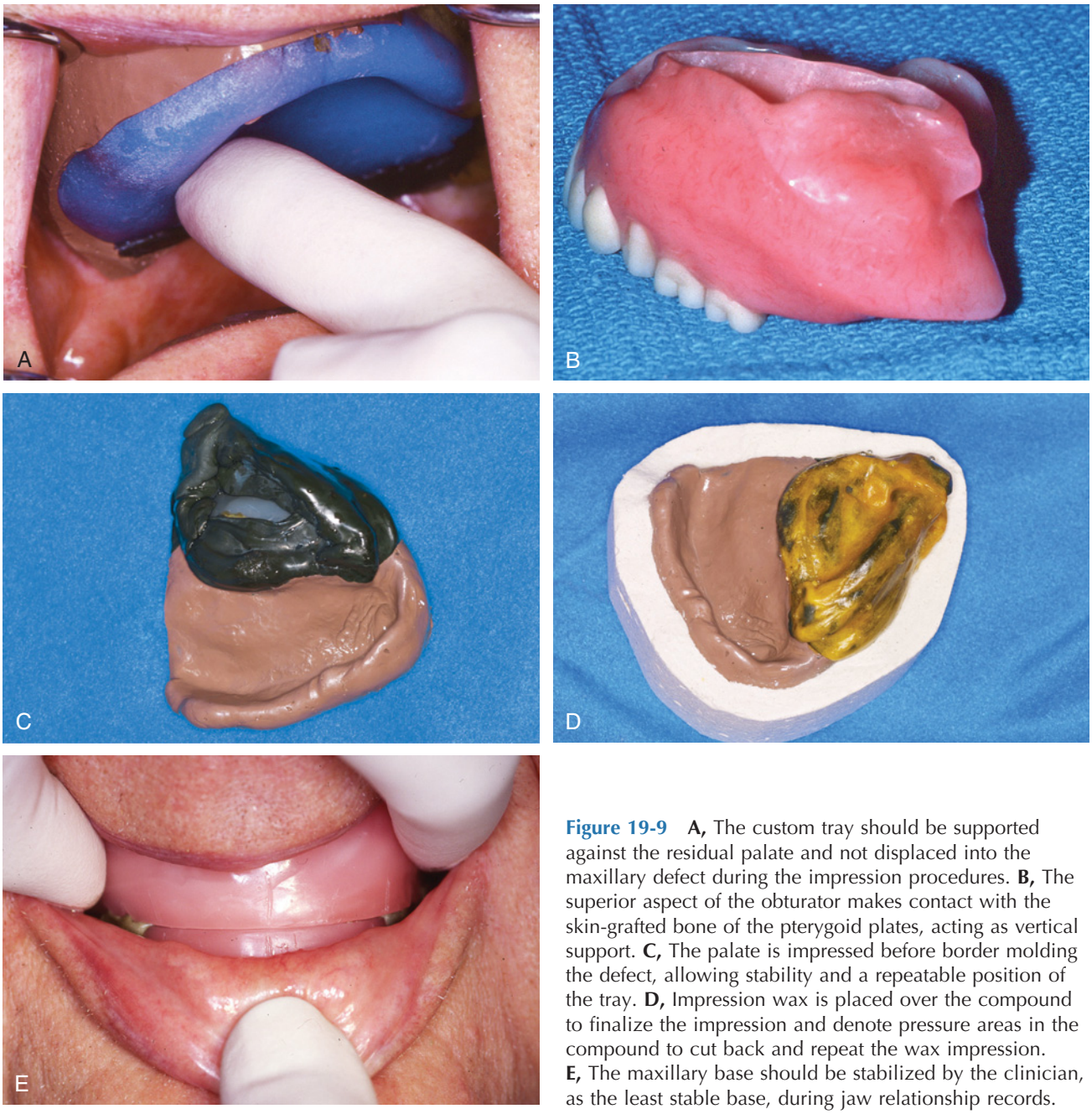


Figure 19-9 **A,** The custom tray should be supported against the residual palate and not displaced into the maxillary defect during the impression procedures. **B,** The superior aspect of the obturator makes contact with the skin-grafted bone of the pterygoid plates, acting as vertical support. **C,** The palate is impressed before border molding the defect, allowing stability and a repeatable position of the tray. **D,** Impression wax is placed over the compound to finalize the impression and denote pressure areas in the compound to cut back and repeat the wax impression. **E,** The maxillary base should be stabilized by the clinician, as the least stable base, during jaw relationship records.

and orient the tray to the defect. The clinician should always be aware that manual seating pressure of the tray during border molding and impression making should be obliquely directed against the remaining alveolar ridge and not against the midpalate as is done when seating a normal maxillary denture tray. Seating against the midpalate often causes the tray to rotate into the surgical site and away from the residual alveolar ridge without operator awareness. At this time the tray should be relatively stable from the established border molding. Obtaining the stability of the tray is important in order to continue the accurate impression on the defect site (Fig. 19-9, *A*).

The scar band should be identified. As the compound is incrementally added, the scar band, cut edge of the soft palate, and extension over the soft palate into the pterygoid area should be denoted in the impression. The composite motion of the mandible opening and lateral movement, swallowing, and speaking should be captured. The lateral and posterior extensions should be developed superiorly as far as possible as long as the defect is extending laterally or posteriorly, and the height of the obturator is compatible with the patient's mouth opening for insertion and removal. If boney sinus walls are present, the skin-grafted walls within the defect should be impressed (Fig. 19-9, *B*). The clinician

must support the tray during these movements because the patient must perform a variety of movements to shape the compound. If the impression tray moves during the patient's movements, an area of compound is overextended. The clinician must find this area of overextension and readapt it before proceeding any further. At completion of border molding, the compound can be slightly relieved and a thermoplastic wax painted on can be used for a final impression. The advantage of using thermoplastic wax is that areas of pressure will show through the wax and the compound can be further relieved. The easiest method of using the wax is to cover the relieved compound, quickly dip the waxed area in the warm water bath, place it in the mouth, and have the patient go through the border molding movements (Fig. 19-9, *C* and *D*).

Maxillary and mandibular processed bases and denture adhesive are used to ensure maximum stability and soft tissue facial support during jaw relation records. The clinician should manually stabilize the least stable base when making the record and watch very carefully for shifts of the bases. In the case of a patient undergoing a maxillectomy, this would be the maxillary base (Fig. 19-9, *E*). If the bases shift, the record should be remade. Because of the instability of the obturator prosthesis, deep vertical overlap or lateral interferences should be avoided in the final occlusal scheme.

Because of facial contracture on the surgical side, it may be necessary to place the anterior teeth in an end-to-end situation. The mandibular anterior teeth may need to be placed more lingually to allow the palatal placement of the maxillary teeth. The facial position of the anterior teeth may be verified at the try-in appointment. Esthetics and lip support are often compromised to aid retention. An end-to-end occlusion in the posterior teeth should be avoided. Horizontal overlap is necessary to avoid cheek biting. When decreased vertical opening is seen in these patients, interocclusal space at maximum opening may be only 1 to 1.5 cm. The clinician may choose to slightly close the vertical dimension of occlusion to allow the patient more functional space; however, only minimal overclosure should be performed because lip and cheek biting may become a problem. Decreased vertical dimension of occlusion also can lead to periodic angular cheilosis.

The palatal contour should be evaluated in an obturator prosthesis. The contour on the surgical side should mimic that of the nonsurgical side. Making these contours too low constricts the tongue, which will then lift the prosthesis into the surgical site during speech and swallowing. Making the contour too high will not allow proper tongue/palate contact during speech, affecting articulation and the impounding of air in the oral cavity. If the posterior teeth were placed in a reverse articulation, it may be necessary to remove the palatal half of these teeth. The height of the palate may be examined visually and with pressure-indicating paste. The patient is instructed to swallow and speak. The paste can be checked for uniform contact of the tongue. If additional acrylic resin is needed to refine the palatal contours, this may be added when the teeth are processed onto the base.

At insertion of the prosthesis, it is not necessary to perform a clinical occlusal remount procedure because processed bases were used and a laboratory remount was done at deflasking. Final evaluation of the prosthesis fit should be done. Evaluating pressure areas and border extensions is best done with a combination of pressure-indicating paste and tissue conditioner. The pressure-indicating paste is effective for the intaglio surface of the prosthesis on the unresected side, but pressure paste often smears on insertion or removal of the prosthesis, and therefore it is quite difficult to have an accurate interpretation of the pressure areas on the obturator portion of the prosthesis. Using tissue conditioner over a thin separating layer of petroleum jelly is useful in checking the obturator portion to monitor tissue displacement or lack of tissue contact in the defect area. Some clinicians use disclosing wax as an alternative to the tissue conditioner.

Denture adhesive can be used to aid in retention, and the prosthesis extension into the surgical site can be made hollow to decrease the weight of the prosthesis. Some clinicians leave the hollowed area open superiorly, and some clinicians choose to place a cap from the superior aspect or the palatal aspect. Placing a cap precludes any reflux of food or liquids into the obturator and the need for the patient to clean this area of the prosthesis.

TROUBLESHOOTING AN OBTURATOR PROSTHESIS

Lack of Retention

With any sizable palatal resection in the edentulous patient, retention is impossible to achieve in the classical sense of a complete denture prosthesis. Adhesives are almost always required for any edentulous obturator prosthesis. The patients should be advised to masticate as little as possible on the defect side because this tends to unseat the prosthesis. Retention is a very difficult problem for the edentulous patients with maxillofacial defects. Every effort should be made to maintain and enhance the longevity of the natural teeth to aid the retention of the prosthesis. Even if only one to two teeth can be saved, the prosthetic prognosis in retention is significantly improved compared with the edentulous obturator. Retaining roots with attachments or magnetic copings can offer improved retention (Fig. 19-10). Dental implants should be considered to solve the poor retention and stability issues. It is also possible to extract teeth and place implants in the residual alveolus concurrent with the maxillary resection. It should be determined if patients are interested in undergoing bone grafting for implant placement, otherwise available sites for implants may be limited to the remaining premaxillary area. Because of the lack of cross arch palatal support, immediate implant loading protocols may overload unilateral implants and two-stage

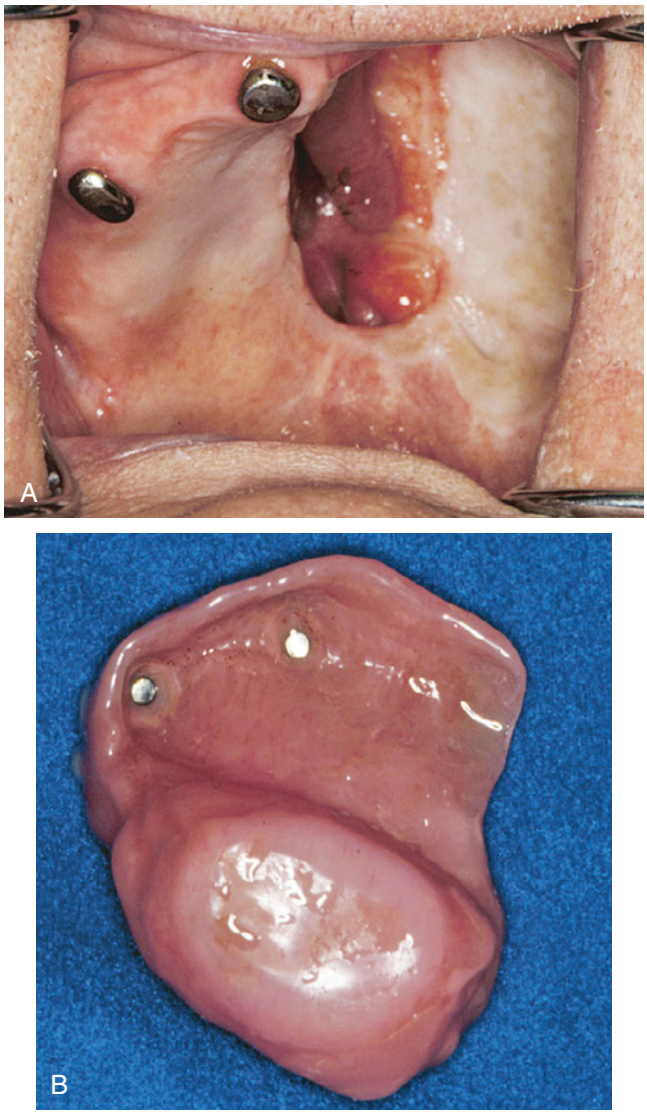


Figure 19-10 **A,** Two severely worn teeth were prepared with copings and magnetic attachments. **B,** The patient wore this prosthesis for 10 years until his death from cardiac arrest.

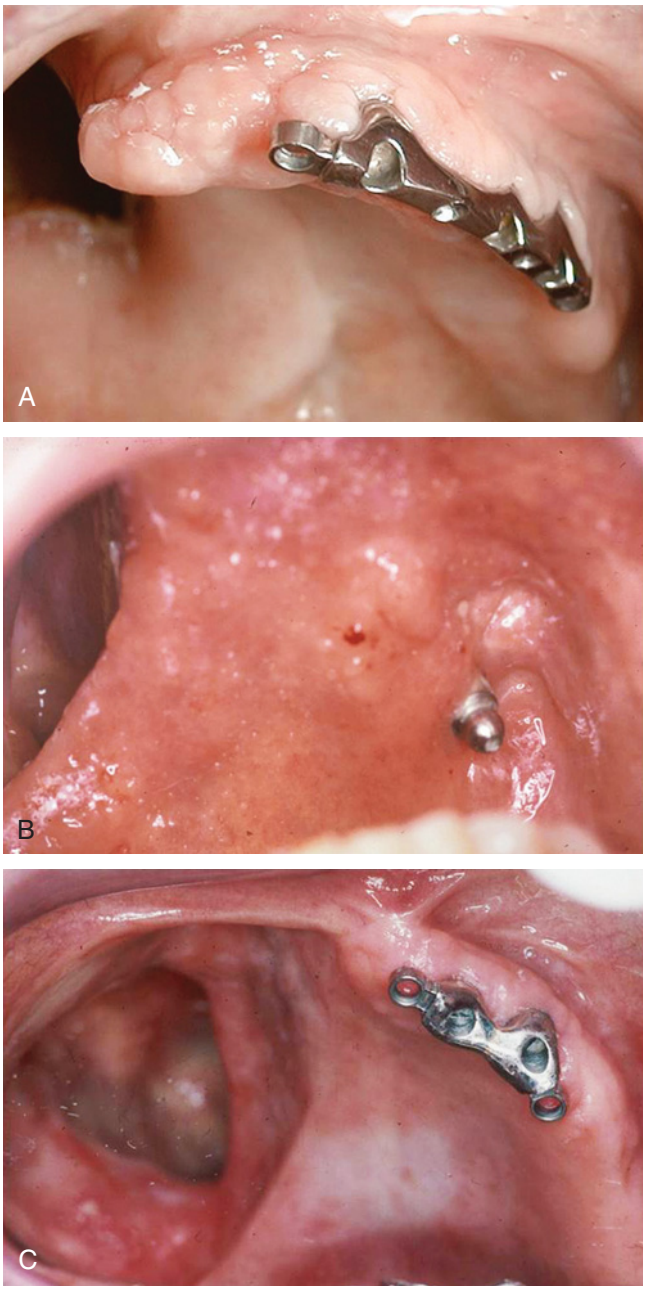


Figure 19-11 **A** to **C,** Implant placement at the premaxilla and tuberosity area can greatly improve the retention and stability of the obturator prosthesis for edentulous patients with maxillary resections. Resections this large should be considered for microvascular boney reconstruction.

implant placement and splinting should be considered (Figs. 19-11 and 19-12).

Nasal Reflux

Explain to the patient that the prosthesis cannot function as a "cork in a bottle," and some reflux is to be expected. An upright head position is required during swallowing. Check the palatal contours for a low palatal contour that constricts the tongue and unseats the prosthesis. Check the tissue adaptation at the posteromedial and posterolateral margins (at the prosthesis/soft palate junction). Apply the tissue conditioning on the obturator portion of the prosthesis and check the extension, as previously described. If the material is thick and successfully decreases reflux, this area should be addressed for a relining procedure. When the required relining area is only 1 to 2 cm in coverage and the remainder of the obturator portion is well fitting, a chairside reline should be considered. Cut deep finish lines to demarcate the area indicated by the thick tissue-conditioning material. These finish lines will confine the relining material. An autopolymerizing reline resin or light-cured resin reline tempered in hot water to increase flow can be added and border molded in the patient's mouth. Conversely,

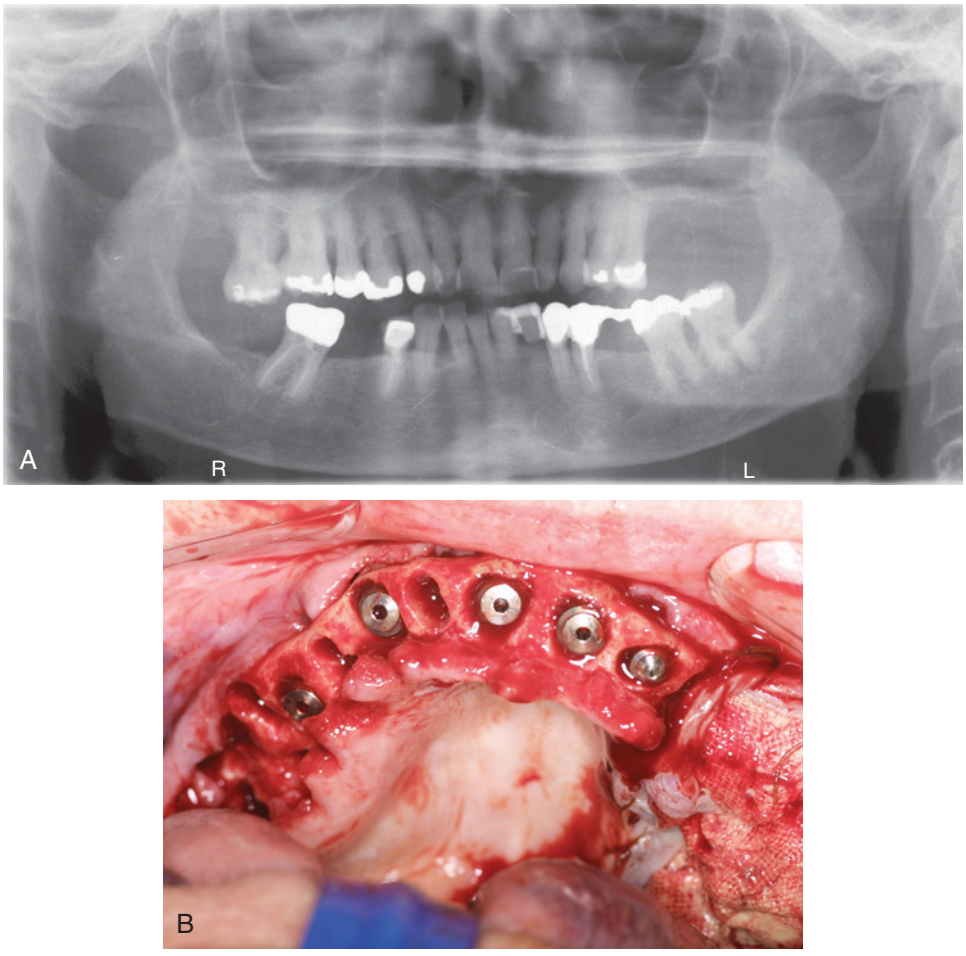


Figure 19-12 **A,** This patient had maxillary left gingival cancer and a second mandibular left gingival cancer and periodontal disease. **B,** She underwent maxillectomy and skin graft, marginal mandibulectomy and skin graft, dental extractions, and immediate implant placement in the maxilla and mandible. She was not irradiated.

if the thickness of the tissue-conditioning material is negligible, it indicates that the prosthesis is well adapted and no reline in that area is required.

Hypernasality

When reflux in the maxillectomy patient has been minimized but hypernasality still exists, one should consider that the velopharyngeal closure may be compromised from surgery. The soft palate may not elevate enough to close the nasopharynx. If the resection includes a portion of the soft palate, the remainder may be too short to contact the pharyngeal walls. The clinician should attempt to add a pharyngeal extension, as in the soft palate obturator prosthesis, over the inadequately functioning soft palate to obturate the pharynx (Fig. 19-13).

SOFT PALATE OBTURATOR PROSTHESIS

A soft palate obturator or speech aid prosthesis is required for patients who have a resection of their soft palate or have a soft palate deficit from a cleft palate. Absence of soft palate tissue disrupts speech and swallowing by allowing nasal escape of air during speech and nasal reflux during swallowing. An immediate surgical soft palate obturator prosthesis usually is not needed. If the pharynx is obturated with any rigid material or a tissue-conditioning material in the operating room, the extension will invariably be overextended, and the patient will experience postoperative pain in the pharynx when he or she awakens and resumes swallowing and movement of the head. Even small, arbitrary acrylic

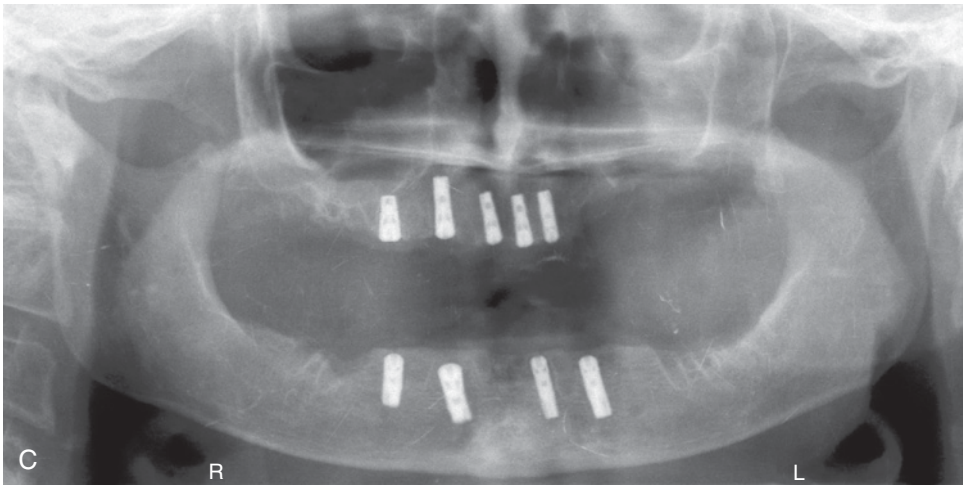






Figure 19-12, cont'd **C** to **E,** She has worn these implant-supported and implant-retained prostheses successfully for 4 years.

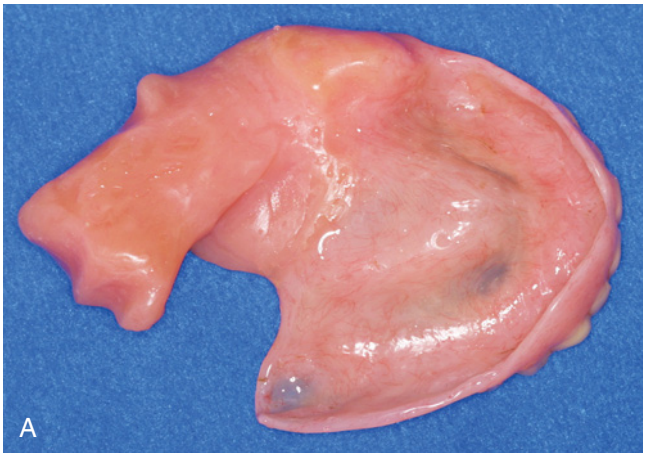




Figure 19-13 **A,** This patient who underwent a maxillectomy had lack of appropriate velar movement due to radiation fibrosis of the velum occurring approximately 3 years after radiotherapy. A pharyngeal extension was added to the prosthesis extending over the soft palate remnant to obturate the pharynx and correct hypernasality. **B,** The Passavant's ridge can be seen through the defect of the soft palate.

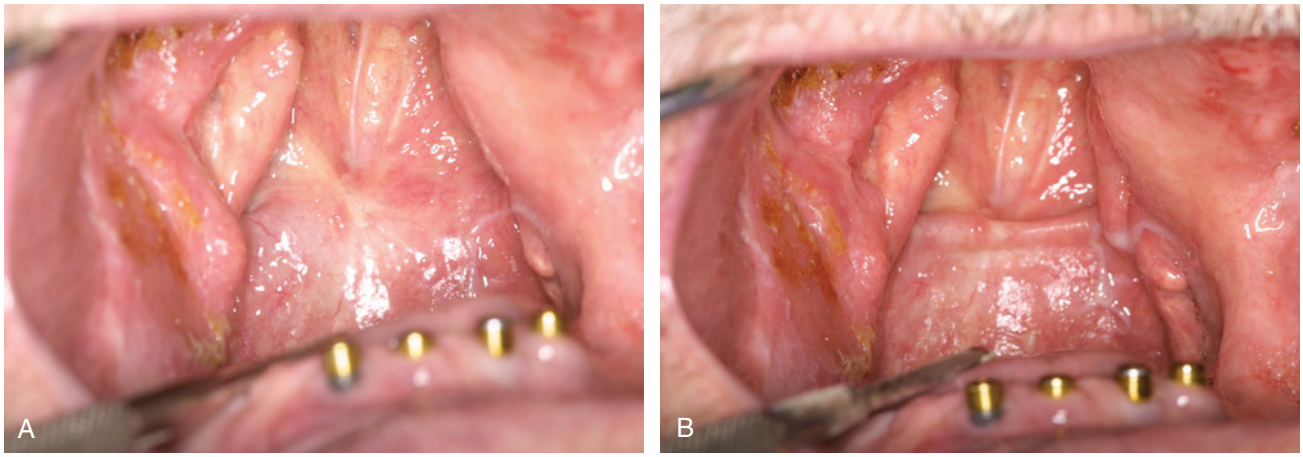


Figure 19-14 **A,** This patient had a resection of squamous cell carcinoma of the soft palate and mandible. The Passavant's ridge on the pharyngeal wall is not evident at rest, but is evident only on phonation **(B).**

resin extensions made on a surgical cast to support a surgical gauze packing placed in the pharynx may be overextended in some areas with the postoperative sphincteric closure of the pharynx.

A pharyngeal extension can be added to a denture prosthesis within a few days after resection. When only the soft palate is resected, patients will resume swallowing with minimal discomfort; however, if the resection is more extensive, patients may not resume normal swallowing immediately because of additional surgical involvement of the pharynx. They may require nasogastric tube feeding or gastrostomy until they can swallow without aspiration. In these situations, the obturator's major function will be to restore speech.

A posterior extension is added to a denture prosthesis to contact the patient's pharyngeal wall movement that occurs during swallowing and speech. The extension should be made at the level of the hard palate, near the level of C1, and at the level of the most active movement of the pharyngeal sphincter. All of these anatomic landmarks are within the same horizontal plane. This movement can be visualized by asking the patient to say "ahh" or by stroking the posterior pharyngeal wall with a mirror handle, initiating a gag reflex. Often a prominent muscular ridge on the pharyngeal wall, called Passavant's ridge, is present when the patient says "ahh" (Fig. 19-14). This ridge has been called a compensatory mechanism because it is present in most patients with cleft palates and has been seen to increase and become more obvious with time in patients with cleft palates and resected soft palates.

A small acrylic resin posterior projection can be added to the denture as a tray to support the impression material. A viscous tissue-conditioning material or modeling compound/thermoplastic wax can be added. Use of a viscous tissue conditioner can be border molded to create the shape of the prosthesis, then reduced with scissors, and resurfaced

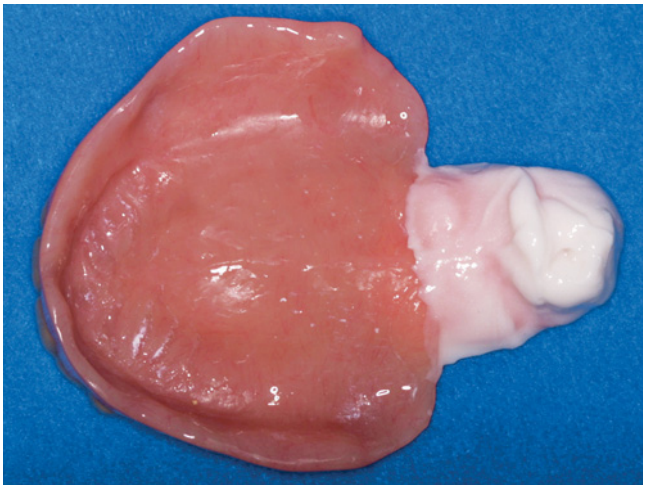


Figure 19-15 An obturator is added to the denture and formed with functional swallowing and head movements and then is evaluated in speech. The height is usually no more than 1 cm.

with a thinner wash of the same material to finalize the obturator contours (Fig. 19-15). The patient should go through the necessary movements that activate the velopharyngeal musculature, such as swallowing, speaking, moving his or her head in a circular manner from side to side, and extending the head as far forward and backward as possible. The impression should be examined for contact with the pharynx bilaterally and posteriorly. If any of the acrylic resin tray projects through the material, it should be generously relieved and that portion of the impression remade. The inferior extent of the pharyngeal extension should be at or slightly below the inferior aspect of the pharyngeal sphincter. The overall height of the pharyngeal obturator should not be more than 1 cm because this dimension will

successfully contact the wall movement without adding excess weight. The clinician may test the final impression for closure of the nasopharynx in swallowing by asking the patient to drink water. The patient also should be able to breathe through the nostrils with the prosthesis in place. Hypernasality and hyponasality may be tested at this time. Ideally, airflow in speech should be appropriate.

If a compound impression is used to create the soft palate obturator, the compound may be painted with thermoplastic impression wax. If the clinician wants the wax to flow during the impression, the wax-coated obturator will need to be quickly dipped in the water bath before insertion, or the patient will need to wear the prosthesis for approximately 30 minutes while repeatedly going through swallowing and head movements.

TROUBLESHOOTING THE SOFT PALATE OBTURATOR PROSTHESIS

Prosthesis Feels Too Long

The patient complains that they "feel the prosthesis in the back" of their pharynx. They also may struggle to initiate the swallow reflex. The prosthesis should be disclosed with the tissue-conditioning material because these complaints signal an overextended prosthesis. A pressure-indicating paste does not reveal the overextension as accurately as tissue-conditioning material, which can be molded as a functional impression, and overextensions will show through the material. If the patient continues to complain after disclosing and adjustments, it is suggested that the entire pharyngeal extension be generously reduced and a new functional impression made, because it is likely the obturator is grossly overextended, making contact at the initiation of the swallowing "squeeze" of the pharyngeal walls. In this case the maximum sphincteric action of the walls is being obstructed by the obturator.

Hypernasality

Evaluate for appropriate tissue contact in swallowing using a tissue conditioner. If a uniformly thin coating of material is evidenced on the obturator and hypernasality persists, the problem is that there is greater pharyngeal wall constriction in swallowing and limited pharyngeal wall movement in speech. During swallowing, pharyngeal constriction is almost always more pronounced than the constriction during speech. As the difference in movement of the pharynx between swallowing and speech becomes greater, the more likely it is that the patient will have hypernasal speech. It usually is not possible to add more material to the obturator, or the patient begins to complain of overextension during swallowing. Increased "compensatory" pharyngeal constriction during speech may be seen as time passes. This compensatory movement may increase and eventually eliminate hypernasality, but predicting this ability for compensation on an individual patient basis is difficult.

PALATAL AUGMENTATION PROSTHESIS

During speech, swallowing, or mastication, the tongue contacts the palate and teeth to move the food bolus and articulate speech sounds into language. When the tongue or contiguous oral cavity structures are resected for neoplastic disease, the deficits in tongue function are related to loss of tissue bulk, denervation, and tethering of the remaining portion of the tongue. Hypoglossal nerve damage causes the tongue to deviate toward the affected side on protrusion, and the tongue tip may not elevate. If the remaining tongue is used to surgically close the oral cavity wound, it will be sutured to the cheek, impairing range of motion and posturing it in an abnormal position. When mandibular deviation occurs in a nonreconstructed partial mandibulectomy patient, the tongue deviates with the mandible and does not make appropriate tongue/palate contact.

CLINICAL EXAMINATION

Patients with any of the preceding surgical findings should be considered for a palatal augmentation prosthesis. Look for normal range of motion of the tongue such as elevation and protrusion; determine if food collects on the palate or pools in other areas of the oral cavity; ask patients if they aspirate when they eat; and finally, listen for articulation errors. These errors may include slurred speech on the "s" and "sh" sounds and lack of intelligibility with *k*, *g*, *t*, *l*, and *d*. If it has been some time since the operation and if the patient has not been wearing dentures, the patient may have accommodated to the lack of tongue mobility and is making tongue/palate contact by inappropriate "overclosure" of the mandible. The only obvious clinical finding in this "overclosed" patient may be abnormal range of motion of the tongue and perhaps a slight dysarthria.

Abnormal attachments of the tongue and floor of mouth soft tissues may preclude making dentures. The ridge may be entirely covered with the tongue flap or with bulky tissue brought from distant sites, such as the pectoralis or rectus muscle. Thinner tissues, such as from the forearm, may be used for reconstruction, but if these are freely movable over the mandible, a stable mandibular denture may not be possible.

INFORMING THE PATIENT

Patients should be aware of the difficulties of wearing a mandibular denture without normal tongue range of motion. If they are experienced denture wearers, they will probably accommodate better than the first-time wearer. Patients will equate receiving dentures with an advancement of their diet

to more solid foods; however, mastication may not be possible. Lateral tongue movement and an ability to elevate the tongue to the height of the mandibular occlusal table are necessary for mastication; some patients will not have lateral motion. Patients who have accommodated to the altered tongue function by overclosure of the mandible should be aware that delivering dentures and restoring the correct vertical dimension of occlusion will require a palatal augmentation prosthesis. A period of learning new compensatory speech and swallowing mechanisms will be necessary. These individuals may be very disappointed with the immediate difficulties experienced with their new prostheses and the apparent "backward" step in their rehabilitation. Speech and swallowing therapy are necessary to optimize function. Adhesives for the mandibular prosthesis are often required. Implants can be placed concurrent with the soft tissue and mandibular resections. When implants are not available, it is often not possible to deliver a denture because of a lack of mandibular support and grossly abnormal soft tissue contours from flaps. The definitive prosthodontic care may only include a palatal augmentation prosthesis with anterior teeth to enhance swallowing, articulation, and esthetics.

Usual denture fabrication techniques should be used. The vertical dimension will be established by looking at facial form and speaking space. The sounds may be quite distorted, but the relationship of the maxillary and mandibular anterior teeth when the patient attempts the "s" sound should be normal. At the try-in stage, the augmentation may be added. A processed maxillary base is suggested because the bulk of acrylic resin needed in the palate could cause considerable processing distortion if the base, teeth addition, and augmentation are processed simultaneously.

A speech and swallowing pathologist can assist in developing the contours. The area of loss of tongue bulk or movement should be correspondingly augmented on the palate with baseplate wax. Each addition should include evaluation with pressure-indicating paste, looking for uniform tongue contact. The tongue may not be able to move to all quadrants of the mouth, so there may not be an impression of the tongue on the entire surface of the augmentation. Placing a tissue-conditioning material on the palatal surface of the denture can be used to create a functional impression of the residual mobile tongue made during swallowing. This technique usually will achieve an improvement in articulation also.

Fine tuning for subtle changes in articulation and air flow (needed for such sibilant sounds as "s," "sh," and plosives such as "t" and "d") is more accurately accomplished with small additions and subtractions of wax after the gross contours needed for swallowing are established. These minute subtraction refinements are more difficult to accomplish if tissue-conditioning material, rather than baseplate wax, is used to form the initial swallowing contacts. Specific target sounds to assess anterior and posterior contact are used. Posterior sounds include "k" and a hard "g." If these sounds are not distinct, the posterior palate must be lowered. The tongue tip may not be centered in the palate because of tethering or deviation toward the surgical side due to hypoglossal nerve damage. Additional wax may need to be added to allow the most elevated portion of the tongue to make definite contact for the "t" and "d" sounds (if the tongue tip no longer elevates, this new area of elevation in the body of the tongue becomes the effective tongue tip). As for the routine denture wearer, a lisp may be present during the "s" and "sh" sounds. During these sounds, the normal tongue curls and approximates the palatal vault in the midline to create an air channel. This narrow channel created with a curled tongue forms the "s" sound, and the same channel is made wider by flattening the tongue for the "sh" sound. Patients undergoing glossectomy or patients with neurogenic abnormalities may not be able to curl the tongue or elevate the tongue to approximate the anterior palate in the midline. Augmenting the palate and placing a groove in the anterior palate can create the necessary air channel. This groove will not necessarily be in the midline, but must coincide with the deviated airflow created by the deviation of the anterior tongue.

Patients with the best results will have most of their tongue remaining and have a tongue tip that is mobile, even though several speech sounds are impaired. The impaired tongue will not be able to move to all positions of the mouth rapidly; therefore, the patient must slow the rate of speech. Despite the best prosthodontic efforts, patients with large range-of-motion deficits may only be able to eat pureed foods or a liquid diet, and they may continue to have errors in certain target sounds.

MANDIBULAR RESECTION PROSTHESES

Special maxillofacial prostheses for the mandible are required because of surgical resection for neoplastic disease. A discontinuity resection of the mandible indicates that a portion of the mandible is resected, and the condyle-to-condyle continuity of the mandible is disrupted. A marginal mandibulectomy implies that a margin of bone is resected, but the continuity of the mandible is maintained. Usually, the margin of resection is at the coronal aspect and is involved with epithelial neoplasms of the mouth.

MARGINAL MANDIBULECTOMY PROSTHESES

A marginal mandibulectomy can be restored with a complete mandibular denture if the soft tissue reconstruction over the mandible is not grossly mobile or compressible. If the tongue or floor-of-mouth tissues are sutured over the mandible to the cheek, the tissue mobility will unseat the denture (Fig. 19-16). Thin microvascular flaps from the forearm are commonly used in the floor of mouth over the mandible, but these tissues do not attach to the bone

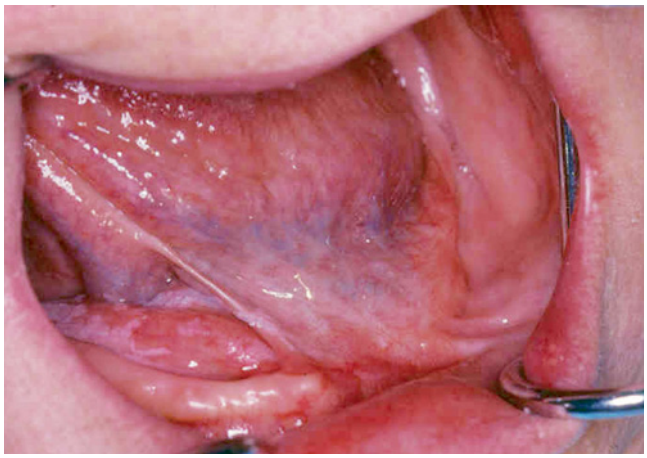


Figure 19-16 Tongue sutured to buccal mucosa following hemiglossectomy. The tissue closed primarily over the mandible, precluding fabrication of a stable denture.

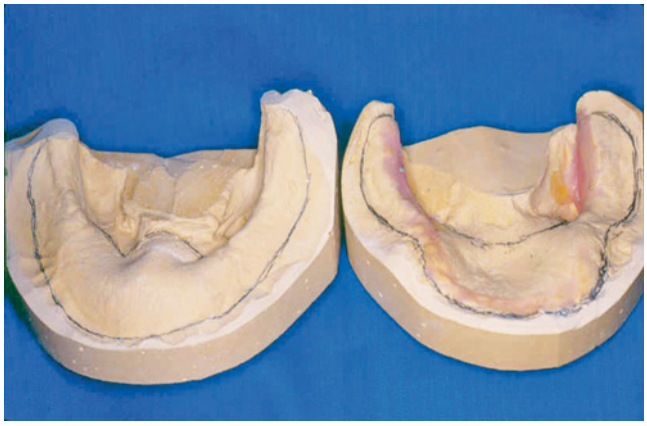


Figure 19-17 This patient had a free soft tissue flap from the forearm placed over a marginal mandibulectomy, replacing missing soft tissue of the floor of the mouth and mandible. The right cast reveals the contour changes after connective tissue debulking 1.5 cm of soft tissue; however, because the flap does not attach to the mandible, the tissue is very mobile, and the patient could not successfully wear dentures.

and are also too mobile for denture stability (Fig. 19-17). The ideal closure is a split-thickness skin graft placed over the bone and sutured to the buccal and lingual tissues. The skin graft will attach to the remnant marrow bone and behave similarly to attached gingiva. The mobile lingual and buccal tissues are separated by nonmobile skin over the mandible (Fig. 19-18). This skin-grafted mandible will respond well to radiotherapy also. Surgeons should be encouraged to use a skin graft on marginal mandibulectomies, unless considerable soft tissue is required to restore gross resection of the tongue and floor of mouth. If a skin graft is not used for primary reconstruction, secondary debulking of the movable flap and placement of a

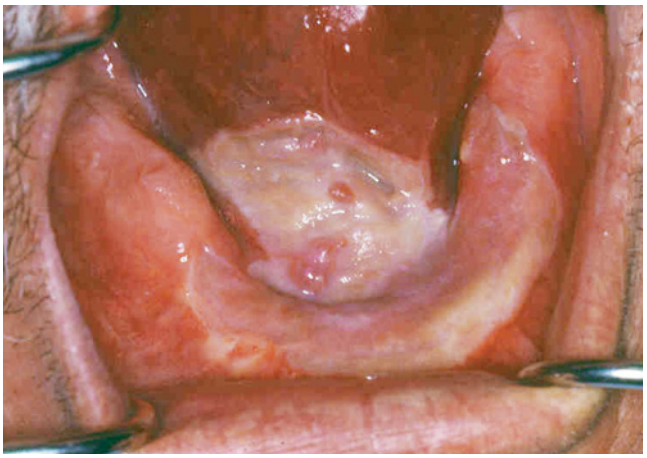


Figure 19-18 This patient had a marginal mandibulectomy and floor-of-mouth resection that was reconstructed with a split-thickness skin graft from the thigh. Given the excellent posterior mandibular height and nonmobile tissue in the anterior mandible, the patient did very well wearing conventional dentures.

supraperiosteal skin graft may be necessary before making a mandibular denture. Processed bases are advantageous.

DISCONTINUITY MANDIBULECTOMY PROSTHESES

Mandibular discontinuity resections are usually in the lateral aspect of the mandible and result from epithelial lesions in the oral cavity overlying the mandible. Predictable use of microvascular free flaps has allowed successful reconstruction of mandibular discontinuity defects with improved blood supply since the mid-1980s and has dramatically improved the treatment prognosis of prosthodontic rehabilitation. However, this reconstruction is not available in all institutions, and not all patients are good medical candidates for complex boney free flap reconstructions. These nonreconstructed lateral resections will continue to require prosthetic rehabilitation. Dentures for edentulous patients with discontinuity mandibulectomy defects are primarily for esthetics and provide limited masticatory improvement because of compromised denture-bearing surfaces, deviated mandibular position, and altered closure pattern. In addition these patients often have impaired tongue function, which further compromises the prosthetic prognosis.

A custom border molded tray should cover the available mandibular body. There is often a desire to extend the denture beyond the mandible into the resected area to gain a broader area of contact or to support the lip. The soft tissues in the resected area should be scrutinized because they usually move when the tongue moves or when the patient opens the mouth. These movements will unseat the prosthesis. If the tongue is "pulled" to the surgical side with the surgical closure, a deep anatomical space is created on

the posterior lingual aspect of the remaining mandible. Because the tongue lacks mobility, this space does not change with tongue movement. Extension of the denture flange into this space improves denture stability. A processed base will allow a thorough evaluation of the base stability before the addition of teeth.

Obtaining maxillomandibular relationship records for this patient is challenging. Patients do not have a condylar hinge movement. Because of unilateral muscle attachments to the intact mandible on the nonsurgical side, as the patient opens the mouth, the chin and midline deviate and rotate as much as 1 to 2 cm to the surgical side. As the patient closes the mouth, the anterior mandibular path is not vertical, but rather it follows a diagonal path toward the nonsurgical side. At final closure, the patient usually reaches the vertical dimension of occlusion with the mandible still in a lateral position. Besides the problem of unilateral muscle attachments, there often is scarring in the surgical area that also prevents the mandible from returning to its normal midline position and correct relationship with the maxilla.

When shaping the maxillary rim, it may be necessary to decrease the upper lip support so as not to accentuate the class II appearance of the mandibulectomy patient. This appearance occurs as a result of the postural mandibular deviation and recessed chin point. The dentist should not "push" the mandible laterally to achieve normal maxillary/mandible horizontal overlap. It is unlikely that the patient will be able to achieve this "operator-assisted" relationship during function. Patients should move the mandible toward the surgical side using their own altered muscles of mastication. This patient-generated position is used as the centric occlusion position. The patient undergoing a lateral mandibulectomy has proprioception for a "repeatable position" within an occlusal area, but it will not be an exact repeatable position as is seen in a balanced centric relation (CR) position of the nonresected mandible. Adapt the occlusal wax rims in harmony with this position.

Vertical dimension of occlusion should be determined by assessing lip competence, facial appearance, and closest speaking space. Normal lip closure may be compromised in these patients because of bisecting of the lower lip during surgery, damage to the marginal mandibular branch of the facial nerve, and lack of bony support; therefore it is important that the patient can close the lips without straining in order to prevent loss of liquids or food bolus. Lip closure and an unstrained facial appearance may be the best determinant of the correct vertical dimension of occlusion. Closest speaking space may be a helpful parameter, but because of possible articulation problems and mandibular deviation, this parameter is difficult to interpret.

After the occlusion rims are formed for horizontal alignment and equal contact in centric occlusion (CO) position, the interocclusal record may be made. Using any recording material with resistance will cause the mandible to rotate as the denture encounters the resistance. Using a plaster for the recording material requires that the patient maintain a position until the material sets. Maintaining a mandibular position without occlusal contact or moving the mandible to a specific location often is difficult for a patient with a partial resection. An alternative is to have the patient close repeatedly and observe the repeatable occlusal table "area." The occlusal rims should be adapted to coincide with this position to offer maximum maxillomandibular wax rim contact. Large notches can be created on the buccal of the occlusal rims. With the patient closed into maximum rim contact, impression plaster or a rigid setting registration material can be injected along the buccal surfaces of the two occlusion rims (Fig. 19-19). In this manner, the patient's mandible is in its most stable position, and the vertical dimension of occlusion is accurate.

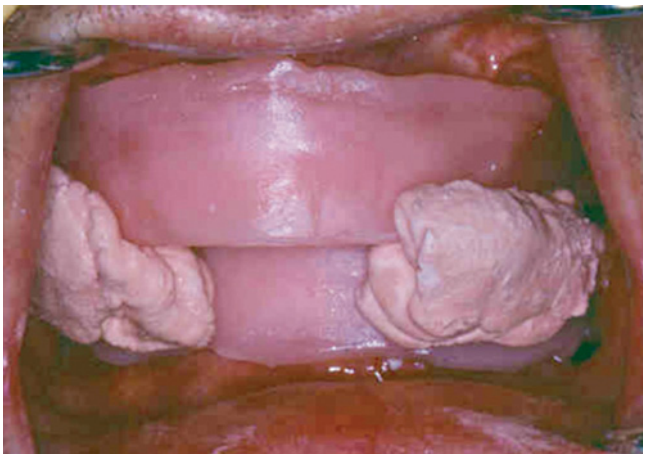


Figure 19-19 The deviated discontinuity jaw relationship records should be made with the wax rims making broad contact at the vertical dimension of occlusion. A rigid recording material such as plaster can be injected into notches along the buccal of the wax rims, making a closed-mouth recording of the static centric occlusion contact.

Mount the processed bases on remount casts. Use of a facebow to achieve a relationship of the condyles to the maxilla is not an issue in the patient with a discontinuity resection because the condylar function is unilateral. However, mounting the maxilla in the correct relationship to the upper member of the articulator will give the clinician an appreciation for the rotation of the mandible. When the relationship of the mandible with the maxilla is viewed, the deviation toward the surgical side, the medial rotation of the mandibular body, and the inferior rotation of the chin point will be evident. Monoplane occlusion is recommended to allow patients freedom to function in an occlusal area. Given the medial mandibular rotation, it is likely that the posterior mandibular teeth may be positioned on the buccal shelf, which is now the functional ridge crest. Placing the anterior teeth more buccal than the vestibule will decrease the class II appearance but usually serves to decrease denture stability. If processed bases are

used, this tooth position can be assessed at the try-in appointment. If the bases become less stable when positioning the mandibular anterior teeth, the teeth should be set more lingually. The mandibular plane will coincide with the maxillary plane. Because of the inferior rotation of the anterior mandible, the vertical height of the mandibular denture in this area may be considerably more than the posterior denture height. Vertical overlap of the anterior teeth may be considered. Because a true protrusive or incising motion or movement of the mandible into a normal "s position" during speech is unlikely in this patient population, vertical overlap may not unseat the denture in function. During the try-in stage, anterior vertical overlap can be assessed in relation to denture stability and its benefit to speech.

For proper maxillary buccal corridors, the maxillary teeth are set in the appropriate buccal/lingual position. Because of mandibular deviation, it may be necessary to place a flat occlusal platform palatal to the maxillary teeth on the nonresected side to achieve occlusal contact. Making a sloped platform to guide the mandible farther toward the nonresected side and achieve a more normal occlusal buccal/lingual alignment usually unseats the mandibular denture rather than moves the mandible. A sloped platform should be avoided in the edentulous patient, unless it is a sloped platform that corresponds to the angle of the path of closure.

Placing prostheses and establishing a vertical dimension of occlusion may alter tongue/palate contact. The patient should be considered for a palatal augmentation prosthesis. It may be formed at the try-in appointment or added later. After processing on the teeth, the dentures are returned to the remount casts, and a laboratory remount is done.

TROUBLESHOOTING PROSTHESES FOR THE PATIENT WITH AN EDENTULOUS MANDIBULECTOMY

Unstable Mandibular Denture

Stability of the base should be evaluated with processed bases at the time of maxillomandibular relationship records before placement of wax rims. Overextension onto movable tissue will unseat the prosthesis. Overextensions should be reduced before making records. If the prosthesis is unstable at the try-in appointment, inappropriate tooth position may be unseating the prosthesis. Denture adhesive usually is necessary. Often implants can be placed in the residual anterior mandible without bone grafting and are very beneficial for this patient population. Until approximately 2003, many head and neck radiation fields had limited anterior mandibular coverage; therefore these irradiated patients can be considered for anterior implants without risk of nonhealing wounds or osteoradionecrosis.

Inability to Chew or Inability to Chew Beyond a Soft Diet

Intact sensation and mobility of the tongue is very important to detect the food particles, form the food bolus, and transport it onto the occlusal tables of the teeth during mastication. Patients with partial mandibulectomies often have impaired range of motion of the tongue and masticatory functional deficits. A liquid diet or a soft diet that is washed down with liquids may be all that the patient can accommodate despite the insertion of dentures. Hard food substances require considerable masticatory power that the edentulous mandibulectomy patient lacks. The patient should be educated to these possible limitations before the prostheses process begins.

PROSTHESES FOR RECONSTRUCTED MANDIBLES

Restoration of continuity with free flaps or free grafts offers a major advantage of maintaining the condyles in the appropriate relationship to each other and to the maxilla, provided the surgeon performed the necessary intraoperative procedures addressing the condylar positions. It should be possible to record a repeatable CR record. For improvement of prosthetic rehabilitation, an adequate volume of bone and soft tissues overlying the bone graft is required. The soft tissues must not be bulky, compressible, or movable. These soft tissue difficulties usually are seen when soft tissue flaps are required to replace considerable intraoral soft tissues resected with the tumor. Secondary preprosthetic surgical procedures are often necessary to alter these soft tissues. The ideal situation would be debulking of the flap and placement of a split-thickness skin graft over the mandibular graft or place implants in the grafted bone. Routine prosthodontic procedures with processed bases are used. As previously described, for the patient with a partial mandibulectomy it is important to select the anterior tooth position and vertical dimension of occlusion so as not to hinder lip competence. The need for a palatal augmentation prosthesis should be assessed if significant loss of tongue bulk or impaired tongue mobility is observed.

MAXILLOFACIAL IMPLANT-ASSISTED PROSTHESES FOR THE EDENTULOUS PATIENT

Prosthodontic rehabilitation for the edentulous patient with maxillofacial defects is very challenging. These patients benefit from implants much more than patients with any other removable prosthesis. Prosthesis success is often compromised because of altered anatomic conditions such as: the loss of bilateral bony support in either arch, load intolerance of the denture-bearing mucosa due to adverse biologic changes from radiotherapy, lack of sensory and motor

control of remaining tissues required for denture adaptation, moveable and compressible flap tissues overlying the arches, and the need for prosthesis extension to support facial contours. Support, stability, and retention can be greatly enhanced with the use of dental implants. Despite the decided advantages, implants are not widely used in this patient population because of comorbidities, potentially impaired healing, burden and cost of therapy, small patient population, and limited conclusive implant research.

RISKS AND BENEFITS ASSESSMENT OF IMPLANTS IN IRRADIATED TISSUES

Radiotherapy is a common primary or surgical adjuvant treatment for cancers of the head and neck. While radiotherapy is effective in destroying residual cancer cells, the side effects to adjacent tissues are well documented and include acute and late damage to all tissue types that hinders normal wound repair. The bone-forming cells, osteoblasts and osteocytes, within the direct path of irradiation are damaged and killed in bone, reducing the capacity for new bone synthesis. The small blood vessels become obliterated with progressive endarteritis. The periosteum loses cellularity and vascularity with impairment of osteoid formation. Osteoclasts continue resorption after radiotherapy. Late effects are seen when bone anabolic processes are exceeded by catabolic processes. These radiation cellular damages impair osseointegration and the boney remodeling necessary for long-term success of implants.

Radiotherapy has been identified as being a statistically significant variable in implant failure. Nevertheless, the need to optimally rehabilitate edentulous oral cancer patients has challenged clinicians to consider risks and benefits of implant rehabilitation.

Key issues are potential morbidity of osteoradionecrosis associated with implant failure, and short term versus long term success. Several radiation factors potentially influence implant success. The important radiotherapy information that must be gained from the radiotherapist includes radiation source, dose, and fractionation schedule; concomitant therapies (i.e., chemotherapy); the anatomic regions of the jaws irradiated in relation to the implant sites; and the sequencing of medical and dental therapies. It is necessary to calculate irradiation dose at each implant site to assess the viability of the bone for osseointegration. Newer forms of radiation delivery, such as intensity-modulated radiation therapy (IMRT), produce nonhomogeneous 3-dimensional treatment volumes that can deliver increased dose to target areas using upwards of 9 directional beams. This can limit the dose given to critical structures of the head and neck; however, this multibeam approach can deliver low-dose radiotherapy to the entire jaw, whereas previous 2 to 3 field arrangements often spared the anterior aspect of the maxilla and mandible entirely. From the available literature, it appears that placement of implants is relatively successful in patients who have been irradiated to doses below 50 Gy at the implant site.

A 10-year survival curve of 446 implants (331/446 irradiated sites) in head and neck cancer patients was 78%. The survival of implant by jaw was 59% maxillary and 85% mandibular. In sites with less than 50 Gy irradiation (included the nonirradiated sites) survival was 84% compared with 71% in sites receiving greater than 50 Gy irradiation.

A retrospective review from 1990 to 2003 of surgically resected head and neck cancer patients who received a total preoperative radiation dose of 50 Gy to the head and neck (with concomitant chemotherapy) revealed a 72% 8-year success rate in mandibular implants (154 total implants) placed in jaw sites that were in the irradiation field compared with 95% (162 total implants) outside the irradiation fields within the same group of 71 patients. The data revealed a continued decline in success rate over time in the irradiated implant sites, defined as implant loss or bone loss greater than one third the implant length. This is hypothesized to be due to the lack of bone remodeling that occurs in bone receiving tumoricidal doses of radiotherapy (Fig. 19-20).

Use of implants should be recommended for all edentulous patients with maxillectomy or palatectomy defects. Studies have shown that edentulous maxillary obturator prostheses have poor retention, stability, and masticatory efficiency. The addition of implants provides greater retention and stability of the obturator prosthesis, leading to improved mastication on both defect and nondefect prosthetic dentition compared to the nonimplant obturator prosthesis. Even though the long-term survival rate of implants in irradiated bone was relatively low (55% to 65%) compared with the nonirradiated bone sites (90% to 95%) for edentulous maxillectomy patients (implants were splinted if multiple), the placement of implants in these patients is justified for the significant functional benefits from implants and negligible morbidity of osteoradionecrosis resulting from failed implants in the maxilla.

Numerous studies have shown that implant-supported or implant-retained overdentures in the routine complete denture patient provide greater improvement in masticatory performance when patients have severely compromised mandibular bearing surfaces. Masticatory benefits of implant placement in the edentulous mandible is less clear when the resected tongue volume is great and the residual tongue mobility impairs movement of the food bolus. However, placement of implants allows the patient to focus less on tongue manipulation of the denture and more on manipulation of the food bolus. Compromised speech is common in patients with tongue, mandible, or floor of mouth resection. Compensatory speech is improved with proper prosthetic lip support and replaced dental structures.

The best approach regarding the sequencing of implant placement for the edentulous patients with maxillofacial defects remains controversial and dependent on the ability to access the patient by the available team members in a

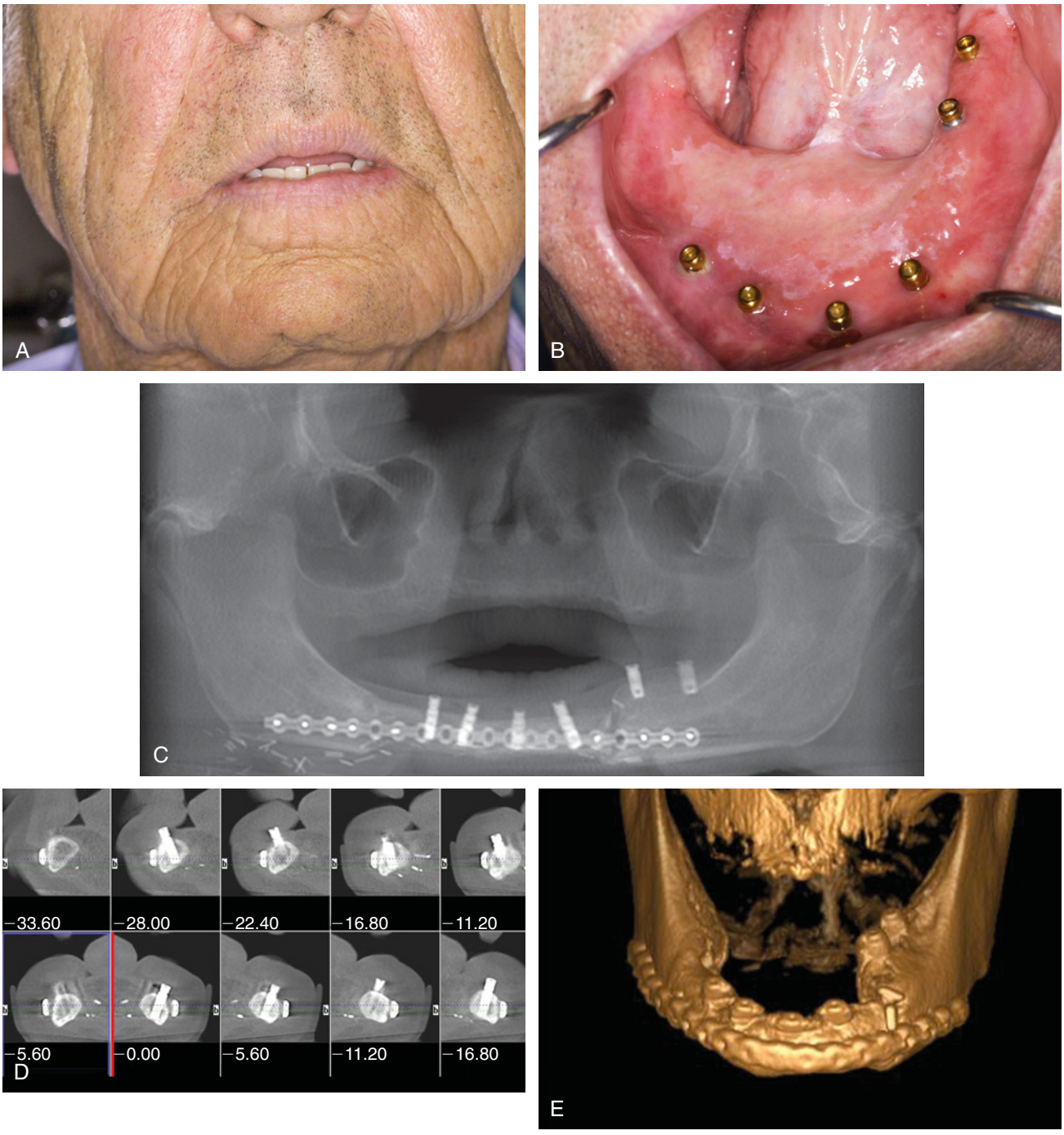


Figure 19-20 **A,** This edentulous patient had a mandibular resection, fibula flap, and immediate implants placed in the native remnant mandible at sites 18, 19, and 31, followed by radiotherapy to 60 Gy. **B** and **C,** After 2 years of overdenture function, continued horizontal loss of bone occurred at all implant sites and the right implant was lost. After HBO, four implants were placed in the irradiated fibula for better prosthesis stabilization. **D** and **E,** The sagittal cone beam reformations reveal the contour of the fibula and its small dimension. Bicortical implant placement is imperative in this bone because of the very fatty marrow and large marrow space.

timely manner. The advantages of implant placement during ablative tumor surgery and/or before radiation are (1) reduced treatment time for prosthetic rehabilitation, (2) initial implant healing before irradiation, and (3) reduction of the need for additional surgery at a time when the treatment burden and comorbidities may have escalated. However, some potential complications associated with this approach include (1) an inability to place as many implants as might be desired for complex, fixed reconstructions due to lack of available bone and lack of time for bone grafting, (2) unilateral and limited implant placement due to resection of the contralateral jaw, (3) late referral for a dental treatment plan after the cancer treatment plan is all ready initiated, (4) being limited to placement of implants in sites of proposed doses expected to be less than 50 Gy, and (5) the potential that the patients may have recurrence or die of disease before employing the implants.

If implant placement occurs during surgery or before primary radiotherapy, it is possible to complete all cancer therapy and oral rehabilitation within 8 to 12 months. A Dutch study examined a simultaneous resection and implant placement protocol for 50 edentulous patients receiving 2 splinted mandibular interforaminal implants. Only 1 patient did not have a prosthesis fabricated, and 3 others did not have a prosthesis at 5 years. The timeline for prosthetic rehabilitation was 9 to 12 months for irradiated patients. One half of the patients were dead at 5 years, but had many months and years of prosthesis function before their death. Eleven percent of irradiated implants failed because of loss of integration, and 1.5% of nonirradiated implants were lost.

Because almost 80% of head and neck tumor recurrences occur before 2 years, many clinicians wish to observe patients for possible recurrence and postpone any implant surgeries until the patient has a disease-free period. This approach has been used for many years, and precludes prosthesis fabrication for many patients. The optimal approach has yet to be determined.

Risk of Osteoradionecrosis

Osteoradionecrosis (ORN) in irradiated jaws can lead to catastrophic failure of jaw fracture. There are few reports of ORN secondary to implant placement or due to loss of osseointegration in the irradiated bone. Two of 60 irradiated patients who received implants reported ORN that occurred in the mandible, and soft tissue necrosis of the floor of the mouth occurred in three patients following implant placement. ORN resulted in loss of the implants and mandibular resection in the two patients. This severe complication may be underreported in the literature. A surrogate risk of ORN in the mandible resulting from implant placement is probably best determined by considering the bone necrosis rate seen following postradiation extraction. It should be relatively safe to place implants in irradiated mandibular sites if the dose is less than 50 Gy, albeit the quality of the integration may be suspect. The ORN risk would be significant for doses above 60 Gy. In a systematic review, the risk of ORN in the mandible was three times that of the maxilla after dental extraction. The magnitude of the surgery including reflection of soft tissue flaps, adjuvant alveoloplasty, exostoses removal, and the nutritional and smoking status of the patient, along with the irradiation dose, should be empirically considered on a case by case basis when performing extractions or implants in the jaws.

Hyperbaric Oxygen Therapy

To minimize the risk of ORN caused by implant placement, including the adjuvant procedures often required to ready the altered soft and hard tissues in the oral cavity, and to improve implant success rate in irradiated sites hyperbaric oxygen (HBO) has been advocated. The use of adjuvant HBO remains equivocal for implants in irradiated tissues because of limited available clinical research. Animal studies support that HBO in irradiated animal bone achieves increased new bone formation, increased bone turnover, and increased vascular supply to irradiated bone. A 2001 literature overview of 4392 implants revealed that HBO improved implant survival in all regions that were subjected to radiation. Ten-year survival in irradiated sites was less than 50%. A large institutional retrospective series of 631 implants in 107 patients spanning a period of 25 years, revealed a treatment shift to using preimplant HBO as a result of the early loss of implants in irradiated sites of the maxilla and mandible. The final analysis revealed that HBO yielded a statistically significant improvement of implant success compared with irradiated sites without HBO and revealed similar success rates compared with nonirradiated sites within the same patients. It should be noted that the quality of the trials related to HBO and implants are retrospective, limited case series (Fig. 19-21). A recent



Figure 19-21 This patient was an unsuccessful denture wearer following floor of mouth and tongue resection. He was given HBO after 58 Gy of radiotherapy. Implants were placed in the native mandible. This reveals the tissues at a 5-year follow-up.

systematic review described a 4% risk of postradiotherapy dental extraction incidence of ORN when using HBO. Of the patients who underwent extraction, none of the patients receiving less than 60 Gy had ORN, but 12% of the patients receiving greater than 60 Gy had ORN.

Another review of available literature on consecutive series of irradiated patients related to extraction sites in irradiated areas and nonirradiated areas of the jaws revealed a 6% risk of ORN in irradiated extraction sites, 4% in preradiation extraction sites, and 0% in nonirradiated extraction sites. When making a treatment decision regarding HBO, clinicians must weigh the magnitude of the radiation in dose and location, magnitude of the planned surgery and patient comorbidities, availability and cost of the therapy, and risk of possible complications of HBO.

Irradiation of Existing Implants

It is anticipated that more and more patients will have implants and implant prostheses predating a diagnosis of head and neck cancer. Many patients will have received a cancericidal dose of radiation therapy to the head and neck region and irradiation has an impact on these existing implants. Because of the atomic number of titanium, it has been calculated and documented with laboratory dosimetry studies that the backscatter of titanium implants within 1 to 2 mm of the implant surface is enhanced at 10% to 21%. This is due to the energy of the primary therapeutic beam and the subsequent secondary backscatter of electrons from the titanium. A 10% enhancement of a 60-Gy dose at the implant interface can cause irreparable bone damage at the very surface where osseointegration and remodeling is required.

The dose enhancement may subject these local tissues to ulceration, exposure of the underlying bone, loss of the implant, and possible ORN. Of additional concern is the backscatter created by noble metals used to fabricate the implant restorations and implant tissue bars. In these cases, the dose enhancement secondary to noble metal backscatter may approach 80%. Some clinicians suggest that the metal superstructures, especially noble metals, be removed and titanium healing abutments placed. A millimeter of porcelain or acrylic resin covering these metal superstructures completely mitigates the secondary radiation emissions.

PROSTHODONTIC TREATMENT CONSIDERATIONS FOR THE IRRADIATED EDENTULOUS PATIENT

Timing of Denture Placement

Radiation therapy in the head and neck region causes long-term histopathologic changes on oral mucosa, bone, and the quality and quantity of the saliva. Some dentists have been reluctant to fabricate dentures, especially the mandibular denture, for the edentulous patient after radiotherapy. The risk of developing an ORN is minimal in patients who have been edentulous and a denture wearer for an extended time (more than 1 year) before undergoing head and neck radiation. For this group of patients, the dentures can be fabricated or reinserted upon resolution of the mucositis. Deferring denture use for 12 to 18 months was advocated many years ago, when radiotherapy was not as well controlled. However, in the presence of high-dose radiotherapy, mucosal telangiectasia in the zone of the keratinized attached tissue, and severe xerostomia, use of a mandibular denture should be closely observed (Fig. 19-22). The risk of ORN is always greater in the patient group who is recently edentulated before or after radiotherapy. The bone remodeling process is seriously disturbed by cancericidal doses of radiation therapy, and if radical alveolectomies are not performed during extraction, the resulting alveolar ridge will be irregular and can increase the risk of soft tissue ulceration leading to bony exposure in a patient wearing complete dentures. The mucosa of the boney undercut of the posterior retromylohyoid ridge often breaks down several days after full dental extractions because the tongue is no longer "contained by the lingually inclined molars" and the friction of the tongue ultimately tears/abrades the mucosa over this undercut. This area is often not healed at the time of radiotherapy. This area of bone should be allowed to sequester with no surgical intervention. Usually soft tissue undermines the bone exposure such that this area of the mandible is covered by soft tissue at the time of sequestering of the bone. Particular notice should be taken during impressions and border molding not to abrade the mylohyoid tissues, because this area of the oral cavity receives high doses of radiotherapy in most oral cavity and head and neck cancers. A denture should not engage the retromylohyoid fossa in



Figure 19-22 Patient had HBO and extraction of 20 to 29 two months earlier. She has severe radiation-induced mucosal atrophy indicated by telangiectasia. Her xerostomia, mucosal damage, and tongue dysfunction make her a poor candidate for successful mucosal-borne prostheses.

the irradiated patient because dislodgement of the denture will certainly abrade this lateral undercut. Patients who continue to smoke add to soft tissue damage and risk of denture pressure areas leading to bone exposure. Because of the risk of ORN, it may be necessary to refrain from making mandibular dentures for patients with irregular/sharp bearing surfaces, extreme xerostomia, and diffusely spread telangiectasias of the denture-bearing tissues. However, a smooth and well-contoured mandibular bearing surface may enable denture use quite soon after therapy.

A U.S. retrospective review of 190 patients who had all their teeth extracted in preparation for head and neck radiotherapy and were subsequently given complete dentures reported a 2.1% rate of ORN. The ORN developed equally before and after denture delivery. Exposed bone was reported in 12% of patients during denture fabrication and immediately after delivery and 7% of patients had bone exposure after wearing the new dentures. All patients had dentures delivered within 1 year of radiotherapy. There was no difference in the bone exposure rate related to time after radiotherapy that the denture was delivered. This study did not review edentulated patients that did not receive dentures; therefore, patients who may have had bone or tissue irregularities that gave cause for denture deferment were not detailed. There are no reports related to a high incidence of ORN in edentulous irradiated denture patients.

Salivary Consideration for the Irradiated Edentulous Patient

The amount and viscosity of saliva is an important determinant of prosthodontic success. Epstein et al reported that the most common patient concerns following radiation was dry mouth (84%), pain (70%), lack of taste (97%), and diminished appetite (70%).Compromised salivary function leads to more friction at the denture mucosal interface and more mucosal irritation. Retention of complete dentures may be compromised because of diminished salivary quantity and changed quality, such as the increased film thickness of the scanty and more mucinous saliva. Dry foods will adhere to the denture surfaces and the denture surface should be highly polished. Lightly polishing the bearing surface of the mandibular denture is advisable along with removing any gross undercuts or projections on the intaglio surface. The dentist should refrain from stippling the dentures because this only collects food and plaque debris as a result of diminished salivary function.

Occlusal Forms

As previously described, many patients present with abnormal jaw relationships, angular paths of closure, sensory and motor deficits, and unfavorable denture-bearing surfaces. A well-executed occlusal philosophy in harmony with the patient's functional path of closure is recommended over any specific occlusal scheme or form. Occlusal trauma may lead to a soft tissue necrosis and exposed bone. These wounds may take months to heal with bone sequestrum being common.

Delivery and Postinsertion Care

Pressure-indicating paste is used to identify areas of excessive pressure, and disclosing wax or thick pressure paste is useful in delineating overextension of denture flanges. It is imperative that the patient refrain from wearing the dentures whenever an ulceration is noted and until an adjustment can be made. Mandibular prostheses should be removed at night; however, obturators are usually worn at night to control secretions and edema within the surgical site.

The risk of serious postradiation sequelae in denture wearers is small. Cooperation of the patient is a necessity to diminish the risk of necrosis.

Bibliography

Aramany MA, Downs JA, Beery QC: Prosthodontic rehabilitation for glossectomy patients, *J Prosthet Dent* 48:78-81, 1982.

Beumer J, Curtis D, Marunick M: *Maxillofacial rehabilitation: prosthodontic and surgical considerations*, St Louis, 1996, Ishiyaku EuroAmerica, Inc.

Beumer J, Curtis T, Morrish R: Radiation complications in edentulous patients, *J Prosthet Dent* 36:193, 1976.

Bornstein MM, Cioca N, Mombelli A: Systemic conditions and treatments as risks for implant therapy, *Int J Oral Maxillofac Implant* 24(Suppl):12-27, 2009

Brown KE: Complete denture treatment in patients with resected mandibles, *J Prosthet Dent* 21:443-447, 1969.

Cantor R, Curtis TA: Prosthetic management of edentulous mandibulectomy patients. Part II: Clinical procedures, *J Prosthet Dent* 25:546-555, 1971.

Christensen JM, Hutton JE, Hasegawa A et al: Evaluation of the effects of palatal augmentation on partial glossectomy speech, *J Prosthet Dent* 50:539-543, 1983.

Desjardins RP: Occlusal considerations for the partial mandibulectomy patient, *J Prosthet Dent* 41:308-315, 1979.

Donoff RB: Treatment of the irradiated patient with dental implants: The case against hyperbaric oxygen treatment, *J Oral Maxillofac Surg* 64:819-822, 2006.

Epstein JB, Emerton S, Kolbinson DA, et al: Quality of life and oral function following radiotherapy for head and neck cancer, *Head Neck* 21:1-11, 1999

Esposito M, Hirsch J-M, Lekholm U, et al: Biological factors contributing to failures of osseointegrated oral implants. (II) Etiopathogenesis, *Eur J Oral Sci* 106:721-764, 1998.

Ewers R: Implant survival in mandibles of irradiated oral cancer patients, *Clin Oral Implants Res* 17:337-344, 2006.

Franzen L, Rosenquist JB, Rosenquist KI, et al: Oral implant rehabilitation of patients with oral malignancies treated with radiotherapy and surgery without hyperbaric

oxygen therapy, *Int J Oral Maxillofac Implants* 10: 183-187, 1995.
Gerngross PJ, Martin CD, Ball JD, et al: Period between completion of radiation therapy and prosthetic rehabilitation in edentulous patients: a retrospective study, *J Prosthodont* 14:110-121, 2005.
Granstrom G: Radiotherapy, osseointegration and hyperbaric oxygen therapy, *Periodontology* 2000 33:145-146, 2003.
Granstrom G: Osseointegration in irradiated cancer patients: an analysis with respect to implant failures, *J Oral Maxillofac Surg* 63:579-585, 2005.
Granstrom G: Placement of dental implants in irradiated bone: the case for using hyperbaric oxygen, *J Oral Maxillofac Surg* 64:812-818, 2006.
Jacob RF, Martin JW, King GE: Modification of surgical obturator to interim prosthesis, *J Prosthet Dent* 54:93, 1985.
Jacob RF, Reece GP, Taylor TD, et al: Mandibular reconstruction for the cancer patient: microvascular surgery and implants, *Tex Dent J* 119:23-26, 1992.
Jacob RF, Yen TW: Processed record bases for the edentulous maxillofacial patient, *J Prosthet Dent* 65:680-685, 1991.
Jacob RF: Duplication of interim speech aid for definitive impression tray fabrication, *J Prosthet Dent* 68:561-562, 1992.
King GE, Jacob RF, Martin JW, et al: Rehabilitation of the nasal and paranasal sinus area. In Thawley S, Panke W, Batasakis J, et al, editors: *Comprehensive management of head and neck tumors*, vol 1, Philadelphia, 1986, WB Saunders.
Korfage A, Schoen PJ, Raghoebar GM, et al: Benefits of dental implants installed during ablative tumor surgery in oral cancer patients: a prospective 5-year clinical trial, *Clin Oral Implants Res* 21:971-979, 2010.
Korfage A, Schoen PJ, Raghoebar GM, et al: Five-year follow-up of oral functioning and quality of life in patients with oral cancer with implant-retained mandibular overdentures, *Head Neck* 2010 Dec 9. (Online ahead of print).
Logemann JA, Bytell DE: Swallowing disorders in three types of head and neck surgical patients, *Cancer* 44:1095-1105, 1979.
Logemann JA: Can data on normal swallowing improve treatment selection? In Myers EN, Barofsky I, Yates JW, editors: *Rehabilitation and treatment of head and neck cancer*, US Department of Health and Human Services, NIH Publications No. 86-2762, Washington, DC, 1986.
Martin JW, Jacob RF, King GE: Boxing the altered cast impression for the dentate obturator: plaster and pumice, *J Prosthet Dent* 59:382-384, 1988.
McKinstry RE, Aramany MA, Beery QC, et al: Speech considerations in prosthodontic rehabilitation of the glossectomy patient, *J Prosthet Dent* 53:384-387, 1985.
Mian TA, Van Putten MC, Jr, Kramer DC, et al: Backscatter radiation at bone-titanium interface from high-energy X and gamma rays, *Int J Radiat Oncol Biol Phys* 13(12):1943-1947, 12/1987.
Nabil S, Samman N: Incidence and prevention of osteoradionecrosis after dental extraction in irradiated patients: a systematic review, *Int J Oral and Maxillofac Surg* 2010 (Online ahead of print).
Nishimura RD, Roumanas ER, Beumer J, et al: Restoration of irradiated patients using osseointegrated implants: current perspectives, *J Prosthet Dent* 79:641-647, 1998
Ozen J, Dirican B, Oysul K, et al: Dosimetric evaluation of the effect of dental implants in head and neck radiotherapy, *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 99(6):743-777, 2005.
Paprocki GJ, Jacob RF, Kramer DC: Seal integrity of hollow-bulb obturators, *Int J Prosthodont* 3:457-462, 1990.
Robbins KT, Bowman J, Jacob RF: Post-glossectomy deglutitory and articulatory rehabilitation with palatal augmentation prostheses, *Arch Otolaryngol Head Neck Surg* 113:1214-1218, 1987.
Taylor TD, LaVell WE: Dental management and rehabilitation. In Thawley S, Panke W, Batasakis J, et al, editors: *Comprehensive management of head and neck tumors*, vol 1, Philadelphia, 1986, WB Saunders.
Taylor TD, Worthington P: Osseointegrated implant rehabilitation of the previously irradiated mandible: results of a limited trial at 3-7 years, *J Prosthet Dent* 69:60-69, 1993.
Visch LL, van Waas MA, Schmitz PI, et al: A clinical evaluation of implants in irradiated oral cancer patients, *J Dent Res* 81:856-859, 2002.
Yerit K, Posch M, Seemann S, et al: Implant survival in mandibles of irradiated oral cancer patients, *Clin Oral Implants Res* 17:337-344, 2006.

CHAPTER

20

Managing Problems and Complications

Steven E. Eckert, David Chvartszaid

Problems and complications may be encountered at any time throughout the applied treatment protocol for implant-supported dental prostheses (Table 20-1). Moreover, the likelihood of the adverse effects of time and health-dependent changes also may be encountered. These realities demand scrupulous and regular follow-up maintenance and monitoring of the prosthesis, the implants, and the host tissue's response that should continue for the rest of the patient's life.

As described in Chapter 16, endosseous implants must be made of a material that is biocompatible and possesses favorable physical and mechanical properties to function as retentive and supporting mechanisms for dental prostheses. They also must be placed in a surgical procedure that is followed by a healing process that ensures long-term survival. Although there are variations in surgical techniques and implant materials, these differences are generally minor. However, the required implant healing interval before implants can be functionally recruited can and often does show greater variety because of different loading protocols.

Trauma avoidance at the healing interface is an integral part of treatment planning for implants placed in the jaw bones. This remains the classic approach used to achieve osseointegration and traditionally requires a period of undistributed implant placement beneath the oral mucosa for 3 to 4 months in the mandible and 6 months in the maxilla. At the end of that healing period, the second stage of treatment begins, during which the mucosa covering the implant is surgically resected and transmucosal components are connected to the implant. This approach is described as the two-stage approach to implant surgery.

In contrast to this procedure, some implants are placed in such a way as to allow an attached healing abutment to pass through the oral mucosa at the first stage of treatment. Because there is no mucosa covering the implant, there is no stage II surgery; thus this process is known as a one-stage approach. In both situations, efforts are made to avoid functional loading of the implant until the bone has a chance to heal adjacent to the implant and ensure an osseointegrated response. There is also current enthusiastic clinician support for the concept of an immediate implant loading protocol (described in Chapter 21). This approach uses a rigid connection of implants shortly after their placement within the jaw. Such rigid implant fixation allows the implants to be used to support a provisional or even a final prosthesis almost immediately after stage I surgery. Success with this treatment approach appears to depend on achieving excellent primary implant stability, and in the case of multiunit applications, on the clinician's ability to rigidly join the implants above the level of the soft tissue. The latter step presumes to reduce micromotion to a level similar to that seen when implants are placed with a standard one-stage or two-stage approach without occlusal loading.

PROBLEMS

The process of osseointegration will be compromised or prevented if the desired bone-to-implant healing is hindered. Long-term survival of the implant would then be unlikely, and this major problem—failure to achieve or maintain osseointegration—is regarded as one of the two most crucial ones in the treatment protocol. The second is incorrectly or unfavorably placed but successfully osseointegrated implants (Fig. 20-1).

Either problem may then preclude the originally planned prosthodontic intervention or else require its substantial modification (e.g., having to fabricate an overdenture instead of a fixed prosthesis). The management of either problem, the second one in particular, could pose a serious challenge to patient management and is best avoided or mitigated by scrupulous patient education and optimal treatment planning. Biological failure of osseointegration is reported to be infrequently encountered and its occurrence or pathogenesis remains inadequately understood. It is therefore far more likely to be accepted by patients as a biological mishap rather than a professional judgment one. Conversely, an inability to use successfully osseointegrated implants as per an original treatment plan (e.g., a fixed prosthesis) would be an unfortunate surgical treatment outcome and not automatically or even readily acceptable

to a patient. The fact that the originally planned fixed prosthetic design may now have to be to be altered to a removable one (e.g., an implant-supported overdenture) might rectify this clinical predicament, but it also might elicit an unpredictable and unfavorable patient response.

TABLE 20-1 POSSIBLE PROBLEMS AND COMPLICATIONS

Time	Description
Stage I surgery	Unfavorable implant position/alignment
Post–stage I surgery	Swelling/ecchymosis
	Infection
	Suture remnants, wound dehiscence
	Neuropathy
	Unfavorable position or angle renders implant unusable for optimal prosthodontic result
Stage II surgery	Failure to osseointegrate
Following prosthesis insertion	Prosthodontic complications
	Soft tissue complications
Delayed complications	Delayed loss of osseointegration
	Component fracture
	Soft tissue complication



Figure 20-1 Far too many implants were crowded into the available maxillary host bone site. This resulted in a lack of adequate access for hygiene maintenance, less than ideal 3-dimensional orientation of the implants' long axes, and encroachment on mobile buccal gingival tissue *(arrow)*. Moreover, it is clear that a surgical template was not used to reconcile optimal prosthetic teeth placement with implant locations. Furthermore, long cantilever arms would be required here to provide suitable support for prosthetic teeth that would provide an acceptable smile. It also should be noted that such long cantilever extensions associated with implants that have been placed in straight-line configurations, rather than in a preferred semilunar arrangement, are more frequently associated with component fracture.

COMPLICATIONS

The term *complication* is used here to describe a far less serious problem, technical hitch, or difficulty resulting from single or multiple related factors that demand additional clinical interventions. There are numerous ways to group the possible complications that can be routinely encountered. They may be referred to as early or late, surgical or prosthodontic, biological or structural, functional or esthetic, or hard-tissue or soft-tissue related. Complications also might be considered as minor, akin to maintenance of traditional prostheses; moderate, requiring modification of existing prostheses; or severe, demanding refabrication of prostheses or replacement of implants. In this chapter, complications are described as ones encountered during either the surgical or prosthodontic treatment stages. However, there are times when there is no clear differentiation between their occurrences.

SURGICALLY RELATED COMPLICATIONS

Surgically related problems can, in turn, be subdivided chronologically into those related to stage I surgery, to the healing osseointegration time interval between the operations, and to stage II surgery. Although surgeons will primarily deal with these occurrences, it is often the referring or prescribing dentist who will be consulted when a problem arises. The patient's closest association is often with the dentist who made the original diagnosis, treatment plan, and referral for the patient. The prescribing dentist must therefore be regarded as that treatment plan's architect and must be aware of the possible complications that may occur during any phase of treatment. Scrupulous treatment planning that reconciles systemic and local oral health considerations, optimal imaging of proposed host bone sites, articulated diagnostic cast analysis, surgical template design, and so on is essential, and if carried out correctly, will significantly reduce the risk of subsequent treatment-related complications. Furthermore, the dentist should be prepared to deal with the patient's apprehensions and concerns and to make necessary referrals to the surgeon.

At Stage I Surgery

It is presumed that thorough treatment planning will result in minimal adverse sequelae. However, any surgical procedure carries with it the risk of bleeding, infection, swelling, and ecchymosis; surgery for the placement of osseointegrated implants is no exception. A meticulous sterile surgical technique, accompanied with appropriate antibiotic prescription and instruction to the patient regarding hygiene and oral rinses, is the best preventive measure to reduce infection-related complications. Excessive bleeding is infrequent and usually noted at the time of surgery or soon after



Figure 20-2 Extensive bruising is dramatically evident in this patient within a week after she underwent maxillary implant surgery.

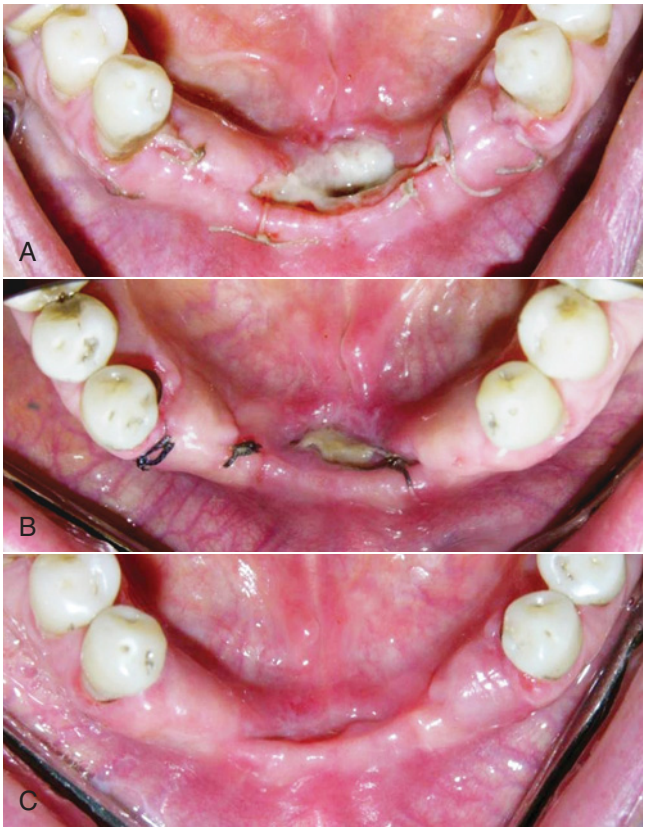


Figure 20-3 **A,** This Kennedy class IV partially edentulous mandible demonstrates the opening of an incision line following implant placement. The necrosed flap in **B** is allowed to heal without further intervention **(C).**

and managed by the surgeon. A life-threatening hemorrhage into the floor of the mouth due to inadvertent perforation of the lingual cortex and damage to associated blood vessels is a very infrequent occurrence but one that should always be kept in mind. Similarly, surgical invasion of the pterygoid space could compromise the vascular structures in this area, creating similar hemorrhagic risk.

Swelling often peaks on the second or third day after surgery, but the measures necessary to minimize or prevent it must be taken immediately after the surgical procedure. These include the application of pressure packs in the form of rolled sterile gauze and the use of cold compresses or ice packs. A transient ecchymosis also is delayed in its appearance and is most likely to occur in elderly patients (frequent recipients of this treatment protocol) and those who have a history of bruising easily or those who take medications that interfere with blood clotting (Fig. 20-2). Good preparation and tutoring of the patient will make it easier for him or her to accept this temporary but unfortunate esthetic appearance.

Infection, if it does occur, may be evident within a few days of the surgical insertion of the implants, or it may not be manifested until a few weeks or even a few months afterward. If the infection occurs soon after stage I surgery, it will most probably be noted by the surgeon first and treated with a regimen of antibiotic medication. If the occurrence of an infection is delayed, the patient may consult the referring dentist with a complaint of discomfort or soreness under the prosthesis. In such instances, there will likely be redness and swelling, and in some cases, the infection will be accompanied by an exudate. Systemic signs also may be present. Referral to the surgeon for debridement and cleansing of the site and antibiotic therapy should be done without delay.

Suture removal is sometimes not complete because of swelling or inaccessibility of the suture remnants. This might manifest as a localized redness or swelling and might result in the patient experiencing discomfort when wearing the denture. This mucosal irritation, sometimes mimicking infection, often is ongoing until the offending suture is removed.

Occasionally, especially when there is significant tension on the incision line through movements of the circumoral muscles or if the sutures loosen early, the incision will reopen (Fig. 20-3). If this occurs within a few days of stage I surgery, the surgeon may choose to close the wound with new sutures. If it occurs later, after the deeper layers of the wound have begun to close, the most prudent strategy is to let the wound close on its own by secondary intention while minimizing the possibility of secondary infection (through chlorhexidine rinses or systemic antibiotics) and avoiding additional trauma from the denture by delaying its reinsertion for 1 to 2 weeks.

Occasionally, damage to the inferior alveolar nerve or its branches may occur during the mucoperiosteal flap elevation or during the osteotomy preparation. The outcome of this damage is often referred to as altered sensation, and it most commonly manifests as numbness of the lip, chin, or mucosa on the affected side. The use of appropriate imaging techniques, paying attention to the details of the anatomy within the surgical field revealed in these images, and careful instrumentation will decrease the incidence of this complication. In most instances, the altered sensation will be transient, though the transient time may vary from a few days to several months. If damage to the nerve has been severe, it may be permanent. Strict follow-up is required for patients with evidence of altered nerve sensation. As with many other complications outlined in this chapter, this complication is usually preventable.

At stage I surgery, even when the most advanced imaging techniques are used, unexpected bony morphological deficits or poor bone quality may preclude ideal prosthodontically planned implant position, angulation, or number of implants placed. This has obvious repercussions on the final prosthetic design and may lead to a decision to change the prosthodontic prescription. If a fixed prosthesis was originally prescribed, an unfavorable implant angle or position could demand a change to a removable prosthesis. Unfavorable implant position or angulation could require a change to a different retention mechanism for an overdenture if a fixed prosthesis was initially prescribed.

Interval Between Stage I and Stage II

It is usual for patients to be requested to refrain from wearing their existing prostheses for a short time after implant insertion. At the end of this period, the tissue surface of the denture is relieved sufficiently to allow for the placement of a tissue conditioner or temporary lining at least 1 to 2 mm thick in the region of the implants. An existing denture that is of minimal thickness may be perforated during this reduction unless it is made thicker by the addition of acrylic resin to its polished surface beforehand. Because the surgical incision may be found in the labial vestibule, final resolution of the swelling in the site often is not complete at 2 weeks after surgery. In this situation, it is usually necessary to trim several millimeters from the length of the labial flange to prevent patient discomfort and stress on the incision site. This is true in either arch. The critical factor is that in relining and modifying the provisional prosthesis, the dentist should avoid causing undue tension and pressure on the sutured incision.

Between the stages of the treatment, the soft liner or tissue conditioner that has been applied to the tissue surface of the denture should be kept in good condition. Doing so will eliminate possible ulcerations caused by the rough and hard flanges of the dentures that develop as the soft liner ages. Soft liners that are old and rough also present a good medium for increased bacterial growth. Keeping the soft liner in good condition can be accomplished either by replacing it every 2 to 5 weeks, depending on the choice of material, or by treating the temporary liner, and especially the seam between the soft liner and the denture base, with a sealant that can be made up using an autopolymerizing acrylic resin powder and a solvent such as 1,1,1-trichloroethane (Box 20-1).

Box 20-1 Recipe for Varnish for Tissue Conditioner

- 50 mL 1,1,1-trichloroethane
- 2 mL autopolymerizing acrylic resin powder
- Using a glass bottle with a tightly closing lid, add the autopolymerizing acrylic resin powder to the trichloroethane solvent. This will take a few hours to dissolve completely. The resulting solution should be as viscous as glycerin. If it is found that it is too thick, add solvent; if it is too thin, add powder.
- A small amount should be dispensed into a plastic medicine cup and applied to the entire surface of the tissue conditioner, paying special attention to the seam between the denture base and the tissue conditioner.

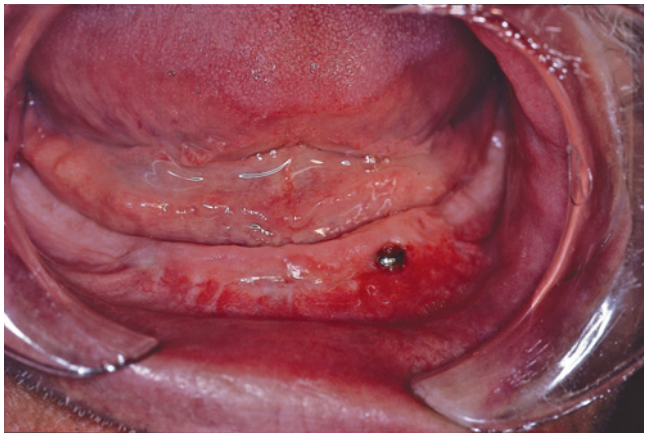


Figure 20-4 A dehiscence has occurred in an edentulous mandible that has undergone the first of a two-stage surgical procedure. Management of this occurrence is straightforward and requires overlying denture relief to avoid tissue irritation or "pinching," together with scrupulous oral hygiene.

After the sutures are removed and the initial soft tissue swelling has reduced, dehiscence of the cover screw of the implant through the mucosa may occur (Fig. 20-4). Experience with one-stage implants demonstrates that implant exposure is not a threat to the success of the implant as long as the site is kept clean. The patient may experience discomfort if the dehiscence of the cover screw is not complete and there is still mucosa partially covering the screw. This tissue can be pinched between the cover screw and the

denture base. This problem can be alleviated by trimming back the soft liner that has been applied to the tissue surface of the denture, thus allowing clearance in the area and preventing the pinching effect.

If a dehiscence occurs where an osteopromotive membrane has been used, this site should be monitored very carefully by the referring dentist and the surgeon. The denture base acrylic resin should be reduced more aggressively in the area to allow an extra thickness of tissue conditioner in an effort to eliminate any possibility of pressure from the denture causing an increase in the size of the dehiscence. The patient should be instructed to keep the site meticulously clean. Antibacterial rinses may prove beneficial. At the first sign of infection, the membrane preferably should be removed.

The time interval between the two surgical procedures is often difficult for the patient. During the surgical procedure the remaining alveolus is often reduced (especially in the anterior mandible), the vestibular depth may be lessened or eliminated entirely (especially with the use of vestibular incision), and the teeth that may have been present and used to retain a partial prosthesis removed. All these factors (and many others) can make the transitional prosthesis seem less stable and retentive than the prosthesis that the patient used before the surgical intervention. It is best to make the patient aware of this temporary challenge ahead of time and to be supportive of the patient during this difficult period.

At Stage II Surgery

Stage II surgery usually reveals whether an implant has actually osseointegrated. There are times, however, when failed osseointegration is not detected until further instrumentation is involved during component manipulation, impression making, or even during the insertion of the final prosthesis. If an implant is found to be mobile or tender to percussion or to the associated stresses of attaching the abutment to it, it should be regarded as a failure and removed. A failed implant should be removed immediately, and failure to do so in a timely manner will result in further osseous destruction. It also should be emphasized that soft tissue impingement is often associated with soreness during component connection and that this painful response should not be mistaken for osseointegration failure.

At stage II surgery, the cover screw that protected the internal threads of the implant is removed and replaced with a transmucosal abutment and center screw or with a healing abutment. If the regular abutment is attached at this time, it is important to ensure that the orientation components of the implant and the abutment (internal or external, hexagonal, octagonal or trilobed) are properly aligned. If this is not the case, there may be a soft tissue reaction or loosening of the components. This particular complication does not occur with the use of the healing abutment because healing abutments have no internal orientation component to engage the one at the top of the implant. The healing abutment does, however, seem to have an increased tendency to loosen. Thus, care should be taken to tighten it securely to the implant, and the patient should be advised to seek attention immediately if it loosens.

Some of the complications that arise at stage I surgery should be identified immediately rather than waiting for them to "surface" when the implants are uncovered at stage II surgery. This is especially true of implants that have an unfortunate buccal or lingual inclination or that are placed too closely (see Fig. 20-1), which may actually preclude using the implant to support a prosthesis. Such an implant should be recovered or "put to sleep" during the surgical procedure.

PROSTHODONTIC-RELATED COMPLICATIONS (TABLE 20-2)

Abutment Related

One of the earliest complications that can occur after stage II surgery and before prosthesis insertion is loosening of the abutment, whether it is a transmucosal abutment with a center screw or a healing abutment. This results in an inflamed and painful soft tissue reaction as the soft tissue grows into the space between the components and is pinched each time the patient occludes. When loosening of the abutment or healing abutment is noted, it is important to evaluate the superior surface of the implant to ensure that there is no soft or hard tissue covering the implant platform. The encroachment of soft or hard tissue on the implant platform can prevent full seating of the abutment, which will in turn result in component malalignment and a tendency toward increased incidence of component loosening. Leaving the selected final abutments attached to the implants after the final impression for the prosthesis has been made would virtually eliminate the risk of this bothersome complication. The top of the abutments should be protected against damage with appropriate healing caps. It must be emphasized that abutments can be damaged from

TABLE 20-2 PROSTHODONTIC-RELATED COMPLICATIONS

Type	Description
Structural	Fracture of prosthesis
	Fracture of prosthesis-retaining screw
	Fracture of abutment screw
	Fracture of implant
Cosmetic	As perceived by patient and dentist
Functional	Speech problems
	Transient masticatory muscle discomfort

contact with opposing teeth and overlying hard material in the provisional removable prosthesis.

Either immediately after stage II surgery, or if preferred, the week after stage II surgery, the tissue conditioner or the soft liner that had been placed into the patient's existing denture after stage I surgery is removed. The position of the abutments attached to the implants is transferred to the denture with an indelible marker guide, and then the denture is adjusted to allow for a thickness of soft liner over the abutments. Occasionally, the dentist will find that the abutments emerge outside of the borders of the denture, and then either the denture base must be enlarged by the addition of autopolymerizing resin, or a change to a very short healing abutment or to an angled abutment is made. If an implant is observed to emerge beyond the borders of the removable prosthesis, this is usually a clue that that implant may be malpositioned. It is usually beneficial to note severe malpositioning of the implants or issues that will impede ideal prosthetic prescription as early on in the treatment as possible because this helps with patient management.

Selecting the correct height of the abutment is not always an easy procedure because there is usually some swelling present after stage II surgery. If the selected abutment is too short, the mucosal swelling may lead to the tissue growing over the top of the abutment or healing cap, thereby allowing it to be pinched between the abutment and the relined denture base. If the selected abutment is too long, the removable prosthesis will be weakened significantly in the process of relieving it to make room for the height of the abutment. If the denture base is not adjusted sufficiently, the denture will not be properly seated, and the result will be an increase of the vertical dimension. In some cases, the patient will be able to cope with this increased height; in others, the resulting vertical dimension will be both esthetically and functionally so altered that the patient cannot or will not manage. In all of these scenarios, the problem can and should be solved by changing the length of the abutments. In all instances, the height of the healing abutments should be just tall enough to protrude above the mucosa without the risk of mucosal overgrowth. Frequently, the abutments placed at the time of surgery are deliberately chosen to be slightly longer to account for tissue edema. After 2 to 3 weeks of healing, it is often beneficial to review the abutment height and to change abutments to a shorter design if necessary.

The stage I surgical complication of insufficient bone to allow ideal implant position and inclination becomes most apparent at the time of prosthesis fabrication. Once the esthetic and functional try-in of the tooth arrangement has been accomplished and an index of the tooth arrangement has been made, discrepancies between the ideal location and angulation of the implants and the actual location and angulation become evident. Implant manufacturers have been ingenious in their design of components to deal with these situations, but the basic problem remains. While nonaxially located implants are widely regarded as risking adverse loading situations, the splinting together of several implants, including imperfectly aligned ones appears to compensate for misalignments without adverse outcomes. Nonetheless, it is prudent to seek to compensate for any misalignment by taking steps to reduce to a minimum the magnitude of occlusal forces, either by changing the prescription to a removable prosthesis or by narrowing the occlusal table, reducing the cusp angle, and shortening the potential cantilever arms.

Implants that are too close together can be difficult to restore and will make it very difficult for patients with a fixed prosthesis to carry out oral hygiene procedures. In the case of the overdenture, placement of implants too close together can significantly limit prosthodontic options and may compromise the final outcome. Implants that are very close together do not leave space for the ideal length of bar and clip (more than 1 cm), and when implants are closer than 3 mm, it is difficult to use standard ball attachments. Recent introduction of the smaller ball attachments with gold alloy or titanium keepers has helped to deal with this complication.

Impression Related

Obtaining an accurate impression for an implant-supported prosthesis is made relatively routine because of the nature of the fit of the impression hardware that has been developed. There are, however, a few complications that may occur. If the implants are close together and also are converging, the impression copings may interfere with each other. If their bulk is not reduced to eliminate this contact, the impression will be inaccurate. When an impression is made directly to the implant, the clinician must be aware of the emergence profile of the healing abutment in comparison to the profile of the impression components. The two profiles often differ, with the emergence profile of the impression transfer component being greater and thereby preventing full seating on the implant platform. This situation can be rectified by custom grinding of the transfer component to reduce emergence profile and allow the component to seat fully. If there are widely diverging implants, there may be a problem in seating the impression tray over the impression copings and laboratory pins or in being able to remove the impression copings off the implant heads. Impressions will not be accurate if the hexagon of the abutments and the implants are not properly aligned and tightened before the impression is made. It may be prudent to confirm seating of the components with periapical radiographs immediately before making the impression. Periapical films are suggested because panoramic films will not always reveal problems with the fit of the component parts due to variations of the angles of the implants. Moreover, if there is even a moderate labial or lingual inclination of the implant, an unseated abutment may not be noted in a panoramic film.

Even if the preceding precautions are taken, the final impression may not always be accurate. A confirmation jig can be used to ensure that the final cast and the clinical situation are equivalent (see Chapter 18).

Try-in of Tooth Arrangement

At this stage of try-in of the tooth arrangement, the effects of possible compromises made at stage I surgery become evident. Unfortunate inclination or location of implants, whether due to anatomical deficits of the host bone or to operator misjudgment, may make it necessary either to revise the prosthodontic prescription or to use alternate hardware components. A frequent example occurs in the maxillary arch if one or more implants are angled labially. An angled or custom abutment will have to be used to avoid having the gold alloy–retaining screw exiting from the labial surface of the prosthetic tooth. This helps correct the esthetic concerns, but it does not correct for the nonaxial loading to which the implant will be subjected during function. As mentioned earlier, the worst complication at this stage is the realization that an acceptable esthetic and functional fixed prosthodontic result cannot be achieved. This is a serious problem that may sometimes be addressed by redesigning the prosthesis as an overdenture one. However, this cannot be regarded as a routine solution because most patients would be very disappointed to find that their treatment plan has been altered in this manner. Experience suggests that this sort of mishap appears to be handled best in the context of conscientious pretreatment patient education that acknowledges the rare possibility that unexpected surgical outcomes might provide.

Framework Try-in

Producing a framework for a fixed implant prosthesis involves several complex laboratory procedures, and occasionally the result is a framework that does not fit passively in the mouth. Sometimes this is visible to the operator; sometimes it is noted only by a response from the patient. This response is most often a report of tightness by the patient, often manifested as a small wincing response that is alleviated when the "offending" screw is loosened slightly. If either occurs, the framework is cut between the segments that do not fit passively. Sometimes the cuts need to be made at more than one site to ensure that there is no stress on the components as they are screwed into place. Once it is established that the components fit completely and passively, they are luted together in the mouth with autopolymerizing resin or light-cured composite, and the master model is altered accordingly, as described in Chapter 18. Then, the casting is reassembled through corrective soldering or laser welding (required for titanium alloy frames) by the laboratory, and a second framework try-in appointment is scheduled.

INSERTION OF PROSTHESIS

Implant-Supported Fixed Prosthesis

Some complications can occur either at the time of, or immediately after, insertion of the fixed implant-supported prosthesis. One of the most common and troubling problems from the patient standpoint is difficulties with speech following insertion of maxillary full-arch prostheses. Several factors are associated with speech difficulties including long periods of prior complete denture wear, horizontal palatal vault, and implant malposition (especially in the anterior region). Initial difficulties with speech may be anticipated with a maxillary fixed prosthesis, especially if there is a large difference between the location of the implants and the incisal edges of the prosthetic teeth. The bulk of the prosthesis necessary to reach forward from the implant abutments to the prosthetic teeth can interfere with the tongue during normal speech. Though this problem usually resolves within a few days as the patient's tongue learns to cope, some patients may find the adjustment phase a challenging one. It may therefore be necessary for them to wear a provisional obturator (a customized small crescent-shaped acrylic resin palatal flange) for several weeks before speech adjustment occurs. This contingency should be explained to the patient early on in the prosthodontic treatment protocol to avoid subsequent misunderstanding. Most patients are unlikely to relish the idea of wearing such a speech obturator indefinitely or even a prolonged period of time.

The incidence of speech problems also is increased if the patient's circumoral muscle activity easily reveals maxillary gingival tissue. In these situations, when the upper lip retracts during speech, it will not form an air seal, and the sound "shshsh" will result when attempting to make the "s" sound. When there is a high lip line, it may be necessary to add a flange to the prosthesis for speech, as well as esthetics. Though the flange solves these problems, it has the potential for creating other problems because it impedes oral hygiene.

A few patients will note masticatory muscle strain and fatigue during the first weeks of wearing a fixed prosthesis, especially a mandibular one. Counseling the patient to avoid stressing the previously relatively inactive muscles of mastication by initially cutting food into smaller pieces and gradually working up to normal chewing usually resolves this problem. The presence of stable dental prostheses, particularly if teeth are not set in the neutral zone, may encourage more "confident" aggressive chewing, which could result in increased risk of cheek or tongue chewing. Just as counseling is needed to avoid stress to the musculature, patients may benefit from the suggestion that they chew slowly until they are accustomed to their new prostheses.

Potential esthetic problems are hopefully dealt with at the tooth try-in stage of prosthesis construction. The

situation is similar to the protocol followed in complete denture fabrication. It must be emphasized, however, that after final prosthesis fabrication and insertion, esthetic modifications to the prosthesis, although feasible, may be more awkward and tedious to carry.

Implant-Supported Overdenture

Insertion of the implant-supported overdenture is sometimes complicated by the necessity to accommodate both the soft tissue anatomy of the posterior part of the mouth and the implant abutment and hardware connection in the anterior. It may be necessary to remove the otherwise useful extensions into the retromylohyoid space to completely seat the overdenture.

Some patients with implant overdentures find that food will collect under the anterior part of the denture. This is due partly to the relatively inaccurate impression of the anatomy here (remember that the impression tray had to be made wider than usual in this area to accommodate the impression copings and was therefore too wide to achieve an accurate impression of mucosa) and partly to the blocking out around the retention hardware that was done before the final processing. A chairside addition of an autopolymerizing acrylic resin to the lingual and labial flanges in this area usually solves this problem.

If a bar and clip assembly is used, the clip may make it very difficult to remove the overdenture, unless it is loosened slightly before the first insertion. It can, of course, be easily adjusted (e.g., retightened) after the other usual procedures of insertion of a complete denture are done. It should also be noted that this sort of "fine tuning" of the many other different attachment mechanisms available may be frequently required.

In the first days after insertion of the overdenture, the patient may experience minor denture irritations under the soft tissue–supported area of the prosthesis. This is corrected as the denture is relieved and adjusted in the customary fashion.

POSTINSERTION

During the years of prosthesis wear, a number of possible complications may occur. Some of these are common to both fixed and removable prostheses, whereas others are more specific. The complications fall under the broad headings of biological and mechanical/prosthodontic ones.

Biological Complications

Biological complications include implant failure, as well as soft and hard tissue complications. Because osseointegration appears to result from an induced and controlled healing response, it is not surprising that half or more of all reported implant failures occur during the early healing phase. The remaining failures occur after occlusal loading takes place and are caused in all likelihood by an inadequate healing response becoming compromised by subsequent loading demands. Meticulous treatment planning addresses the remote possibility of the small, if inevitable, failures. This will ensure successful prosthodontic treatment outcomes even when fewer implants than hoped for actually osseointegrated. The obvious example would be the conversion of a proposed five-unit fixed implant-retained prosthesis to a two-unit or three-unit implant-supported overdenture if some of the implants should fail. Soft and hard tissue problems also are encountered. The former tend to involve the diverse gingival changes associated with inadequate hygiene or soft tissue trauma or are related to incorrect prosthesis design. They are readily managed via dentists' conventional oral hygiene interventions and conscientious home care. Conversely, the management of inflammatory bony processes, manifested as extensive or rapid marginal bone loss, remains a source of controversy. To date, no scientifically based protocols exist to deal with them since no compelling data have been presented that justify managing inflammatory processes (other than gingivitis) around teeth and implants as identical clinical entities. However, it must be asserted that some practitioners (with a traditional "periodontal mindset") regard adverse bone changes around implants as another version of periodontal disease–like sequelae. This book's editors regard osseointegration or biological failure as a compromised healing reaction that may be adversely affected by time-dependent mechanical and microbiological changes that may challenge the induced ankylotic-like attachment.

Mechanical/Prosthodontic Complications

All three components of the completed implant-retained system—the prosthetic retaining screw, the abutment screw, or the screw-shaped implant itself—are subjected to repeated stresses of occlusal and parafunctional loading, and it is possible for these stresses to cause fractures of the prosthesis. Most common is the fracture of the gold alloy screw, usually at the base of the head of the screw. If the top of the threaded area is accessible, this problem is relatively easy to manage. The screw fragment can be removed by carefully touching the outside of the top of the fractured piece, which is remaining in the center screw of the abutment, with a tapered fissure bur in either a slow-speed handpiece or a high-speed handpiece running at very low speed. Another approach is to use a hemostat to grasp the screw fragment and to turn it counterclockwise to remove the screw. If the screw is fractured beneath the top of the abutment, it may be teased out by engaging the top of the screw with an explorer and rotating the explorer tip in a counterclockwise direction. If this proves difficult or if the screw fragment cannot be reached, the entire abutment and center screw can be removed, and the gold alloy screw can then be retrieved on the bench rather than in the patient's mouth.

Cementing a fixed prosthesis would of course preclude fracture of retaining screws, but loosening of the restoration can occur because prosthetic abutments must be connected to the implant using screw retention. Cementation is a popular retentive approach in many clinical circles because it is presumed to be more "user friendly." However, screw-retained prostheses are electively and easily removable, which we regard as a plus from a long-term monitoring and maintenance point of view. Furthermore, clinical experience suggests that correction of postinsertion adaptation and complaints or complications, as well as modifications to facilitate patient adaptation, are far more easily addressed with screw-retained prostheses.

Fracture of the abutment screw can occur either at the level of the top portion or at the spindle or threaded area deep within the implant. In the case of the fractured hexagonal top, removal can be accomplished with a tapered fissure bur to create a slot into which a standard screwdriver is fitted. The center screw can then be easily reversed out of the implant.

Removal of an abutment screw that is fractured farther down its length is more difficult, and great care must be taken to avoid damaging the internal threads of the implant. The use of an explorer to tease the screw out of its seat is described in the previous paragraph. An abutment screw retrieval or rescue kit is available to use in cases where removal is more difficult. The kit contains an end-cutting tool that is intended to grasp the top of the fractured component when pressure is applied. It is then rotated counterclockwise to remove the screw fragment from the implant. Often this procedure is not as easily accomplished as this description suggests, especially if the abutment screw fragment seems to have bonded itself to the interior of the implant. Another approach is to very carefully prepare a "well" at the top of the screw fragment with a small round bur (accompanied by generous irrigation) and then to use a larger round bur, held either in a handheld torque driver or in the cutting tool holder provided in the retrieval kit. The larger round bur is pressed onto the prepared top surface of the screw and turned counterclockwise to remove it.

Removal can be further complicated by soft tissue overgrowth or collapse into the space immediately above the implant. Not only does this prevent a clear view of the top of the fractured abutment, but also there is often some bleeding because with a fractured retaining component, the implant-supported bridge usually is mobile and pinches the mucosa, causing it to become inflamed.

The instrumentation involved in an attempt to remove the broken abutment screw must be used with extreme care to avoid damage to the threads in the interior of the implant. If the internal threads of the implant have been damaged, it will be difficult or even possible to insert the replacement abutment screw. Considerable skill is needed to do this and in such a case, the fixture tap may be tried. This is included in a commercially available retrieval kit that occasionally may be used to repair the threads. However, it is important to emphasize the difficulty of this undertaking and the need for a specialized skill set because a special kit per se is far from a panacea.

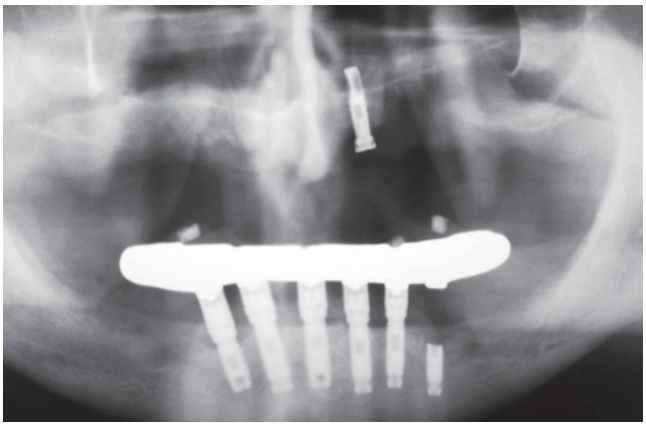


Figure 20-5 The fractured mandibular implant was detected during a routine recall examination. The patient was asymptomatic other than presenting with gingival irritation and bleeding adjacent to the fracture site. The prosthesis was removed and the superior part of the implant unscrewed from the prosthesis and discarded. The undersurface of the prosthesis was smoothed and polished and the access hole sealed. The soft tissue overlying the residual implant material was allowed to heal over. The resultant increased cantilever length can always be reduced depending on an assessment of the occlusal stresses at the site. Two implants were originally placed in the maxilla to support an overdenture, but the right one failed to osseointegrate. The single remaining maxillary implant was successfully osseointegrated and continued to be used as adjunctive support for the prosthesis.

It is arguably prudent to consider referring most mechanical/prosthodontic complications to a prosthodontist even before attempting retrieval of fractured screws. Otherwise, a strong case should be made for appropriate specialist referral when initial attempts at remedying the situation do not quickly rectify the problem.

The implant itself also can fracture (Fig. 20-5), though fortunately this is a very rare occurrence. The abutment and prosthetic retaining screws act as "fuses" and usually will fracture before damaging stresses can cause fracture of the implant. If an implant does fracture, it is usually at the level of the base of the abutment center screw, and, in most cases, it happens when the bone level also has reached this point. The remaining implant fragment usually remains osseointegrated and must be removed by the surgeon using a trephine.

Whenever component hardware fractures occur, the implant-supported bridge and its relationship to the opposing dentition, the occlusal scheme, and the presence and extent of cantilevers should be assessed very carefully to determine if it is prudent to make alterations to prevent



Figure 20-6 Time-dependent wear and tear take their toll on the integrity of the prosthetic material employed in the fabrication of implant-supported fixed prostheses. It is relatively easy to replace the prosthetic teeth in the case of **A,** but somewhat more technically challenging to repair the fracture as seen in **B.** In the latter case, the original design features may have to be reconsidered and a new and stronger framework made. Alternatively, the acrylic resin may be removed and if feasible, a new part soldered to replace the original cantilever. In this case, serious consideration also should be given to a shorter cantilever.

further complications. Long cantilever extensions, especially when implants have had to be placed in straight-line configurations rather than in a preferred semilunar arrangement, seem to be more frequently associated with component fracture (see Fig. 20-1). Even with the more desirable arch form implant distribution (Fig. 20-6), a heavy occlusal load on the cantilever portion of the bridge can cause fracture of the gold-retaining screw or even the abutment screw at the most anterior implant.

SUMMARY

Virtually all clinical health interventions involve biological and technical risks. The implant prosthodontic intervention is no exception and a number of unexpected mishaps may be encountered. However, the consequences are rarely ominous ones such as serious infections or other morbidities. Most problems and complications associated with the oral rehabilitative exercise can be prevented and often readily rectified.

Bibliography

Ardekian L, Dodson TB: Complications associated with the placement of dental implants, *Oral Maxillofac Surg Clin North Am* 15(2):243-249, 2003.

Astrand P, Ahlqvist J, Gunne J, et al: Implant treatment of patients with edentulous jaws: a 20-year follow-up, *Clin Implant Dent Rel Res* 10(4):207-217, 2008.

Attard NJ, Zarb GA: Long-term treatment outcomes in edentulous patients with implant-fixed prostheses: the Toronto study, *Int J Prosthodont* 17(4):417-424, 2004.

Baelum V, Ellegaard B: Implant survival in periodontally compromised patients, *J Periodontol* 75(10):1404-1412, 2004.

Balshe AA, Assad DA, Eckert SE, et al: A retrospective study of the survival of smooth- and rough-surface dental implants, *Int J Oral Maxillofac Implants* 24(6): 1113-1118, 2009.

Berglundh T, Persson L, Klinge B: A systematic review of the incidence of biological and technical complications in implant dentistry reported in prospective longitudinal studies of at least 5 years, *J Clin Periodontol* 29(Suppl 3):197-212, 2002.

Binon PP: Treatment planning complications and surgical miscues.[erratum appears in *J Oral Maxillofac Surg* 66(10):2195-2196, 2008], *J Oral Maxillofac Surg* 65(7 Suppl 1):73-92, 2007.

Cehreli MC, Karasoy D, Kokat AM, et al: Systematic review of prosthetic maintenance requirements for implant-supported overdentures, *Int J Oral Maxillofac Implants* 25(1):163-180, 2010.

Eckert SE, Choi YG, Sanchez AR, et al: Comparison of dental implant systems: quality of clinical evidence and prediction of 5-year survival, *Int J Oral Maxillofac Implants* 20(3):406-415, 2005.

Eckert SE, Meraw SJ, Weaver AL, et al: Early experience with Wide-Platform Mk II implants. Part I: Implant survival. Part II: Evaluation of risk factors involving implant survival, *Int J Oral Maxillofac Implants* 16(2):208-216, 2001.

Eckert SE, Meraw SJ, Cal E, et al: Analysis of incidence and associated factors with fractured implants: a retrospective study, *Int J Oral Maxillofac Implants* 15(5):662-667, 2000.

Ellies LG, Hawker PB: The prevalence of altered sensation associated with implant surgery, *Int J Oral Maxillofac Implants* 8(6):674-679, 1993.

Esposito M, Coulthard P, Oliver R, et al: Antibiotics to prevent complications following dental implant treatment, *Cochrane Database Syst Rev* (3):CD004152, 2003.

Esposito MAB, Koukoulopoulou A, Coulthard P, et al: Interventions for replacing missing teeth, *Cochrane Database Syst Rev* 19(3):CD004970, 2006.

Friberg B, Grondahl K, Lekholm U, et al: Long-term follow-up of severely atrophic edentulous mandibles reconstructed with short Brånemark implants, *Clin Implant Dent Relat Res* 2(4):184-189, 2000.

Greenstein G, Cavallaro J, Romanos G, et al: Clinical recommendations for avoiding and managing surgical complications associated with implant dentistry: a review, *J Periodontol* 79:1317-1329, 2008.

McGlumphy EA, Larsen PE, Peterson LJ: Etiology of implant complications: anecdotal reports vs prospective clinical trials, *Compendium* (Suppl 15):S544-S548, 1993; quiz S65-66.

Rangert B, Krogh PH, Langer B, et al: Bending overload and implant fracture: a retrospective clinical analysis, *Int J Oral Maxillofac Implants* 10(3):326-334, 1995.

Zarb GA, Schmitt A: The longitudinal clinical effectiveness of osseointegrated dental implants: the Toronto study. Part III: Problems and complications encountered, *J Prosthet Dent* 64(2):185-194, 1990.

CHAPTER 21

Immediately Loaded Complete Dental Prostheses

Steven E. Eckert

The concept of osseointegration and the role that dental implants provide in retention, support, and stability of dental prostheses have been well explained throughout this text. The ongoing evolution of the steps necessary to achieve osseointegration has led to better understanding of the process itself and of methods to reduce the time necessary to achieve this bone-to-implant contact.

During the earliest descriptions of osseointegration, there was debate regarding the type of bond that was achieved between bone and implant.[1-4] A chemical bond was initially postulated, but with better understanding, it became evident that a pure chemical bond would likely be subject to rapid degradation. Today, although a chemical bond is still thought to play a role, the process of osseointegration is perceived as a biological phenomenon of exceedingly close physical adaptation between living bone and alloplastic implant.[5-8]

The physical adaptation occurs over a period of time through remodeling of bone adjacent to the implant surface. On the day of implant insertion surgery, there are a number of considerations to ensure a high likelihood of clinical success (Box 21-1). These factors have been carefully described in the dental implant literature and have served the profession well as it adhered to this very specific clinical protocol.

Achievement of osseointegration will occur if a favorable host is presented with a biocompatible material for dental implant. However, these two factors alone will not create a high predictability of success unless other considerations are made. Indeed the shape of the dental implant must provide a degree of fixation within the bone while the surface of the implant must encourage cellular recruitment to allow new bone formation at the interface of the implant and bone. The surgical procedure must avoid unnecessary trauma when the osteotomy is created and when the implant is placed. It is critical that the temperature of the bone remain well below that which creates irreversible change. A critical temperature of 43° C is often described.[9-12] Once the implant is physically inserted into the bone, a period of time is required before the biological process is completed. After biological healing allows the achievement of "osseointegration," a fixed, rigid prosthesis is inserted to allow multiple implants to function in support of one prosthesis.

This description of events is obviously predicated on a number of factors that are not under the control of the clinician. Certainly clinicians can select patients carefully to ensure that their health, bone quality, bone quantity, and psychological status are favorable to achieve the desired results. Patients must ultimately cooperate in the maintenance of implant-supported prostheses otherwise bacterial disease could result in ongoing destruction of the bone-to-implant union. There are, however, a number of factors that are under the control of the clinician. Obviously the macroanatomy and microanatomy of the implant will play a role in initial fixation of the implant and later in the recruitment of multipotential cells that will differentiate into osteoblasts and participate in the deposition of bone onto the implant surface.

A myriad of macroscopic designs have been proposed for dental implants.[13-18] These may be categorized as cylinders, stepped cylinders, and conical designs with some conical implants being described as tapered cylinders. It is unclear whether the major diameter or the minor diameter of the implant is used to describe the overall shape. A number of implants are available with increasing minor diameters while the major diameter remains constant. Manufacturers may choose to describe this as a parallel-sided implant or as a tapered implant. Most modern implants have threads; however, there is no standard thread design, with variations in the thread angle, depth, and configuration. Terminology remains somewhat vague because there is no clear definition for macrothread design versus microthread design. To further complicate matters, some implants combine macrothread and microthread patterns. In these situations the microthread is used to maintain bone level or to enhance soft tissue response.

The general rationale for modification of implant design is to achieve an acceptable level of initial stability within bone. It is thought, although scientific evidence remains inconclusive, that a higher degree of implant insertion torque may correlate with a lower amount of movement between the implant and supporting bone. The so-called micromovement of the implant should be limited to less than 100 μm to increase the likelihood of achieving bone-to-implant contact. An optimum level of insertion torque

Box 21-1 Requirements to Promote Osseointegration

- Favorable host
  - Patient health status that allows patient to undergo surgical intervention
  - Adequate bone quality
  - Adequate bone quantity
  - Psychologically predisposed to desire intervention
  - Patient is committed to oral hygiene needed to maintain prostheses
- Biocompatible material for implant
- Appropriate shape of implant (macrostructure)
- Appropriate surface of implant to allow bone-to-implant contact (microstructure)
- Specific surgical procedure
  - Gentle handling of soft and hard tissues
  - Careful consideration of critical bone temperatures (<43° C)
  - Primary closer of soft tissue
- Undisturbed healing
- Rigid fixation of implants in final prosthesis

has yet to be established, and it would appear that such an optimum level may never be established as a universal standard but instead will be applied to each specific implant design.

The microscopic design of an implant is discussed relative to the surface of the implant. Early implant designs used a machining process that gradually turned the implant as the threads were produced. This created a peak to valley microscopic structure of approximately 0.5 to 1.0 µm. Because this structure was created in a machining process, the surface was anisotropic. A gradual shift has occurred towards the creation of isotropic implant surfaces, whereby the surface of the implant is modified through abrasion, anodizing, laser treatment, or acid degradation. These processes are sometimes combined to create a favorable microscopic roughness to the implant surface. It is thought that the roughening of the implant surface will result in recruitment of a higher level of cellular activity during the earliest healing phases following surgical implant placement.[19-24]

The combination of a favorable macroscopic and microscopic structure for the implant will result in an implant that achieves higher initial stability while allowing cellular activity to proceed with bone deposition adjacent to the implant. If the microscopic movement of the implant can be controlled, it is thought that osseointegration may occur even if an implant is used to support a dental prosthesis during the early healing phase. This observation has led to a number of treatment approaches designed to allow immediate restoration of dental implants. The process is often referred to as *immediate loading*, and it appears that it can be predictably achieved in keeping with the previously described factors to ensure osseointegration.

Immediate load of dental implants does not suggest immediate achievement of osseointegration. Instead it is a process that is highly dependent upon all the initial factors to achieve the biological phenomenon that is desired.

The description of "undisturbed healing" was originally related to implants that were placed beneath the oral mucosa. Factors such as transmucosal loading were described when provisional prostheses were placed; however, the number of adverse consequences with such loading appeared to be low. Clinicians began placing implants with transmucosal abutments of a design that passed through the oral mucosa at initial insertion. Experience demonstrated that implants beneath the tissue or placed at tissue level continued to undergo the process of osseointegration without any obvious signs of clinical distress.

Schnitman described the use of implants to provisionally support a fixed prosthesis immediately after implant insertion.[25,26] In this study, additional implants were placed with the intention of using several implants to provisionally support the prosthesis while the definitive implants were submerged. Upon completion of the standard healing period, most of the provisional implants remained immobile and were described as osseointegrated.

Subsequent to this study a number of clinicians have confirmed that immediately loaded implants could achieve integration with supporting bone.[27-39] The previously described requirements to achieve osseointegration (see Box 21-1) remain critical; however, some of these factors are achieved through different means than those described in earlier literature. The modifications to the original guidelines (Box 21-2) primarily affect the implant design, surface, rigid fixation, and demand for early intervention.

Critical assessment of the immediate load concept lends credibility to the approach. This treatment approach allows initial implant stability to be coupled with rapid biological response while depending on prosthetic principles to create rigid fixation of implants.

Implant design changes allow a more aggressive thread pattern on the implant that can reduce initial micromotion to a level below 100 µm, but this reduction may not be permanent in all instances. Upon implant placement there is an immediate stability of the implant within bone termed *primary stability*. During the initial healing phases, the primary stability degrades as bone injured during the osteotomy preparation remodels. Healing bone results in "secondary stability" that eventually exceeds the initial level of bone stability.

Primary stability needs to be thought of as a mechanical connection of implant to bone.[40] Secondary stability occurs as the biological adaptation of bone to the implant surface replaces the mechanical connection between alloplast and living tissue.[41,42] As described previously, changes in surface design will accelerate the biological integration of implant within bone, but surface changes alone will not eliminate the need for healing. Bone modeling and remodeling must

Box 21-2 Modifications to Requirements for Osseointegration Allowing Immediate Load

- Appropriate shape of implant (macrostructure)
  - Thread pattern on implant is "more aggressive," thereby allowing a greater insertion torque
- Appropriate surface of implant to allow bone-to-implant contact (microstructure)
  - Microtextured or microroughened implant surface recruits greater cellular response, thereby speeding initial healing of bone-to-implant surface
- Pattern of implant placement that creates maximum implant separation
  - Tipping of posterior implants to broaden the distribution of implants
  - Separation of implant-restorative platforms improves stability of prosthesis and reduced cantilever
- Rigid connection of implants at time of implant surgery
  - Connection of implants in a curvilinear pattern allows each implant to lend support to the other implants
  - Connection at time of implant placement fixes implant position in jaw
  - Immediate connection of implants reduces stress and strain in bone that would occur if initial bone healing occurred before implant connection

occur to create an initial and ongoing union of bone and implant. During the early phases of bone reorganization, it is critical that micromotion is minimized. Immediate cross arch connection of three or more implants will allow the creation of a restorative platform in which each implant acts to support the others.

From a mechanical standpoint, it is recognized that broad distribution of support accomplishes a reduction in the moment of force transmitted to the underlying implants. This recognition has led to a design whereby implants are tipped in such a way as to increase the distance between the restorative platforms of individual implants. Malo described the "all on four" concept to achieve this pattern of broad implant distribution.[43,44] Secondary advantages of the tipped posterior implant are that the implant orientation may use available bone, while using a longer implant and avoiding the need for bone grafts and the tipping of the implant allows the clinician to avoid anatomical structures such as the mental foramen, anterior loop of the inferior alveolar neurovascular bundle, or the maxillary sinuses.[45,46] Initial reports on this treatment approach have demonstrated high implant survival rates that mimic those achieved with traditional treatment methods.

The future of immediate implant loading appears to be promising. It is anticipated that better appreciation of implant design as it correlates with the insertion torque of the implants will lead to further refinement of this process. Modifications of the implant surface at the molecular level, often described as nanotechnology, may further reduce the healing time required before definitive prostheses are made.

IMMEDIATE LOAD COMPLETE DENTURE TECHNIQUE

The technique used to create a definitive prosthesis supported by dental implants in the immediate and definitive stages may be summarized in a series of phases. The initial phase is designed to create a prosthesis that will be inserted on the day of implant insertion. This initial phase requires traditional prosthetic treatment to create a removable complete denture that will guide the surgeon in placement of the implants. Once implants are placed, the second phase of treatment will commence whereby an impression of the splinted implants is made and the prosthesis is oriented to this impression. The second phase ends with the insertion of a "healing" prosthesis that will protect the soft and hard tissue during initial healing and will rigidly connect implants to reduce micromotion to below a level that would threaten implant survival. The final phase of treatment creates a definitive prosthesis supported by implants.

The first and third phases of treatment are thoroughly discussed elsewhere in this text. It is only the second phase of treatment that demands further explanation (Figs. 21-1 to 21-6). In this phase the implants must be rigidly connected. This may be accomplished through fixed splinting of the implants using autopolymerizing resin or through the use of orthodontic wire that is connected from one implant to the next. Once the implants are connected an impression will be made over the implants to capture the underlying soft tissue.

A cast is then formed with implant analogs connected to the transfer components. The implant analogs will remain in the master cast and will provide the foundation for support of the prosthesis. The complete denture that was fabricated during phase one of treatment will then be oriented to the two anterior implants using autopolymerizing resin to connect transfer components to the denture. To accomplish this, a window will be created in the denture to allow access to the screws retaining the transfer components. While the autopolymerizing resin is curing, the patient will be asked to close into centric occlusion. Once curing has finalized, the prosthesis will be rigidly fixed to the two anterior transfer components. The denture will then be transferred to the laboratory whereby the denture base material will be relieved, the posterior components will be oriented to the prosthesis, and autopolymerizing resin will be used to create a solid connection among the

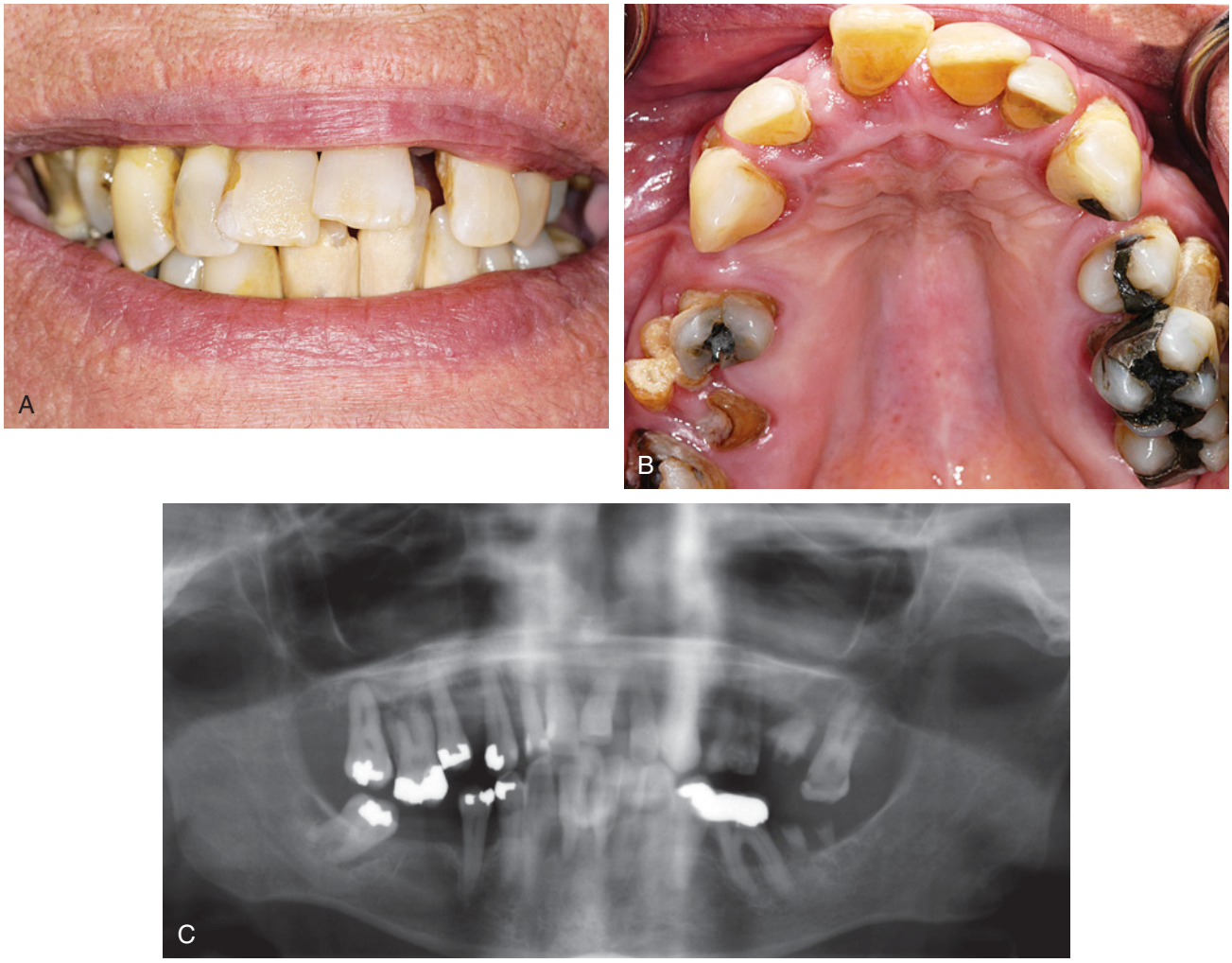


Figure 21-1 Preoperative (**A** and **B**) and radiographic **(C)** images of patient with advanced periodontal disease, missing teeth, dental caries, and defective dental restorations. *(Clinical images courtesy Dr. Mark Adams, Denver, Colorado.)*

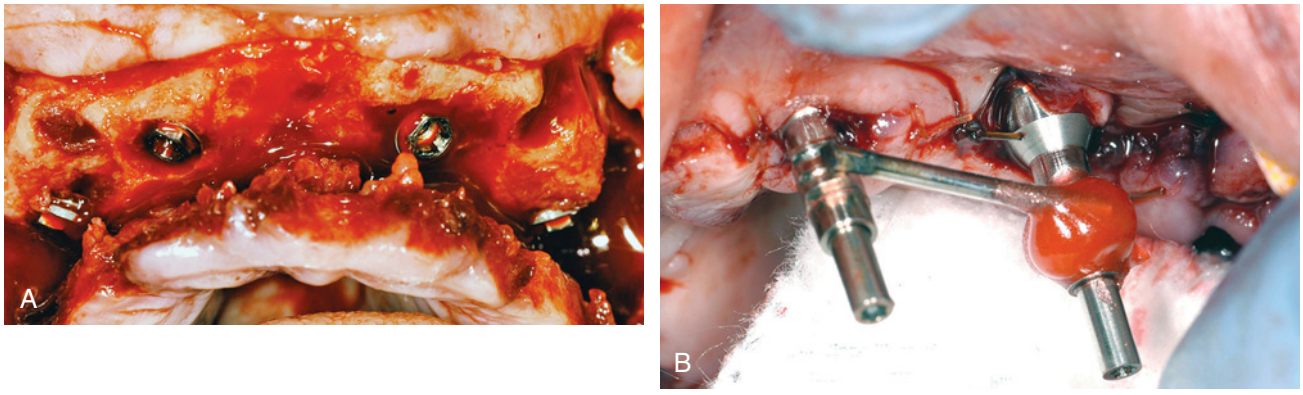


Figure 21-2 **A,** Placement of four implants in maxillary arch using tipped posterior implants to allow increased implant length and avoid critical anatomical structures (maxillary sinus), as well as increasing the anterior to posterior spread of the implants. **B,** Connection of implants using transfer components that are attached to implants. The components are connected using 0.048″ orthodontic wire that is luted to implants using autopolymerizing resin. *(Clinical images courtesy Dr. Mark Adams, Denver, Colorado.)*

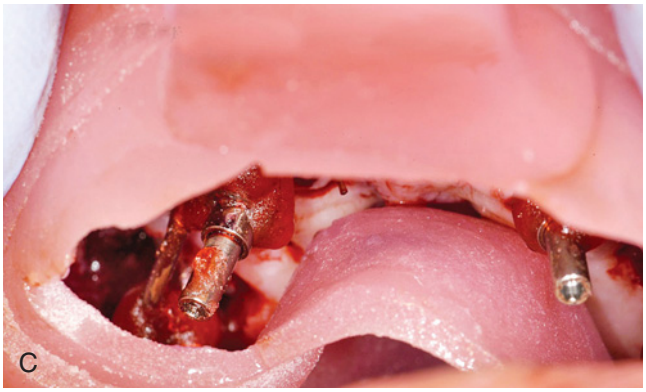
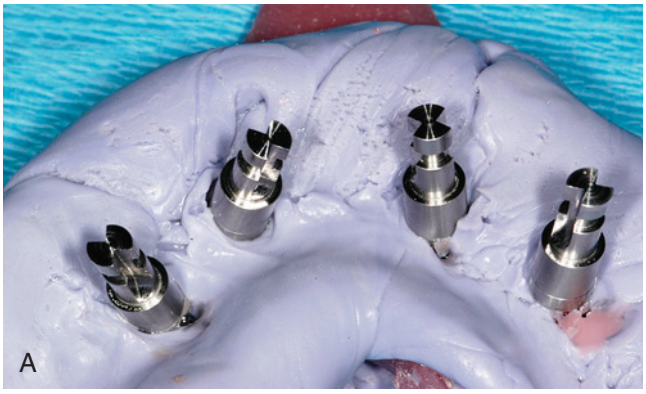




Figure 21-2, cont'd **C,** Try-in of custom tray. Note open window in tray to allow access to retaining screws. **D,** The impression material flows around the splinted implants and the adjacent tissues. *(Clinical images courtesy Dr. Mark Adams, Denver, Colorado.)*



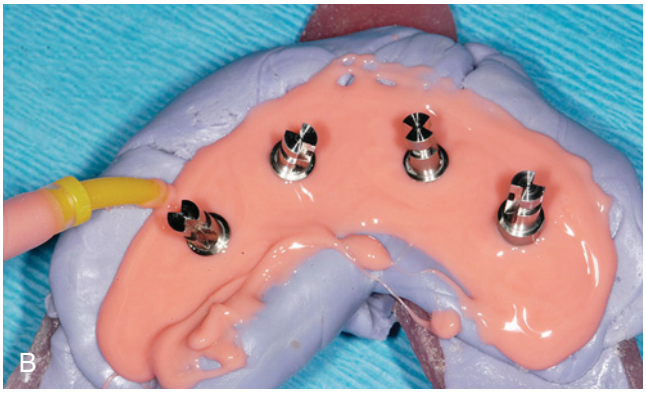


Figure 21-3 **A,** Soft tissue impression with implant analogs in place. **B,** Application of soft tissue material to impression. *(Clinical images courtesy Dr. Mark Adams, Denver, Colorado.)*

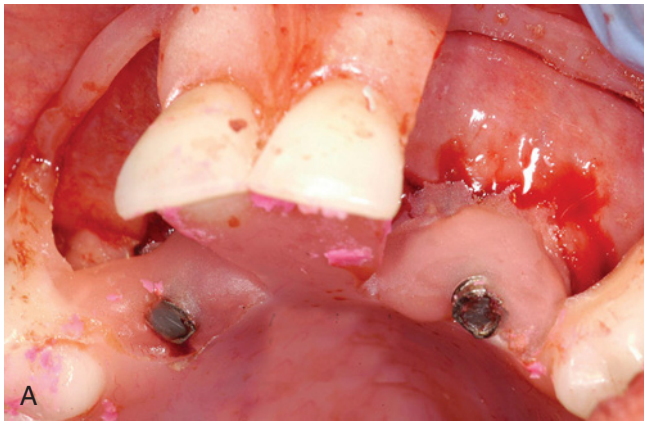






Figure 21-4 **A,** Maxillary complete denture with open anterior windows in position of the lateral incisors allows implant transfer components to be rigidly connected to denture base using autopolymerizing resin after the prosthesis is fully seated against the hard palate. **B,** Close up of luted components. **C,** Centric relation record made with both prostheses luted in position. *(Clinical images courtesy Dr. Mark Adams, Denver, Colorado.)*

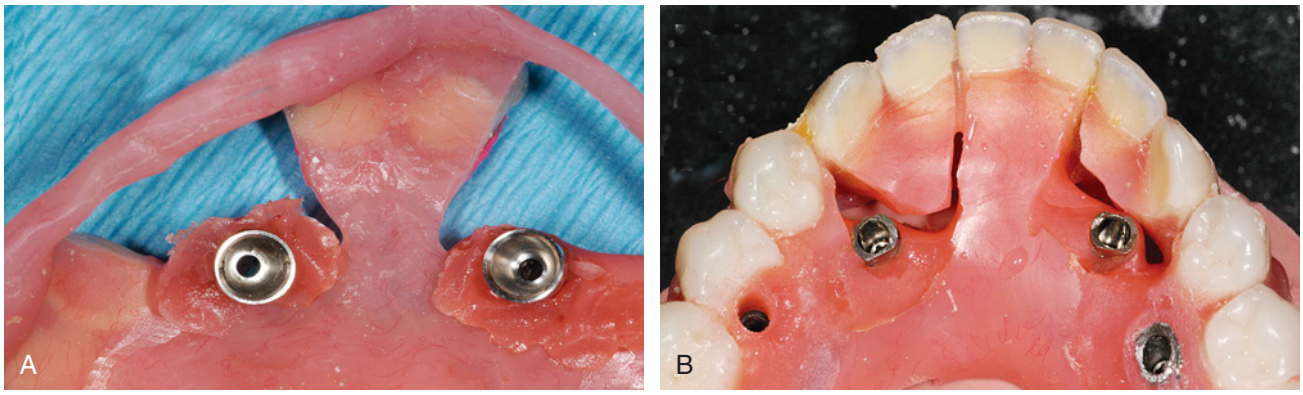


Figure 21-5 **A,** Denture with luted transfer components. **B,** Denture teeth replaced in anterior windows. *(Clinical images courtesy Dr. Mark Adams, Denver, Colorado.)*



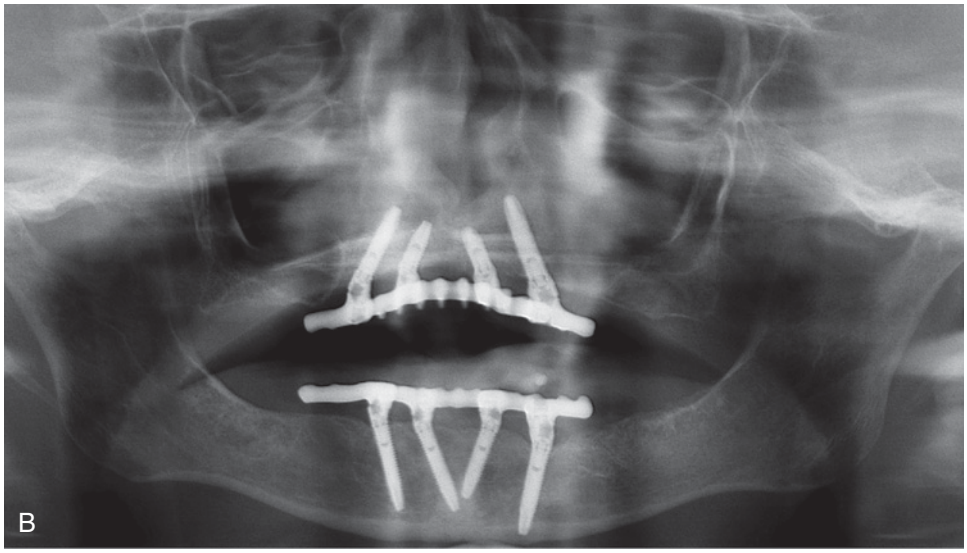


Figure 21-6 Clinical **(A)** and radiographic **(B)** images of prostheses and implants in position. *(Clinical images courtesy Dr. Mark Adams, Denver, Colorado.)*

components. The prosthesis is then finished and polished and inserted onto the implant components.

References

1. Albrektsson T, Brånemark PI, Hansson HA, et al: Osseointegrated titanium implants. Requirements for ensuring a long-lasting, direct bone-to-implant anchorage in man, *Acta Orthop Scand* 52(2):155-170, 1981.
2. Brånemark PI, Adell R, Albrektsson T, et al: Osseointegrated titanium fixtures in the treatment of edentulousness, *Biomaterials* 4(1):25-28, 1983.
3. Hansson HA, Albrektsson T, Brånemark PI: Structural aspects of the interface between tissue and titanium implants, *J Prosthet Dent* 50(1):108-113, 1983.
4. Linder L, Albrektsson T, Brånemark PI, et al: Electron microscopic analysis of the bone-titanium interface, *Acta Orthop Scand* 54(1):45-52, 1983.
5. Wennerberg A, Albrektsson T, Andersson B: Bone tissue response to commercially pure titanium implants blasted with fine and coarse particles of aluminum oxide, *Int J Oral Maxillofac Implants* 11(1):38-45, 1996.
6. Gottlander M, Johansson CB, Wennerberg A, et al: Bone tissue reactions to an electrophoretically applied calcium phosphate coating, *Biomaterials* 18(7):551-557, 1997.
7. Wennerberg A, Albrektsson T: Suggested guidelines for the topographic evaluation of implant surfaces, *Int J Oral Maxillofac Implants* 15(3):331-344, 2000.
8. Sul YT, Johansson CB, Jeong Y, et al: Oxidized implants and their influence on the bone response, *J Mater Sci Mater Med* 12(10-12):1025-1031, 2001.
9. Eriksson A, Albrektsson T, Grane B, et al: Thermal injury to bone. A vital-microscopic description of heat effects, *Int J Oral Surg* 11(2):115-121, 1982.
10. Eriksson AR, Albrektsson T: Temperature threshold levels for heat-induced bone tissue injury: a vital-microscopic study in the rabbit, *J Prosthet Dent* 50(1):101-107, 1983.
11. Eriksson RA, Albrektsson T, Magnusson B: Assessment of bone viability after heat trauma. A histological, histochemical and vital microscopic study in the rabbit, *Scand J Plast Reconstr Surg* 18(3):261-268, 1984.
12. Albrektsson T, Jansson T, Lekholm U: Osseointegrated dental implants, *Dent Clin North Am* 30(1):151-174, 1986.
13. Rieger MR, Adams WK, Kinzel GL: A finite element survey of eleven endosseous implants, *J Prosthet Dent* 63(4):457-465, 1990.
14. Albrektsson T, Sennerby L: State of the art in oral implants, *J Clin Periodontol* 18(6):474-481, 1991.
15. Las Casas EB, Ferreira PC, Cimini CA Jr, et al: Comparative 3D finite element stress analysis of straight and angled wedge-shaped implant designs, *Int J Oral Maxillofac Implants* 23(2):215-225, 2008.
16. Stanford CM: Surface modifications of dental implants, *Aust Dent J* 53(Suppl 1):S26-S33, 2008.
17. Stein AE, McGlmphy EA, Johnston WM, et al: Effects of implant design and surface roughness on crestal bone and soft tissue levels in the esthetic zone, *Int J Oral Maxillofac Implants* 24(5):910-919, 2009.
18. Cehreli MC, Karasoy D, Kokat AM, et al: A systematic review of marginal bone loss around implants retaining or supporting overdentures, *Int J Oral Maxillofac Implants* 25(2):266-277, 2010.
19. Albrektsson T, Wennerberg A: Oral implant surfaces: Part 2—review focusing on clinical knowledge of different surfaces, *Int J Prosthodont* 17(5):544-564, 2004.
20. Albrektsson T, Wennerberg A: Oral implant surfaces: Part 1—review focusing on topographic and chemical properties of different surfaces and in vivo responses to them, *Int J Prosthodont* 17(5):536-543, 2004.
21. Albrektsson T, Wennerberg A: The impact of oral implants—past and future, 1966-2042, *J Can Dent Assoc* 71(5):327, 2005.
22. Sul YT, Johansson C, Wennerberg A, et al: Optimum surface properties of oxidized implants for reinforcement of osseointegration: surface chemistry, oxide thickness, porosity, roughness, and crystal structure, *Int J Oral Maxillofac Implants* 20(3):349-359, 2005.
23. Albrektsson T, Sennerby L, Wennerberg A: State of the art of oral implants, *Periodontology 2000* 47:15-26, 2008.
24. Meirelles L, Albrektsson T, Kjellin P, et al: Bone reaction to nano hydroxyapatite modified titanium implants placed in a gap-healing model, *J Biomed Mater Res A* 87(3):624-631, 2008.
25. Schnitman PA, Wohrle PS, Rubenstein JE: Immediate fixed interim prostheses supported by two-stage threaded implants: methodology and results, *J Oral Implant* 16(2):96-105, 1990.
26. Schnitman PA, Wohrle PS, Rubenstein JE, et al: Ten-year results for Brånemark implants immediately loaded with fixed prostheses at implant placement, *Int J Oral Maxillofac Implants* 12(4):495-503, 1997.
27. Balshi TJ, Wolfinger GJ: Immediate loading of Brånemark implants in edentulous mandibles: a preliminary report, *Implant Dentistry* 6(2):83-88, 1997.
28. Tarnow DP, Emtiaz S, Classi A: Immediate loading of threaded implants at stage 1 surgery in edentulous arches: ten consecutive case reports with 1- to 5-year data, *Int J Oral Maxillofac Implants* 12(3):319-324, 1997.
29. Brånemark PI, Engstrand P, Ohrnell LO, et al: Brånemark Novum: a new treatment concept for rehabilitation of the edentulous mandible. Preliminary results from a prospective clinical follow-up study, *Clin Implant Dent Relat Res* 1(1):2-16, 1999.
30. Randow K, Ericsson I, Nilner K, et al: Immediate functional loading of Brånemark dental implants: an 18-month clinical follow-up study, *Clin Oral Implants Res* 10(1):8-15, 1999.
31. Jaffin RA, Kumar A, Berman CL: Immediate loading of implants in partially and fully edentulous jaws: a series of 27 case reports, *J Periodontol* 71(5):833-838, 2000.
32. Buchs AU, Levine L, Moy P: Preliminary report of immediately loaded Altiva Natural Tooth Replacement

dental implants, *Clin Implant Dent Relat Res* 3(2): 97-106, 2001.
33. Balshi TJ, Wolfinger GJ: Immediate loading of dental implants in the edentulous maxilla: case study of a unique protocol, *Int J Periodont Restor Dent* 23(1): 37-45, 2003.
34. Henry PJ, van Steenberghe D, Blomback U, et al: Prospective multicenter study on immediate rehabilitation of edentulous lower jaws according to the Brånemark Novum protocol, *Clin Implant Dent Rel Res* 5(3):137-142, 2003.
35. Belser UC, Schmid B, Higginbottom F, et al: Outcome analysis of implant restorations located in the anterior maxilla: a review of the recent literature, *Int J Oral Maxillofac Implants* 19(Suppl):30-42, 2004.
36. Gallucci GO, Bernard JP, Bertosa M, et al: Immediate loading with fixed screw-retained provisional restorations in edentulous jaws: the pickup technique, *Int J Oral Maxillofac Implants* 19(4):524-533, 2004.
37. Jaffin RA, Kumar A, Berman CL: Immediate loading of dental implants in the completely edentulous maxilla: a clinical report, *Int J Oral Maxillofac Implants* 19(5):721-730, 2004.
38. Jayme SJ, de Oliveira RR, Muglia VA, et al: The effects of different loading times on the bone response around dental implants: a histomorphometric study in dogs, *Int J Oral Maxillofac Implants* 25(3):473-481, 2010.
39. Kronstrom M, Davis B, Loney R, et al: A prospective randomized study on the immediate loading of mandibular overdentures supported by one or two implants: a 12-month follow-up report, *Int J Oral Maxillofac Implants* 25(1):181-188, 2010.
40. Degidi M, Daprile G, Piattelli A: Determination of primary stability: a comparison of the surgeon's perception and objective measurements, *Int J Oral Maxillofac Implants* 25(3):558-561, 2010.
41. O'Sullivan D, Sennerby L, Meredith N: Influence of implant taper on the primary and secondary stability of osseointegrated titanium implants, *Clin Oral Implants Res* 15(4):474-480, 2004.
42. Gotz W, Gedrange T, Bourauel C, et al: Clinical, biomechanical and biological aspects of immediately loaded dental implants: a critical review of the literature, *Biomed Tech (Berl)* 55(6):311-315, 2010.
43. Malo P, Rangert B, Nobre M: "All-on-Four" immediate-function concept with Brånemark System implants for completely edentulous mandibles: a retrospective clinical study, *Clin Implant Dent Relat Res* 5(Suppl 1): 2-9, 2003.
44. Malo P, Nobre Mde A, Petersson U, et al: A pilot study of complete edentulous rehabilitation with immediate function using a new implant design: case series, *Clin Implant Dent Relat Res* 8(4):223-232, 2006.
45. Krekmanov L: Placement of posterior mandibular and maxillary implants in patients with severe bone deficiency: a clinical report of procedure, *Int J Oral Maxillofac Implants* 15(5):722-730, 2000.
46. Krekmanov L, Kahn M, Rangert B, et al: Tilting of posterior mandibular and maxillary implants for improved prosthesis support, *Int J Oral Maxillofac Implants* 15(3):405-414, 2000.

CHAPTER 22

Current and Possible Future Directions in Implant Prosthodontics

Nikolai Attard, Emad S. Elsubeihi, David Chvartszaid, George Zarb

This chapter focuses on current clinical considerations and research directions that are likely to influence ongoing developments in this exciting treatment modality. It complements Chapter 16 *The Science of Osseointegration* by expanding on topics related to aspects of systemic health and host bone response, imaging and surgical protocols, the timing of prosthodontic loading, and oral ecological concerns.

Over the past three decades, most of this book's authors undertook numerous and diverse studies on the osseointegration technique's efficacy and effectiveness, with gratifying clinical outcome results. This collective experience has therefore justified our ongoing pedagogic commitment to expanding edentulous patients' treatment with implant prosthodontics. Osseointegration has inarguably had a dramatic and profound influence on prosthodontic and preprosthetic surgical practice because its well-documented clinical benefits (Box 22-1) are based on scientifically rigorous research, plus published evidence of its versatility in both partially and completely edentulous patients (Fig. 22-1).

An early compelling observation was that successful prosthodontic treatment outcomes for edentulous patients were achieved even when a few implants failed to osseointegrate in some patients. This suggested that the resultant modified fixed implant-supported prostheses could be successfully supported by fewer implants than the originally prescribed number. Alternatively, the surviving implants could be used for overdenture treatment. As a result, virtually all treated patients demonstrated successful adaptive experiences irrespective of whether their prosthesis was a fixed full-arch or overdenture design. *It appeared that the major determinant of patient satisfaction with removable prostheses was patient-perceived comfort and stability, since these concerns were readily rectified irrespective of the number of implants available*. Furthermore, osseointegration was observed to be associated with retardation in the bone resorptive process that would otherwise be likely to occur in the edentulous site(s) of proposed implant placement. Evidence of minimal surgical morbidity also became a significant consideration when prescribing the protocol for elderly patients.

Brånemark's pioneering work in osseointegration catalyzed several developmental and research initiatives (Box 22-2), although they have not all been validated in the literature. This poses a clinical practice dilemma because advertised clinical and commercial hype risks outweighing the need for robust long-term evidence that ensures optimal clinical prognoses. It is therefore tempting to sum up the current mix of educational innovation and commercial promotion as reflecting enlightened empiricism, a high professional entrepreneurial spirit, and aggressive marketing. However, it also must be conceded that all three initiatives are required to advance research and high professional standards and that the speed of emergence of new clinical developments and associated protocols often precedes rigorous scientific proof and efficacy and effectiveness outcome studies.

This chapter seeks to synthesize key concerns and developments that continue to impact profoundly on routine clinical decision making in implant prosthodontics under the following headings: (1) systemic health and host bone response, (2) imaging protocol, (3) surgical protocols, (4) prosthodontic loading, and (5) oral ecological concerns.

SYSTEMIC HEALTH AND HOST BONE RESPONSE

Long-term prospective outcome studies from numerous universities on implant prosthodontic treatment confirm the merits of the osseointegration technique. Its most likely success determinants (Box 22-3) are discussed in Chapter 16, and describe specific factors that have to be controlled if the induced wound healing process of osseointegration is to take place. Early investigations attempted to relate implant failure to the status of changes in bone quality or

Box 22-1 Clinical Yield from Long-Term Prospective Clinical Studies in Osseointegration

- Enhancement of, or virtual guarantee of, prosthesis retention/stability
- Retardation in bone reduction in the implanted edentulous sites
- Minimal treatment outcome morbidity
- Enrichment of patients' life quality

Box 22-3 Proposed Determinants of Osseointegration Success

- Implant biocompatibility
- Implant design
- Implant surface
- Host bed
- Surgical technique
- Loading conditions

Box 22-2 Research Developments

Developments in implants/implant components
- Implant material biocompatibility
- Macroscopic features: design changes in implants and their components
- Microscopic features: implant surface characteristics

Developments in surgical/prosthodontic techniques
- Impact of systemic and local factors

Site development using autologous grafts, bone substitutes, and synthetic graft materials as fillers
- Recruitment of alternate host sites (e.g., pterygoid plates and zygomas)
- Distraction osteogenesis
- Timing of loading protocols

Patient-mediated concerns
- Behavioral issues
- Quality of life issues
- Health economic benefits of treatments



Figure 22-1 A selection of clinical treatment examples underscores the expanded scope of implant-supported prosthodontics that evolved from the original edentulous management experience. **A,** *Treatment 1,* Long-standing severe localized periodontal disease caused removal of teeth and bone grafting the area. Teeth restored with splinted 12-11 implant-supported crowns after an appropriate healing period.

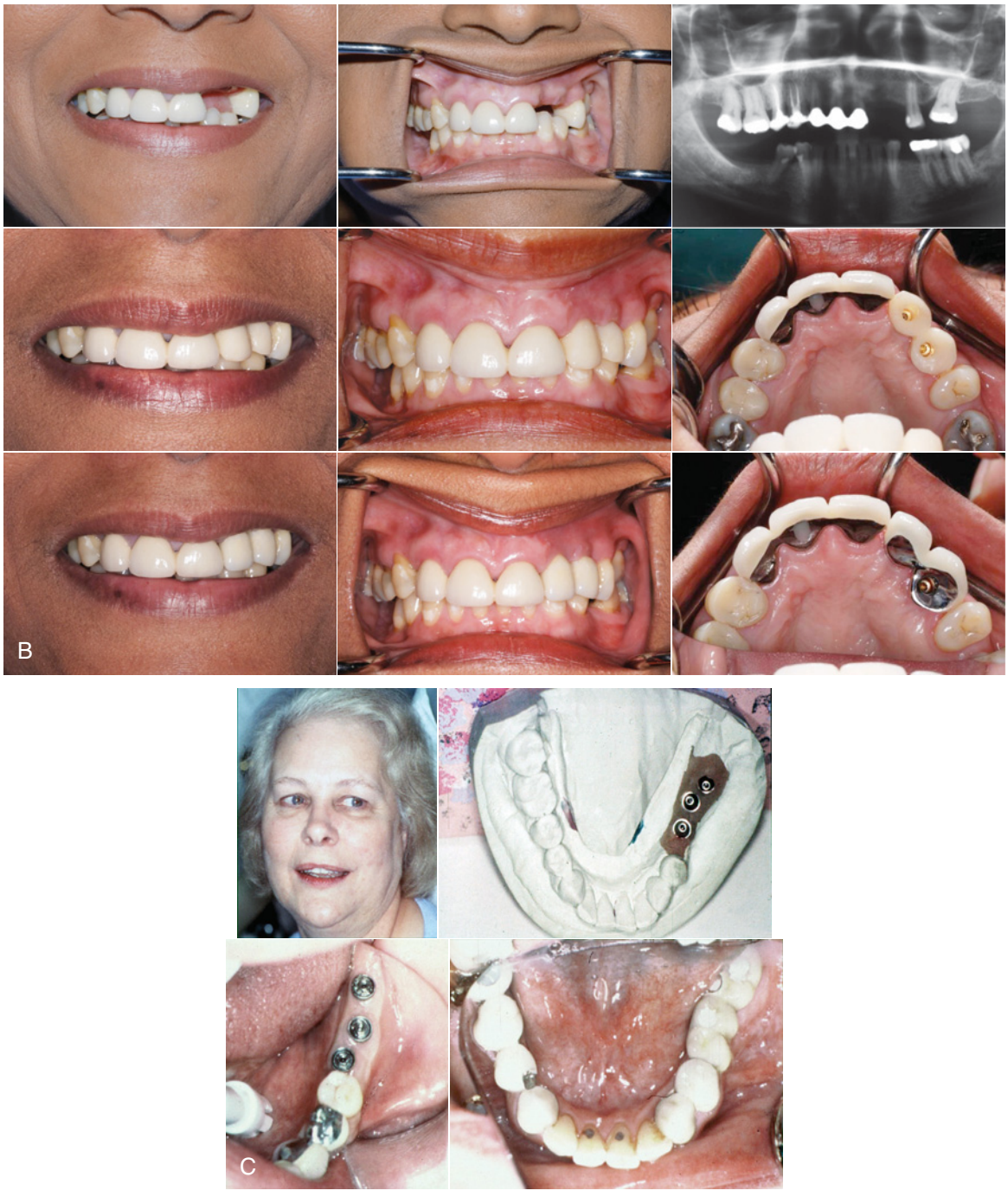


Figure 22-1, cont'd **B,** *Treatment 2,* Teeth 22 and 23 were missing for several years. Implants were deliberately submerged to provide vertical space to accommodate a fixed prosthesis in a class 2, division II-type incisal relationship. The provisional prosthesis was worn before the final one (porcelain fused to metal splinted crowns) was inserted. **C** to **E,** *Treatments 3 to 5* demonstrate fixed and removable implant solutions for mandibular posterior partial edentulism. Routine rehabilitations were achieved irrespective of the associated compromised bone morphology resulting from teeth loss in *Treatment 3,* an oncological intervention in *Treatment 4,* or trauma in *Treatment 5*. **F,** *Treatment 6* addresses prosthetic replacement for the exenterated left orbital contents.



Figure 22-1, cont'd.

quantity, as well as systemic diseases and conditions that could adversely affect wound healing. They provided some indications on factors that might influence osseointegration (Table 22-1); however, strong evidence is restricted by a lack of methodological rigor in many of the reported studies. The relatively sparse information base is further complicated by our currently limited knowledge regarding local hormonal, metabolic, and cellular processes in the jaws. Nonetheless, a number of specific considerations such as smoking, radiation therapy, and osteoporosis and its pharmacological management deserve emphasis.

SMOKING

Substantial evidence exists to support the conclusion that cigarette smoking is associated with increased risk of implant failure, increased periimplant marginal bone loss, and poor soft tissue health. In fact, it is estimated that implant failure is about twice as common in smokers as compared with nonsmokers. In general, cigarette smoking impairs soft tissue wound healing by affecting the circulatory and immune systems and by impairing normal cellular function. Furthermore, it appears that cigarette smoking during

adulthood is associated with decreased hip and vertebral bone density later in life in both women and men. However, the exact mechanism by which smoking exerts its negative effect on bone is not yet fully understood. Bone loss occurs if there is an imbalance between the amount of bone resorbed and the amount of bone formed. The available evidence examining whether one or both of these mechanisms contribute to the bone loss associated with smoking is limited. It has been demonstrated that lower bone density in the lumbar spine in smokers was associated with higher serum calcium and urine pyridinoline levels, which is consistent with increased bone resorption. Furthermore, it was also suggested that increased bone resorption associated with smoking is in part due to decreased production and acceleration of degradation of estrogen, leading to early menopause and a higher rate of bone loss. On the other hand, histomorphometric investigations suggested that reduced bone formation is responsible for the deficit in bone volume seen in smokers. In vitro and animal studies have shown that several components of cigarette smoke, such as nicotine and aryl-hydrocarbons, can depress osteoblast activity, reduce collagen synthesis, and inhibit osteodifferentiation and osteogenesis. Other components of cigarette smoke, such as carbon monoxide (which binds to hemoglobin to form carboxyhemoglobin) and hydrogen cyanide (which inhibits cellular respiratory enzymes), result in tissue hypoxia and alter tissue healing. The effect of these components on jawbone behavior at the tissue and cellular levels needs to be fully explored.

Smoking cessation should be strongly advised to patients for a variety of health reasons, including its detrimental impact on implant success. Some investigators have suggested that even temporary cessation of smoking before and immediately after surgical intervention may yield improvements in implant success. *However, given the high rates of implant success generally reported in clinical trials and the tremendous improvements in patients' quality of life that result from methodical application of this technique, smoking is not considered to be an absolute contraindication to implant therapy.*

OSTEOPOROSIS

The term *osteoporosis* has been used somewhat loosely in the dental literature and often to imply postmenopausal osteoporosis. Several reports suggest that osteoporosis is not a risk factor for implant failure in the jaws; however, these were limited to case reports and case series studies where the diagnosis of osteoporosis was not confirmed. Interestingly, biochemical analysis of bone derived from the human osteoporotic femoral head showed evidence of

TABLE 22-1 SUMMARY OF INFLUENCE OF VARIOUS FACTORS ON IMPLANT PROSTHODONTIC TREATMENT OUTCOMES: PATIENT-RELATED FACTORS

Local	Systemic/Behavioral	Prosthodontic/Surgical Technique	Implant-Related Factors
No Demonstrable Negative Effect*	Age and gender Controlled diabetes mellitus Controlled cardiovascular disease Controlled hypothyroidism Hereditary ectodermal disease HIV/AIDS Systemic corticosteroid therapy	Incision technique Immediate loading Exposed threads Lack of bicortical stabilization Number of supporting implants	
Possible Risk of Failure Jaw site	Maxilla in postmenopausal women not receiving HRT Vitamin D–dependent rickets Sjögren's syndrome Bisphosphonate therapy	Clinician's skill and experience Compromised infection control Lack of initial stabilization Distribution of implants	Implant diameter Implant design†
Increased Risk of Failure* Compromised bone quantity Compromised bone quality	Cigarette smoking Irradiated maxilla Recent chemotherapy Intravenous bisphosphonate therapy	Immediate placement in infected extraction sockets	Implant length Implant material†

HRT, Hormone replacement therapy.
*Note that with the exception of smoking and diabetes mellitus, the influence of other systemic conditions on implant failure is based on case reports and retrospective studies with small sample sizes.
†Implant microscopic and macroscopic characteristics are discussed in Chapter 16.

Table data from Elsubeihi ES, Zarb GA: Implant prosthodontics in medically challenged patients: the University of Toronto experience, J Can Dent Assoc *68:103-108, 2002; Scully C, Hobkirk J, Dios P: Dental endosseous implants in the medically compromised patient,* J Oral Rehabil *34:590-599, 2007; Madrid C, Sanz M: What impact do systemically administrated bisphosphonates have on oral implant therapy? A systemic review,* Clin Oral Implants Res *20(Suppl4):87-95, 2009.*

overhydroxylation of lysine and a consequent reduction in the stabilizing cross-links of the collagenous framework that has been suggested as contributing to increased fragility of bone. Indeed, mechanical testing of healing femoral fractures in rats indicated that ovariectomy temporarily impairs fracture healing for up to 4 weeks after fracture. The administration of 17-β estradiol during fracture repair also resulted in a dose-dependent increase in the peak force required to break the healed fracture. These observations may explain the recent findings of an increased risk of maxillary implant failure when tested with the reverse-torque method at stage II surgery in osteoporotic patients not receiving hormone replacement therapy. Interestingly, other investigations reported no correlation between changes in bone mass in different parts of the skeleton and dental implant failure. This observation underscores the need for a better understanding of the effects of systemic factors on jawbone changes at both the tissue and cellular levels.

Hormonal influences on bone homeostasis have generated considerable research. For example, experimental evidence has shown that estrogen depletion leads to a significant loss of bone mass in the edentulous mandible, but not in the dentate mandible, possibly because of the protective effect of the periodontal ligament's mediation of functional and parafunctional forces. The reduction in bone mass of the edentulous mandible of estrogen-depleted animals was associated with an increase in bone turnover where both bone resorption and bone formation rates are increased, with the former exceeding the latter, resulting in bone loss. Evidence at the gene expression, cellular, and tissue levels in other parts of the skeleton further supports these findings.

A recent publication reported that in a subject population with known bone mineral density (BMD) scores, a diagnosis of osteoporosis (or osteopenia) in postmenopausal women did not affect implant survival rates when compared with postmenopausal women without such a diagnosis. These data involve a relatively large subject population (almost 200 subjects) who were followed for up to 10 years (mean of approximately 4.5 years) and whose bone health status could be accurately determined from BMD scores using standardized normalization and accepted World Health Organization (WHO) criteria.

Clinical diagnosis of osteoporosis per se is therefore not a contraindication for dental implant placement. However, in patients with a diagnosis of osteoporosis and where the local jaw bone quality is judged to be of inferior quality (e.g., type IV bone, particularly in the maxilla [see Fig. 22-3]), clinical prudence suggests that an appropriately longer healing period should be allowed before subjecting the implants to high occlusal stresses. Interestingly, functional loading of healed dental implants in patients may increase the bone mass in the jaws, an observation that is consistent with lack of effect of estrogen depletion on the dentate mandibles of animals.

BISPHOSPHONATE THERAPY

There is a general consensus among the guidelines produced by a number of international organizations, especially national oral and maxillofacial surgeon associations, that surgical interventions (including implant placement) in patients receiving intravenous bisphosphonate therapy may cause bisphosphonate-related osteonecrosis of the jaw (BRONJ). Hence, dental implant placement is contraindicated in this patient group.

On the other hand, the current general consensus among dental specialties is that dental implant placement is not contraindicated in patients receiving oral bisphosphonate therapy (mainly for the treatment or prevention of osteoporosis) for less than 3 years. Short-term follow-up studies on small groups of patients taking oral bisphosphonate therapy for less than 3 years have shown that dental implant treatment has the same success rate as that in healthy patients without the risk of developing BRONJ. Although the risk of developing osteonecrosis with oral bisphosphonate administration remains extremely low even beyond 3 years, the difficulty in management of osteonecrosis and its debilitating effects on the patient demand that this matter be discussed with prospective patients. Several proposals have been advanced to deal with the very large number of patients who have been taking oral bisphosphonates for more than 3 years (estimated 190 million prescriptions yearly worldwide) and who would like to undergo implant therapy. One approach focuses on serum levels of C-terminal telopeptide, which is a fragment produced from collagen chains as a result of osteoclast resorption activity. It has been suggested that in patients taking oral bisphosphonates for more than 3 years and those taking bisphosphonates with corticosteroids, a drug holiday of 3 months from before (until the serum C-terminal telopeptide level is >150 pg/ml) until 3 months after dental implant placement (i.e., until wound healing is completed) can reduce the risk of BRONJ development. This approach was based on the assumption that bisphosphonates reduce the resorptive activity of the osteoclasts, resulting in reduced levels of serum C-terminal telopeptide that are less than 150 pg/ml. However, some studies have demonstrated a lack of association between serum C-terminal telopeptide levels and the number and size of necrotic bone areas in patients with BRONJ. Given the long half-life of bisphosphonates in bone, the benefits of the drug holiday protocol and the validity of monitoring the risk of BRONJ with serum C-terminal telopeptide levels remain to be demonstrated in rigorous clinical trials.

It also must be mentioned that there is some evidence in the literature suggesting that BRONJ may develop even if implants were placed before the bisphosphonate therapy was initiated, although this possibility is probably a remote one. Nonetheless, it suggests that these points should be kept in mind: (1) that BRONJ can develop spontaneously, (2) that bone remodeling continues around implants,

(3) that soft tissue problems also can develop around implants, and (4) that either or both of the latter events can trigger the development of BRONJ.

IRRADIATION THERAPY

The impact of radiation therapy on implant outcomes is somewhat controversial, as is the ability of hyperbaric oxygen to ameliorate the detrimental effects of radiation as reported in some trials. In general, higher radiation doses (especially if above 55 Gy) have been associated with compromised surgical and prosthodontic outcomes. Cellular changes in bone vitality, vascularity, and regenerative potential impede the healing pathways necessary for successful osseointegration and maintenance of osseointegration, although it also must be kept in mind that other co-morbidities are likely to be present in patients undergoing high doses of radiation. These co-morbidities can significantly complicate prosthodontic management with or without osseointegrated implants and may include xerostomia, smoking, maxillofacial defects, a history of chemotherapy, and a risk of cancer recurrence. Some trials have reported promising results with the use of hyperbaric oxygen in patients with radiation treatment, although this finding has not been universally accepted and confirmed in clinical research. The lack of ready availability of the hyperbaric oxygen technique around the world also must be considered.

OTHER SYSTEMIC CONDITIONS

Case reports and retrospective studies with small patient sample sizes indicate that there may be an increased risk of implant failure in patients with Sjögren's syndrome, patients with vitamin D–dependent rickets, and patients receiving active chemotherapy. On the other hand, no evidence of increased risk of implant failure has been demonstrated in patients with controlled diabetes mellitus, controlled cardiovascular disease, controlled hypothyroidism, HIV, hypophosphatasia, scleroderma, and ectodermal dysplasia. However, it should be emphasized that with the exception of the studies on smoking, diabetes mellitus, and irradiated maxillae, the quality of most reports does not allow for firm conclusions, and further studies are needed. Anecdotal opinion suggests that the degree of disease control may be more important than the nature of the disorder itself, and therefore, careful assessment of each individual patient is essential.

IMAGING PROTOCOL

Traditional imaging modalities that include a mixture of periapical, panoramic, and conventional tomographic films have proven to be indispensable in the preoperative planning for all types of implant prosthodontic procedures. They facilitate decisions regarding optimal implant placement and permit design of surgical templates that function as a location prescription during the surgical procedure. The expanded use of medical computed tomography (CT) permitted cross-sectional images at multiple sites in substantially shorter periods of time and provided improved contrast of these images for better visualization of bone graft material. However, a significant drawback to medical CT remains the substantial radiation absorbed by the patient.

Cone-beam computerized tomography (CBCT) offers certain advantages over medical CT in terms of availability, acquisition time, and radiation doses that are fractions of those associated with CT. It also lends itself to provision of so-called virtual planning via 3-dimensional visualization of the anatomical sites available for implant placement. Precisely fabricated surgical guides can then be stabilized by fixation pins inserted in the bone (Fig. 22-2). This advanced approach has significant merits, but it is not without



Figure 22-2 Accurate imaging of the osseous structures permits fabrication of a maxillary surgical stent **(A)** that is secured intraorally in the predetermined position by means of pins **(B)** and provides a very accurate guide for implant placement.

drawbacks. As with many emerging and exciting new developments, longer term clinical research is required to determine their true validity and reliability.

A recent report from the European consortium tasked with developing guidelines for the use of CBCT for dental and maxillofacial radiology, the Sedentexct Report (May 2009), proposed the following guidelines:

- Although medical CT imaging has been the imaging method of choice for examining hard-tissue abnormalities of the craniofacial skeleton and jaws, CBCT imaging may now be the preferred method because of a reduced radiation dose.
- CBCT should be used when conventional projection radiography does not provide adequate information for treatment planning. Such clinical situations may include the evaluation of persistent disease, the localization of unerupted or impacted teeth, the evaluation of palatal clefts and dentoalveolar trauma, and selected implant cases.
- To keep radiation doses to patients as low as reasonably achievable, the smallest volumes should be used for a particular imaging task.
- CBCT machines should be optimized by the operator for dose reduction before use. Consideration should be given to technical factors, voxel size, and the number of acquired projections.

SURGICAL PROTOCOLS

Skilful employments of surgical technique plus patients' healing potential are significant determinants of implant success. The surgical objectives are to locate and place the required number of implants in the prosthodontically planned host sites as atraumatically as possible while achieving primary stability. This stability is dependent on the surgical technique used plus host site bone quality and quantity, which in turn determine the optimal dimensions of the selected implants.

An empirically based classification of bone quality and quantity describes commonly encountered variations in jaw quantity and quality as determined by clinical examination and radiographic imaging (Fig. 22-3). Clinical experience suggests that it may be used as a convenient starting point in treatment planning the surgical protocol for edentulous patients.

BONE QUALITY

Bone quality may be described subjectively by the surgeon during the surgical procedure. However, it has to be acknowledged that there are currently no specific tools that conclusively determine bone quality before any implant surgical intervention is undertaken. Although imaging techniques are indispensable for quantitative assessment, they do not provide confirmatory evidence regarding helpful diagnostic imaging of the quality of host bone architecture. Bone quality in the mandible is typically cortical in nature anteriorly and more trabecular posteriorly. The maxilla is generally trabecular with minimal cortical bone present. However, alveolar bone morphology is highly variable, and the transition between anterior and posterior regions is gradual and not readily discernible. Bone quality appears to influence treatment outcomes, with high success rates described in the anterior mandible and somewhat lower ones reported for the maxilla. These clinical observations catalyzed surgical initiatives and research to improve

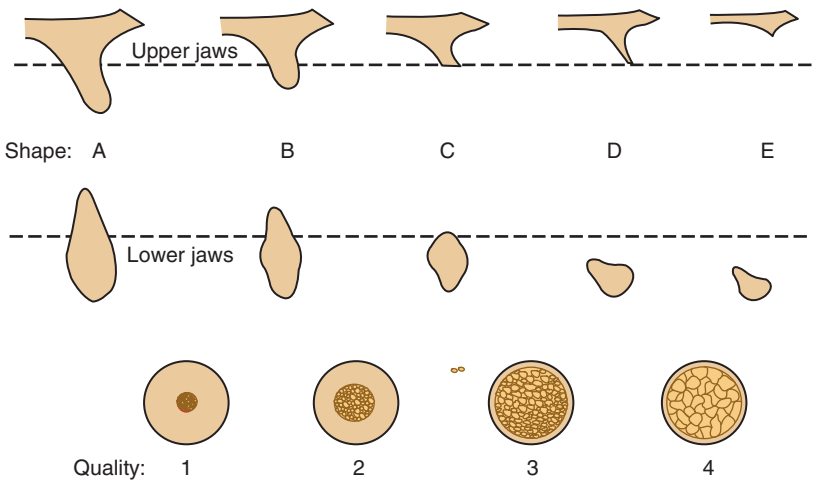


Figure 22-3 Lekholm-Zarb classification of edentulous anterior jawbone quantity and quality. Types A through E reflect a range of resorptive patterns relative to the presumed demarcation of the alveolar and basal jawbone *(dotted line)*. Quality (Types 1 through 4) reflects a range of cortical and cancellous patterns, which have been consistently used in planning oral implant treatment. *(From Misch CE:* Contemporary implant dentistry, *ed 3, St. Louis, 2008, Mosby.)*

success rates for clinical situations where poor bone quality is encountered. Modified surgical techniques and implant design improvements were rapidly introduced to deal with implant placement in bone of less-than-optimal quality. They included self-tapping implants, underpreparation of host sites, and the use of osteotomes to compress the bone. The presumed advantages of such techniques are bone preservation and localized increase in bone density at the osteotomy site. It is now widely acknowledged that the widespread use of modified surgical placement protocols in poor quality bone in combination with the contemporary use of implants with moderately rough surfaces has significantly improved success in type IV bone.

Further research at the cellular level is also required to determine the various steps of the healing phenomenon and to devise methods of harnessing and improving it. Numerous attempts to coat implant surfaces with organic factors (bone morphogenetic proteins [BMPs]) and inorganic materials (such as hydroxyapatite) that stimulate mesenchymal progenitor cell migration and differentiation also have been proposed, albeit with inconclusive results. *Clinical experience also suggests that implant failure is often a localized phenomenon and that operator judgment, skill, and experience continue to play important roles in successful treatment outcomes.*

BONE QUANTITY AND SITE IMPROVEMENT

Well-documented studies on the time-dependent patterns of residual ridge reduction (RRR) that characterize edentulism indicate how this frequently compromises implant placement and poses surgical challenges because the preferred implant locations may be precluded by the available bone quantity. This has inarguably been a frequent challenge in planning implant prosthodontics and a catalyst for even more surgical skill and ingenuity than that required for routine implant placement in the anterior mandible. Although it may be noted that the most frequently needed site for managing edentulism is indeed the mandible, the need to devise and refine surgical techniques that permit implant placement in more challenging sites has yielded impressive advances.

Early efforts to compensate for inadequate bone volume concentrated on compensatory ridge augmentation using the traditional gold standard of an autogenous bone graft. This approach had been developed by oral maxillofacial surgeons for reconstructive maxillofacial surgery and is still used when augmentation of a large edentulous site is required. Subsequent harvesting of intraoral autogenous bone from the chin and other parts of the mandible for diverse site development needs soon followed and expanded the surgeons' scope for providing suitable host bone sites. The scope of this exciting initiative was expanded even further with the use of bone substitutes and synthetic graft materials as fillers.

A great deal of empirical evidence supports the use of such techniques, making implant site development an integral part of modern-day treatment planning. Short-term to medium-term clinical studies have reported varying successes and have shown no major differences between implant survivals in regenerated versus native bone in numerous case-specific scenarios. However, it must be noted that the nature and quality of the resulting osseointegration remains speculative, with scientific evidence still lacking to confirm the routine predictability of the described methods. Moreover, these techniques all too frequently and quite erroneously suggest simple solutions. What is often overlooked is that they also rely on superb clinical skills and technique, impeccable imaging, and scrupulous patient selection and treatment planning.

Research has established that a healing phase for any graft is required before implant placement. However, the time required for this intermediate bone graft healing phase has been inconclusively determined. The currently suggested intermediate healing phase is approximately 6 months, although this may not be applicable to all patient groups. The impact of such surgical interventions and the associated morbidity still needs to be investigated in elderly patients.

The need to find alternatives to autogenous bone harvesting has also led to consideration of the possibility of bone regeneration. Basic science research in various animal models confirms the bone regeneration capacity of various growth factors such as BMPs, transforming growth factor-β (TGF-β), platelet-derived growth factor (PDGF), and the maintenance of de novo bone under functional loading. Regrettably, robust and conclusive clinical research and information on the use of these regenerative materials is lacking, although short-term results appear to offer promise.

In addition, other researchers have embarked on clinical studies that focused on the surgical technique itself as a substitute to bone grafting procedures. These surgical techniques include positioning of implants in alternative sites such as pterygoid plate and zygomatic implants and tilting of implants, distraction osteogenesis, and lateralization of the inferior alveolar nerve, as well as the use of diverse-sized implants (Fig. 22-4). The reported promising results from these research endeavors tend to be of the short-term to medium-term variety. Therefore more rigorous long-term follow-up studies are required to confirm their reliability and predictability in a variety of clinical situations.

PROSTHODONTIC LOADING

In the early years following the introduction of osseointegration, edentulous patients were treated with a minimum of five to six implants in the anterior mandible and maxillae to support a cantilevered fixed bridge and with an interim healing period of 4 to 6 months between the two surgical

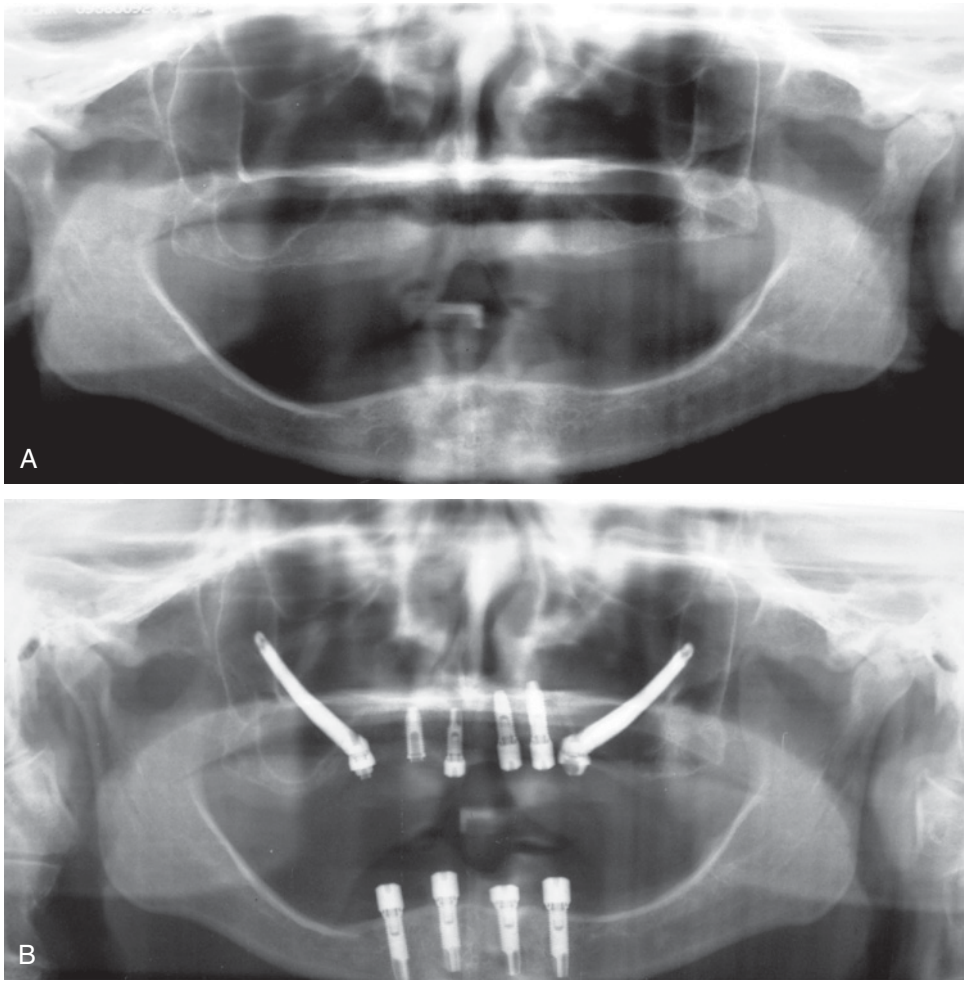


Figure 22-4 Clinical examples of diverse implant treatment applications that include tilting of implants and the use of diverse-sized ones (**A** and **B**) plus zygomatic ones (**C** to **E**) to support a fixed maxillary prosthesis.

stages before the implants were prosthodontically loaded. Specific anterior zone locations were selected so as to identify favorable host site dimensions for implant placement and avoid challenging anatomic structures, such as the maxillary sinuses and the inferior alveolar canals and their contents. Bioengineering considerations led to wide implant distribution along the arch form so as to provide mechanical support for diverse prosthesis designs; however, it was quite clear that the treatment was time consuming and expensive. Moreover, the realization that most patients' denture difficulties could be frequently rectified with a dependable long-term improvement in denture stability led to the notion that patients did not automatically need a conversion of their unstable complete denture into a fixed osseointegrated one. An overdenture supported and retained by osseointegrated implants was also a viable option. Furthermore, current research now even suggests that mandibular overdentures can be effectively stabilized by only one implant, an application that offers both clinical and financial advantages. The surgical operation is shorter and less expensive and the approach kinder to the patient, particularly in the context of systemic health and age considerations. Considerable evidence now endorses the functional benefits obtained by patients who wear mandibular implant-stabilized overdentures irrespective of the number of supporting abutments prescribed and the components used to provide retention (see Chapter 17).

In the last decade, the original protocol of a variable time interval between implant placement and prosthesis loading was challenged. Immediate or early loading protocol alternatives were proposed, mainly in site-specific areas such as the anterior zone of the mandible and diverse host locations for single implant replacements. *It should be understood that early implant loading does not recruit the biological phenomena of osseointegration per se—it relies instead on primary mechanical implant stability. Time-dependent secondary implant stability occurs some time later and relies on completion of interfacial bone formation and remodeling.*

The presumed advantages of the change in time-related loading protocols include the following:

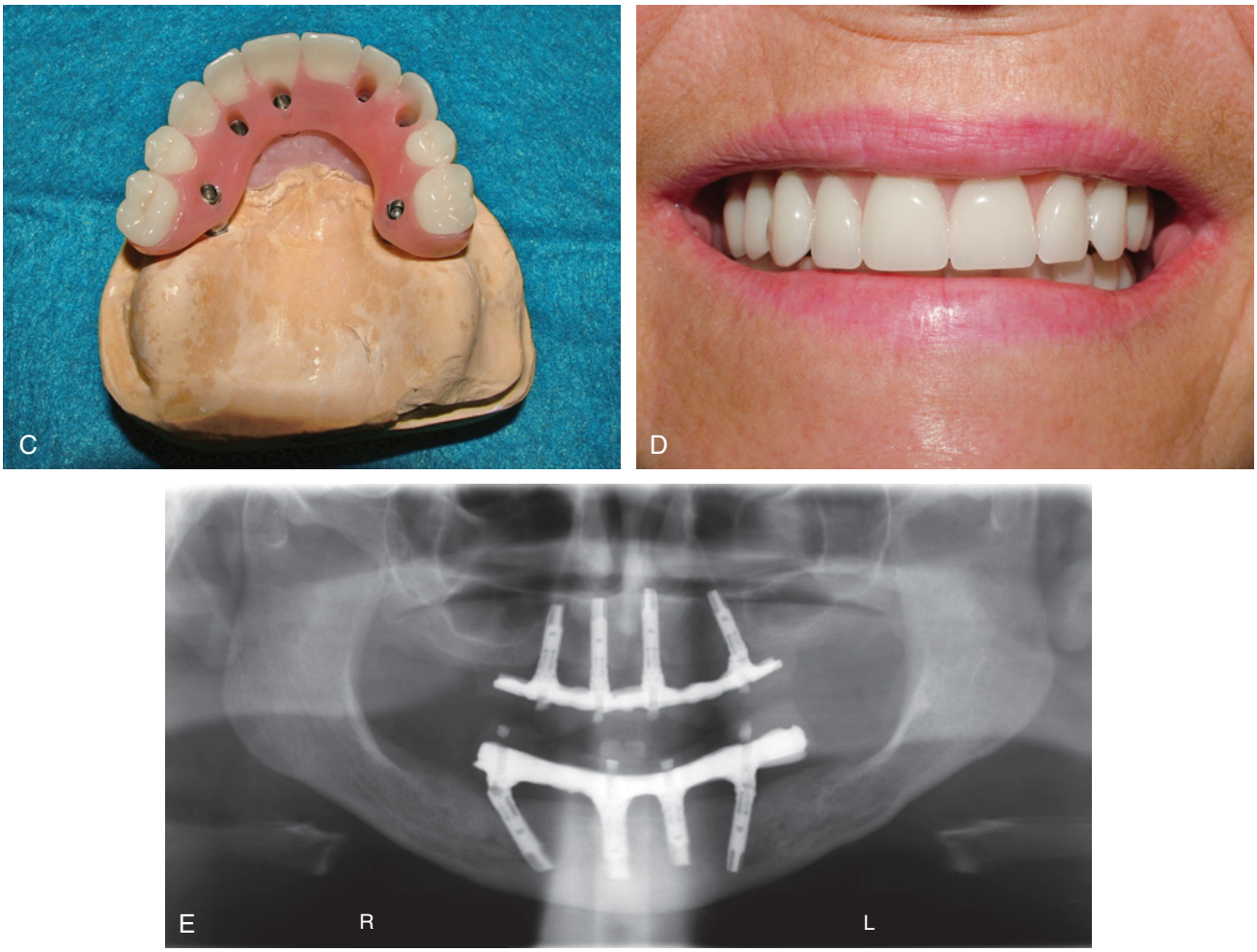


Figure 22-4, cont'd.

1. Offering patients a choice, given the very favorable prognosis for specific sites (anterior mandible) and the availability of various implant designs.
2. Reducing or eliminating the time interval associated with the healing phase before loading of the implants, offering the patient a reduced time commitment.
3. Performing one-stage surgery in an effort to reduce the surgical morbidity.

Several published studies confirm that immediate or early loading with a fixed or overdenture implant-supported prosthesis is a viable option. In addition, the recent introduction of computer-guided technology (CBCT) also permits prosthesis planning and fabrication before surgery. This is an exciting and advanced technique that can lead to tangible benefits for patients. It does, however, require substantial investment in preparatory time for the dentist and access to expensive and sophisticated technology that may not be readily available or fiscally realistic.

The biomechanics of the healing implant–bone interface remains a fascinating if complex concern for various researchers, from tissue engineers to clinical specialists. It appears that time-dependent stress-strain states in mesenchymal tissue influence cellular differentiation in the various stages of bone healing. This occurs in fractures, in distraction osteogenesis, and in implant-related osteotomies. It must therefore be emphasized that current clinical experiences with different implant-loading protocols (though ingenious and exciting) are based on limited if scrupulous observation and documentation. A full understanding of the biomechanics of implant–bone interfaces remains an ongoing endeavor.

It is therefore prudent to suggest that the following considerations still need to be comprehensively addressed:

1. The impact of these approaches on the patient's quality of life.
2. The optimal protocol of immediate loading to be followed: specifically, the minimum healing time required, the number of implants needed to support fixed or overdenture prostheses, and the prosthetic design.
3. The true economic benefits of immediate implant loading in the context of prescribing a provisional or a final prosthesis.

4. The long-term success of both the individual and collective steps of the technological and surgical protocols selected.
5. Although clinical skill and judgment, plus optimal patient selection and operating protocols, appear to virtually guarantee favorable long-term treatment outcomes, the choice of a validated implant system also appears to contribute to clinical success.

ORAL ECOLOGICAL CONCERNS

Ecology is described as a branch of biology dealing with relations of microorganisms to one another and to their physical surroundings. In a broader sense, it also includes the relationship between changes in a particular environment and the resulting impact on specific presences or participants. Oral ecological responses to prosthodontic interventions can therefore be regarded as a balance between the implicit invasiveness of any procedure (e.g., making crown preparations with subgingival margins, using edentulous ridges for occlusal support, implanting tooth root substitutes) and the local host tissue responses. Consequently, any surgical or prosthodontic treatment technique may elicit changes that lead to specific ecological upsets that are manifested as clinical complications. These include recurrent caries and periodontal disease around a crowned tooth or inflammatory and morphological changes in residual ridges under complete dentures. While the development of such adverse ecological shifts is time-dependent, they also reflect patient-mediated commitment and dentist-mediated judgment and skills. It is therefore quite remarkable to note the very minimal recorded local or systemic morbidity in long-term prospective studies in implant prosthodontics.

One particularly interesting clinical observation when using osseointegrated implants is the rarity of their failure after loading. When encountered, such an adverse event has often been erroneously attributed to a so-called peri-implantitis. This is described as an inflammatory process affecting the tissue around an implant which results in loss of supporting bone. It has led to several hypotheses regarding the etiology of implant failure and a somewhat rigid insistence on a similar periodontitis-like pathogenesis. It has even led to treatment interventions based on periodontal therapy protocols. The literature on the management of failing implants is still based on empirical considerations that are often derived from periodontal experiments, from data extrapolated from in vitro findings, or from anecdotal case reports performed on a trial-and-error basis. To date, no compelling data have been presented to justify managing inflammatory processes (other than gingivitis) around teeth and implants as identical clinical entities.

It is arguably imprudent to presume that potential periodontal pathogens present in the mouth will automatically act as peri-implant pathogens. Furthermore, early concerns about the possible adverse role that moderately rough surface implants, as opposed to machined surface ones, would have on peri-implant gingival tissues have been resolved in recent publications, and it appears that the roughness in an implant's surface per se does not affect the health of the surrounding tissues. A recent retrospective study reported on outcomes in 593 patients (2182 machined "smooth surface" implants placed between 1991 and 1996) as compared with those on 905 patients (2425 "rough-surface" implants placed between 2001 and 2005). All data were collected from one institution and related to patient age, gender, implant diameter, length, and anatomic location. Associations of patient/implant characteristics with implant survival were summarized using hazard ratios and corresponding 95% confidence intervals. After 5 years, the reported results revealed survival rates of 94.0% and 94.5%, respectively. Implant length and anatomic location were identified as being significantly associated with failure among smooth surface implants, but this was not the case among moderately rough surface ones.

The reader should keep in mind the fact that tooth and implant attachment mechanisms are significantly different.

TABLE 22-2 SUBTLE, IF PROFOUND, DIFFERENCES BETWEEN TEETH AND IMPLANT ATTACHMENT MECHANISMS DEMAND A DIFFERENT INTERPRETATION OF WHAT INFLUENCES THEIR RESPECTIVE VULNERABILITY TO FAILURE

Teeth	Implants
Attachment mechanism (periodontal ligament) is the result of evolution and has not been replicated	Interfacial osteogenesis (ankylotic-like) is an induced healing response that is readily replicated
Variable mobility is present; increased mobility may be reversible	Immobile (ankylotic-like); mobility is synonymous with failure
Can be intruded, extruded, or moved	Cannot be intruded, extruded, or moved because of ankylotic-like attachment
In young patients, teeth continue to erupt	In young patients, implants are "left behind" while surrounding tissues change
Proprioception	So-called osseoperception
Has a rich plexus of blood vessels and nerves in the periodontal ligament	A relative absence of such a sophisticated circulation and probably innervation
Data present to show progress of mucosal inflammation to periodontal disease	Similar data are not present

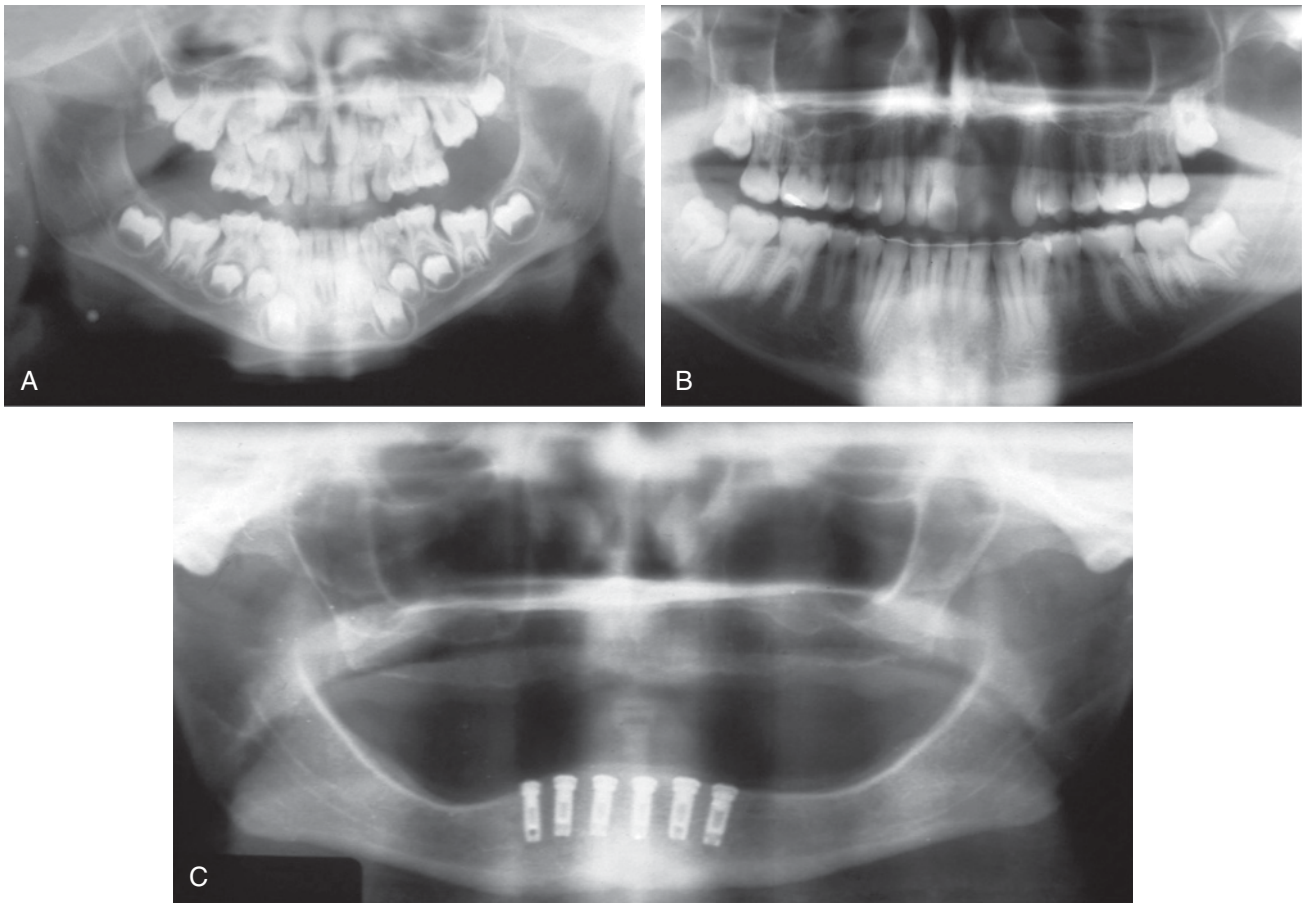


Figure 22-5 Periodontal ligament vs. osseointegrated interface. In the natural dentition (**A** and **B**), well-integrated developmental events lead to a structural continuity that is made possible by the periodontal ligament's evolutionary history. In contrast, the structural continuity between osseointegrated implants and their host bone sites **(C)** results from an induced and controlled wound-healing process that may be influenced by a number of determinants (see Box 22-3).

An evolutionary process dictates the natural dentition's attachment to bone, while implants rely on an induced healing response to create osseointegration (Fig. 22-5). Additional differences between an implant and a tooth are also quite obvious (Table 22-2); they are therefore unlikely to show identical failure mechanisms. The theory of a periodontitis-like cause for peri-implantitis may be regarded as circumstantial at best because it ignores the likelihood of a compromised healing or osseointegrated response, which could eventually succumb to the diverse and unpredictable magnitudes, frequencies, and durations of occlusal loading. The cause of biological failure of osseointegration remains unclear and the possibility of this being multifactorial cannot be excluded. However, our current perception is that a reconciliation of the healing process around an implant together with its specific relationship to host site and morphology, plus the time-dependent nature of the loads to which it is subjected, remains the major determinant of implant success or failure. This perception does not ignore the fact that pathogenic microorganisms in plaque around teeth or implants may have additional systemic health implications and that plaque should therefore be controlled.

SUMMARY

In the past three decades, the dental profession has dramatically changed its approach to the management of edentulous patients, particularly prosthetically maladaptive ones. An entirely new treatment protocol can now be employed to address the edentulous predicament given the spectrum of changes that have been catalyzed by commercially pure titanium implants combined with traditional surgical protocols employing delayed loading. Three decades of clinical experience and research have demonstrated the potential of different biomaterials with roughened surfaces, immediate loading, and various surgical techniques for host site improvement. Time and even better research in patient-mediated concerns, particularly economic benefits, will

ultimately determine to what extent the complete denture will be eclipsed by the implant-supported prosthesis. In the meantime, there is little doubt that both techniques can address the edentulous individual's needs because patients and dentists have already benefited enormously from this enriched spectrum of treatment possibilities.

Bibliography

Al Fadda SA, Attard NJ, David L: Five-year clinical results of immediately loaded dental implants using mandibular overdentures, *Int J Prosthodont* 22(4): 368-373, 2009.

Attard NJ, Zarb G, Laporte A: Long-term treatment costs associated with implant-supported mandibular prostheses in edentulous patients, *Int J Prosthodont* 18(2):117-123, 2005.

Attard NJ, Zarb GA: Long-term treatment outcomes in edentulous patients treated with overdenture implant-supported prostheses, *Int J Prosthodont* 17(4):425-433, 2004.

Attard NJ, Zarb G: Immediate and early implant-loading protocols: a literature review of clinical studies, *J Prosthet Dent* 94:242-258, 2005.

Balshe AA, Assad DA, Eckert SE, et al: A retrospective study of the survival of smooth- and rough-surface dental implants, *Int J Oral Maxillofac Implants* 24(6),1113-1118, 2009.

Eckert SE, Parein A, Myshin HL, et al: Validation of dental implant systems through a review of literature supplied by system manufacturers, *J Prosthet Dent* 77:271-279, 1997.

Elsubeihi ES, Zarb GA: Implant prosthodontics in medically challenged patients: the University of Toronto experience, *J Can Dent Assoc* 68:103-108, 2002.

Elsubeihi ES, Heersche JM: Comparison of the effect of ovariectomy on bone mass in dentate and edentulous mandibles of adult rats, *Eur J Prosthodont Restore Dent* 17(1):9-21, 2009.

Esposito M, Hirsch J, Lekholm U, et al: Differential diagnosis and treatment strategies for biologic complications and failing oral implants: a review of the literature, *Int J Oral Maxillofac Implants* 14:473-490, 1999.

Holahan CM, Koka S, Kennel KA, et al: Effect of osteoporotic status on the survival of titanium dental implants, *Int J Oral Maxillofac Implants* 23(5):905-910, 2008.

Lam E: Is routine radiography for a new patient considered overtreatment? *J Can Dent Assoc* 76:a59, 2010.

Lazarovici TS, Yahalom R, Taicher S, et al: Bisphosphonate-related osteonecrosis of the jaw associated with dental implants, *J Oral Maxillofac Surg* 68:790-796, 2010.

Lekholm U, Zarb GA: Patient selection and preparation. In Brånemark PI, Albrektsson T, et al, editors: *Tissue-integrated prostheses: osseointegration in clinical dentistry*, Chicago, 1985, Quintessence.

Madrid C, Sanz M: What impact do systemically administrated bisphosphonates have on oral implant therapy? A systematic review, *Clin Oral Implants Res* 20(Suppl 4):87-95, 2009.

Pharoah M, Lam E: Diagnostic imaging. In Zarb G, et al, editors: *Osseointegration*, Chicago, 2008, Quintessence.

Sedentexct. Radiation protection: cone beam ct for dental and maxillofacial radiology provisional guidelines (V1.1 May 2009). A report prepared by the Sedentexct Project. www.Sedentexct.Eu.

Sennerby L, Roos J: Surgical determinants of clinical success of osseointegrated oral implants: a review of the literature, *Int J Prosthodont* 11:408-420, 1998.

Scully C, Hobkirk J, Dios P: Dental endosseous implants in the medically compromised patient, *J Oral Rehabil* 34:590-599, 2007.

von Wowern N, Gotfredsen K: Implant-supported overdentures, a prevention of bone loss in edentulous mandibles? A 5-year follow-up study. *Clin Oral Implants Res* 12:19-25, 2001.

Watzek G, Gruber R: Morphological and cellular parameters of bone quality, *Applied Osseointegration Res* 3:3-10, 2002.

Zarb GA, Schmitt A: The longitudinal clinical effectiveness of osseointegrated dental implants: the Toronto Study. Part II: The prosthetic results, *J Prosthet Dent* 64(1):53-61, 1990.

PART VI

Additional Considerations in the Management of Edentulous Patients

CHAPTER 23

The Impact of Socioeconomic, Cultural, and Technological Changes and the Notion of Standards of Care and Alternative Protocols

C. Peter Owen, Michael I. MacEntee

Although the idea of tooth loss as an inevitable consequence of aging has been discarded in many societies, complete dentures will continue as a therapeutic and rehabilitative challenge for very many more years.[1] Rates of edentulism differ both within and between countries typically in association with socioeconomic disparities. Within affluent countries there are communities—usually of elders and others with low incomes—who have difficulty acquiring the knowledge and financial resources necessary to retain their teeth, and when edentulous, some have difficulty even obtaining mucosa-borne dentures. But edentulism is the normal state for the majority of the adult population in many regions of the globe. Consequently, the need for complete dentures will remain high and challenging for the foreseeable future almost universally. The main concern is that edentulous patients everywhere are predominantly poor and socially disadvantaged. They have difficulty accessing health care, and particularly services such as prosthodontics that require continuous observation, adjustment, and renewal.

Edentulism does not necessarily imply a need for dentures. What could be a devastating experience for some might be an accepted consequence of life for others. With loss of teeth comes loss of chewing ability, change in food choice, and an elevated risk of digestive, hormonal, and cardiac disorders. There is even, some claim, an increased risk of dementia associated with an inability to chew effectively.[2]

In most cultures it is quality of life and social stigma that strike most annoyingly with the loss of teeth.[3] There are several layers to this and many associations. Age, for example, is obviously associated with tooth loss, and more

so in some cultures than in others; however, there are more important, if subtle, associations with external circumstances such as poverty over which we as individuals have little or no practical control.

We cannot approach the subject of tooth loss and dentures without considering poverty, distributive justice, and the social contract in health care.[4] Loss of teeth is as much a socioeconomic phenomenon as it is a biological consequence of disease. It is a fact that poor people in contrast to affluent people have fewer teeth[5]; consequently, our consideration of complete dentures as a health service must look carefully at the accessibility of this service to people with limited financial resources or who live in remote regions without easy access to dentists or others who can make dentures.

Advances in implantology and the benefits that oral implants offer people without teeth are remarkable. However, most edentulous people, now and for the foreseeable future, have no realistic way of accessing a competent implant service. Typically, they are poor and in remote communities where their only choice of treatment at best is mucosa-borne complete dentures. We cannot ignore the treatment needs of this large and diverse population. Therefore the objective of this chapter is to present a concept of providing appropriate care cost effectively and to describe techniques that make complete dentures accessible to those who do not have access to alternative care.

STANDARDS OF CARE

Improvements in technology and techniques may on occasion have unintended consequences: sometimes they provide what seems such an obvious solution to a problem that the solution becomes almost universal and applied inappropriately. (As the saying goes, "When all you have is a hammer, everything looks like a nail.") When the focus is on the solution and not on the patient and the patient's circumstances, it is necessary to step back and reconsider what care should be considered normal, or the "standard."

The recommendation[6] that an overdenture supported by two implants should be the "first choice" standard of care for the treatment of the edentulous mandible has been subjected to several serious challenges.[7,8] It arose from a reasonable concern to improve the standard of care and treatment outcomes in prosthodontic services recommended for people with edentulous mandibles. However, it overlooked the implications of the recommendation for the very large number of patients who are poor or who live where oral implants are unavailable. The recommendation is meaningless where the options for prosthodontic care are quite simply nothing or, at best, mucosa-borne complete dentures. We believe that dentists cannot be held to unrealistic standards. Furthermore, even in communities where oral implants are readily accessible, we believe that it is unreasonable and ethically inappropriate to promote implants as the optimal standard of care for patients who quite clearly do not want them. The extensive history of mucosa-borne complete dentures indicates quite surely that they have served as an effective substitute for natural teeth in maintaining dignity and health. It is readily acknowledged that there are much better alternatives available to edentulous people today, but unfortunately the alternatives are only available to the few, not to the many.

MINIMUM ACCEPTABLE PROTOCOLS

A series of principles that should, at the very least, be followed for any given treatment modality can be gathered into a Minimum Acceptable Protocol or MAP (where the "P" becomes synonymous with "Principles") (Box 23-1). A MAP offers an inclusive and comprehensive alternative to the therapeutic restrictions inherent in many standards of care.[9] It offers a selection of treatments complying with the principles, and from which an appropriate treatment can be selected to suit the resources available and preferences of the patient. Moreover, in accord with the principles of social justice and responsibility, the MAP offers the possibility of maximizing treatment outcome while minimizing the outlay of resources for the least advantaged in society.

A continuum of care based on the MAP brings all the evidence together into a set of guidelines and pathways to identify the most appropriate and timely intervention for a particular patient (Fig. 23-1). If, for example, a patient has few or no financial resources, is edentate and has worn complete dentures successfully, then a favorable outcome is likely to be another set of mucosa-borne dentures. Alternatively, the choice becomes wider if a country's health care system has resources for an implant prosthesis.

AN "APPROPRIATECH" METHOD FOR COMPLETE DENTURES IN FOUR CLINICAL SESSIONS

The following technique "Complete Dentures in Four Clinical Sessions" (CD4) is based on the concept of "appropriatech." It offers the possibility of clinical techniques based on time-honored principles of prosthodontics that provide cost-effective and useful treatments to meet the biological, social, financial, and psychological circumstances of a particular patient at a particular time.[9-11]

The CD4 technique uses materials that are readily available and relatively inexpensive almost everywhere.*

*Materials and equipment are identified usually by generic names.

Box 23-1 Guidelines for a Minimum Acceptable Protocol for the Construction of Complete Dentures

Initial Preparatory Phase

- The patient's specific goals regarding expectations of comfort, function, and esthetics should be recorded before treatment.
- The patient's experience, if any, with complete dentures and his or her self-assessment of any existing prosthesis should be recorded before treatment.
- It is preferable to ensure that there is a healthy mucosa before taking final impressions.
- A healthy mucosa usually may be achieved with a combination of methods, such as the use of tissue conditioners, leaving the dentures out before impression taking, and adjustment of the existing dentures.
- If a candidal infection is diagnosed and recorded, this preferably should be treated before impression taking.

Treatment Phase

- The final impression can be made in a material and supported in a variety of ways, which will allow the operator to achieve optimum conformity to the requirements of appropriate coverage, intimate tissue contact, and border (peripheral) seal.
- The center line for the maxillary anterior teeth and the occlusal plane should be determined by the operator, and this information transferred by setting some teeth and/or marking and adjusting an occlusal rim.
- A method should be used to record the centric relation position at the desired vertical dimension of occlusion, such as an interocclusal recording material, or by means of an intraoral tracing.
- The vertical dimension of occlusion should allow for an interocclusal (freeway) space. The amount of this space should be sufficient for function, speech, and esthetics and be appropriate to each patient.
- The arrangement of the anterior teeth should show evidence that the technician and clinician have taken into account a variety of factors to reconcile appearance with function, such as soft tissue profiles, phonetics, occlusal plane orientation, neutrality, and that the appearance is appropriate for that specific patient.
- The patient should be part of the decision-making process for the appearance of the teeth, guided by the clinician.
- The arch form should show that the clinician has arranged for the teeth to be in a position of neutrality to the available denture space and muscle forces and should contribute to stability in function.
- The occlusal scheme should be clearly capable of contributing to the stability of the dentures when in function.
- There should be even contact on all posterior teeth in the intercuspal position (centric occlusion), which should enable the patient to return to this position during function without causing instability of the denture or disharmony with the muscles and joints.
- The occlusion should be finally adjusted according to observations made after processing.
- Attempts should be made to identify any possible border/peripheral overextensions and/or fitting surface discrepancies, either by observation or by the use of appropriate materials.
- The patient should receive instructions on proper hygiene and the need for future visits.

Posttreatment Phase

- At recall, the mucosa should be checked, even if there are no complaints.
- When assessing complete dentures for the need to make adjustments or to determine the need for replacement, the clinician should assess loss of vertical dimension, stability, retention, the patient's reported ability to chew to his or her satisfaction, and the patient's satisfaction with his or her appearance.

FIRST CLINICAL SESSION

Impressions

After the normal examination procedures and discussion with the patient on the limitations and expectations of using complete dentures, this visit entails making the definitive impressions for the master casts, and the initial location and recording of the positions of the maxillary anterior teeth.

The final impression is made in a stock tray adapted with the judicious application of soft wax (peripheral wax is ideal) to accommodate the patient's functional anatomy. Wax "mucosal" stops hold the periphery of the stock tray away from the depth of the functional vestibule, and also help to locate the tray correctly on the ridge when making the impression. Softened peripheral wax also can be "border-molded" to extend the periphery of the tray where needed, usually along the lingual vestibule and into the retromylohyoid fossae (Fig. 23-2, *A* and *B*). The impression is recorded with an irreversible alginate material.* This is a relatively stiff material, and typically, when it sets, it records the shape of the vestibule beyond the functional limits of the underlying muscles. However, a careful clinical examination of the vestibule will help to locate the functional limits, which can be marked with an indelible marker on the impression and transferred to the casts (Fig. 23-2, *E* and *F*).

*Irreversible hydrocolloid (alginate) is available almost everywhere, but an impression compound can be used as an alternative.

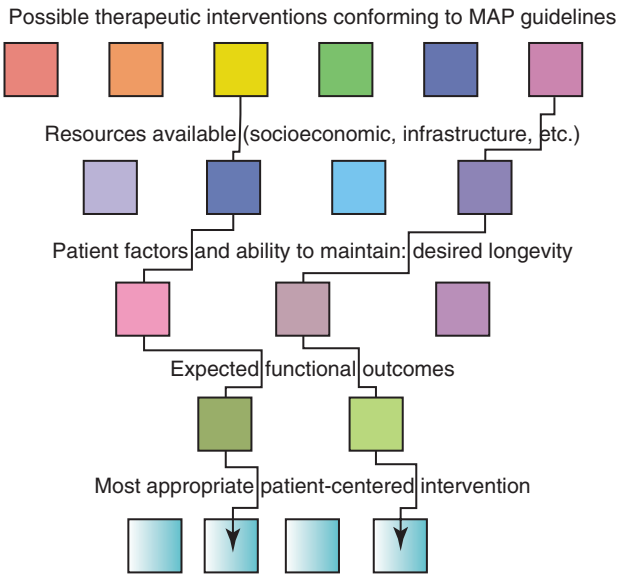


Figure 23-1 Protocol-based guidelines conforming to the Minimum Acceptable Protocol (MAP) for a patient-centered approach to treatment. The various colors reflect a range of options but are not themselves indicative of a given option.

Alternatively, the impression material extending beyond the functional vestibule can be removed with a sharp knife or a scalpel, and the initial impression relined with a more fluid mix of alginate material (add 25% more water) to capture (border mold) the position and shape of the vestibule as formed by the surrounding muscles in motion (Fig. 23-2, *C* and *D*). Finally, indelible lines are drawn along the posterior border and "postdam" area of the maxillary impression (see Fig. 23-2, *D*), and also on the mandibular impression to outline the retromolar pads.

Position of Maxillary Anterior Teeth

The optimal supportive and esthetic position of the anterior teeth is identified with a preformed anterior tooth arrangement guide (ANTAG) made from modeling wax reinforced with 10% sticky wax (Fig. 23-2, *G*). The wax guide is softened in warm water, adapted to the anterior maxillary ridge, and chilled to capture the shape of the residual ridge over the premaxilla. Softened peripheral wax is added and molded to the guide to simulate the anteroposterior and vertical position of the teeth (Fig. 23-2, *H* and *I*). Measurements are taken vertically from the crest of the residual ridge to the "incisal" edges of the wax, and horizontally from the labial surface of the wax to the incisive papilla. The dental technician will use these measurements to arrange the anterior teeth on the denture base. An alternative method would be for the technician to place the teeth in average positions relative to the ridge crest, such as 8 mm vertically and 8 mm horizontally. The color (shade) and shape (mold) of the anterior teeth are selected from the three most commonly used molds and the two most popular colors available from local suppliers of acrylic resin teeth.

First Laboratory Session

The dental technician will pour the impressions in dental stone as soon as possible to make the maxillary and mandibular master casts. The indelible marks indicating the postdam area and the retromolar pads on the impressions should transfer to the casts and can be highlighted if necessary. The postdam area is scored on the upper cast, and the denture bases are processed in a clear heat-cured acrylic resin. The casts are retrieved from the processing flask when possible, to support the denture bases on an articulator later. "Remounting casts" can be made if the master casts are severely damaged when deflasking the denture bases. The clinical measurements recorded from the ANTAG are used now to arrange the maxillary anterior denture teeth in baseplate wax on the denture base, and wax occlusal rims in baseplate wax are attached to the base distal to the maxillary canines, and a full wax occlusal rim is attached to the mandibular base (Fig. 23-2, *J* and *K*).

SECOND CLINICAL SESSION

Establishing the Vertical Dimension of Occlusion

The extension and adaptation of the denture bases are assessed and adjusted for comfort, stability, and retention in the patient's mouth. If the retention of either base is inadequate and cannot be improved, the base can be relined now with a suitable low-viscosity impression material (such as zinc-oxide-eugenol paste). The maxillary incisors and canines are adjusted suitably in the wax to the patient's satisfaction using normal guidelines of appearance and phonetics. The vertical dimension of occlusion (VDO) is determined by adjusting the maxillary and mandibular wax occlusal rims until they contact at an esthetically acceptable height with the mandible located comfortably in centric relation (CR).

Recording the Horizontal Jaw Relationship

The horizontal relationship of the wax rims at the established VDO is recorded with a thoroughly softened wax or other recording medium; wax reinforced with aluminium powder is recommended because when it is thoroughly softened, it remains soft for a long enough time to make a reliable jaw relation record (Fig. 23-2, *L*). The record must be made clinically at a repeatable horizontal position, typically called CR or the relaxed retruded position of the mandible. The retruded position should be recorded by using repeated closures with the denture bases stable and supported comfortably on the residual ridges by the

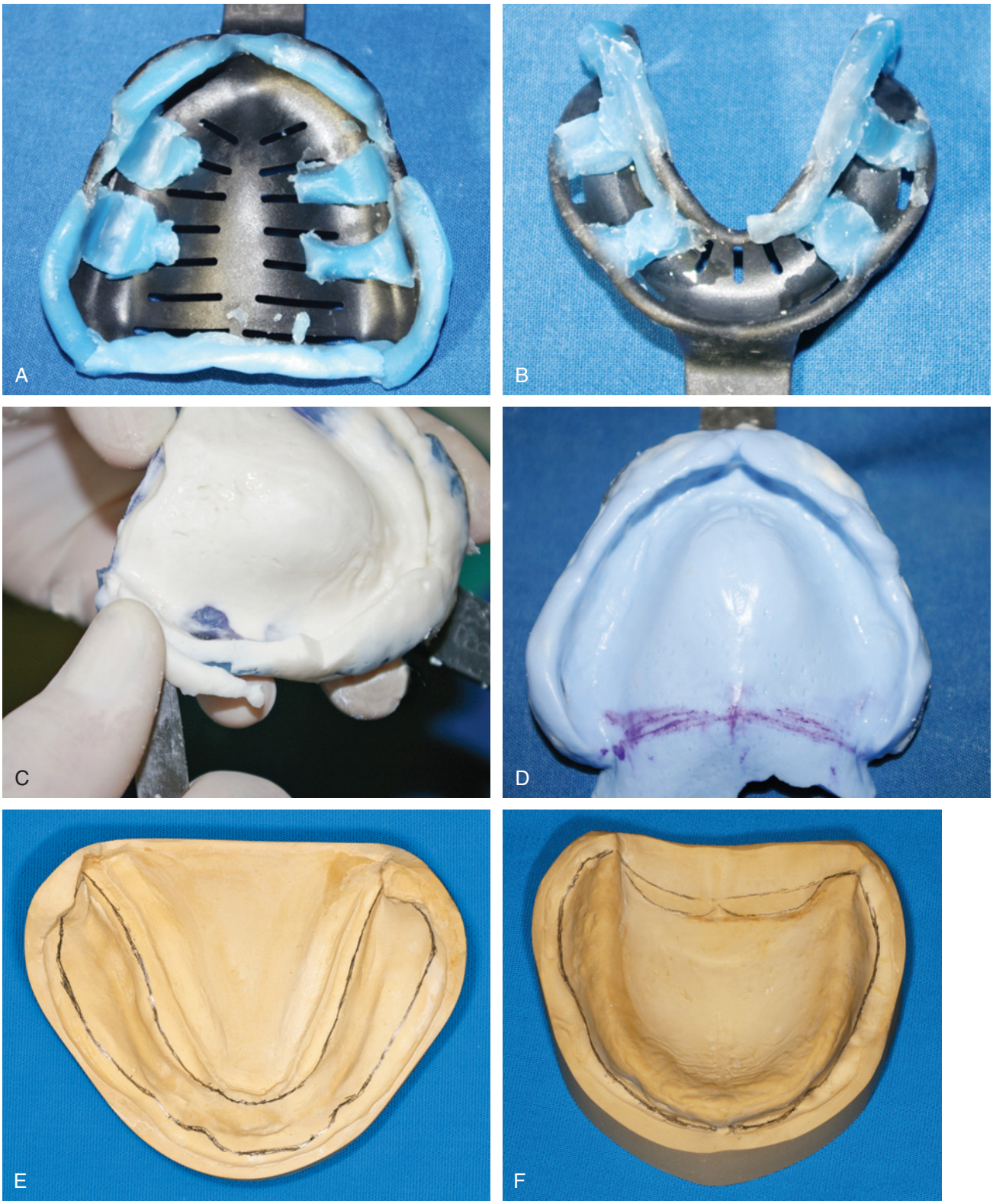
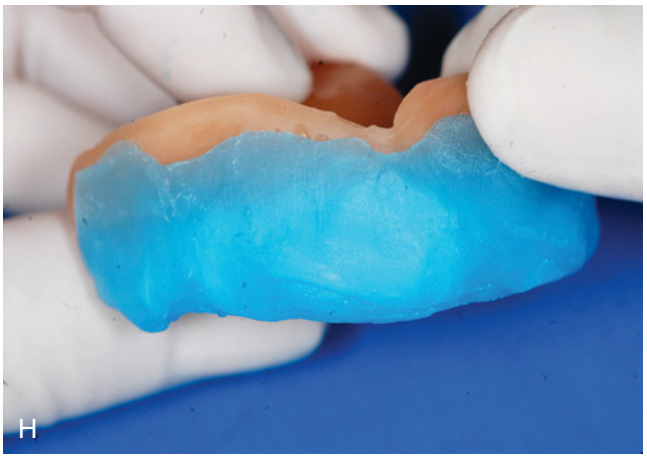


Figure 23-2 Some of the steps in the CD4 technique. **A** and **B,** Stock trays modified with peripheral wax. **C,** First alginate impression being cut back to take a second wash. **D,** Final upper impression (double alginate) with postdam area marked. **E** and **F,** Casts marked for correct extension of the bases (from a single alginate).

Continued





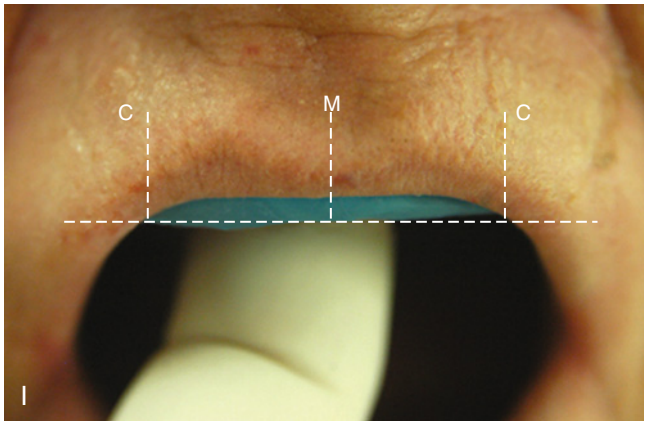








Figure 23-2, cont'd **G,** ANTAGs. **H,** Soft peripheral wax added to ANTAG. **I,** Some measurements using the ANTAG to determine upper anterior tooth positions. **J** and **K,** Bases ready for second visit. **L,** Jaw relation record.



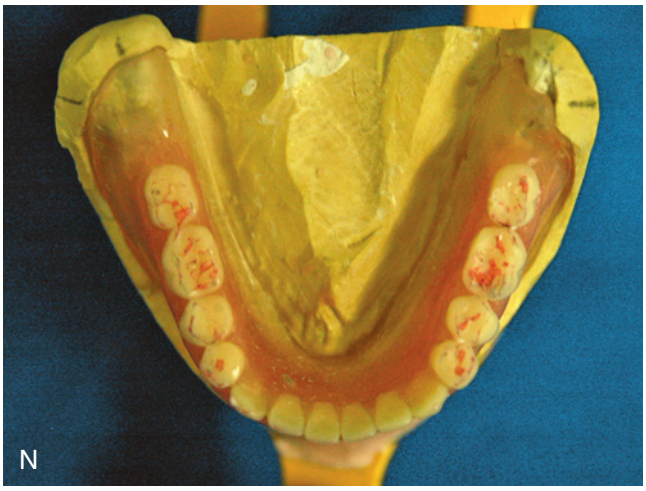










Figure 23-2, cont'd **M,** Check bite for remounting. **N,** Balancing contacts. **O,** Occlusal indicator wax to confirm functional interocclusal contacts. **P, Q,** and **R,** Satisfied patients at the recall visit.

operator. It is important to record this position accurately during this session, because there is no other opportunity to change the position before the teeth are processed in resin on the bases.

Second Laboratory Session

The casts with the denture bases with the wax record are mounted on an articulator. It is sufficient to mount the casts in the "middle" of a relatively simple dental articulator, allowing average condylar movement so that the remaining teeth can be arranged in the following sequence:

1. The labial surfaces of the mandibular incisors should align horizontally to or slightly behind a line rising vertically from the labial vestibule, and vertically to contact the maxillary incisors in harmony with the protrusive and lateral guidance of the simple articulator.
2. Mandibular premolars and molars are placed in the wax bilaterally with the central groove of their occlusal surfaces on a line from the incisal tip of the canine to the midpoint vertically and horizontally of the retromolar pad (hence the need to have recorded this in the impression).
3. The maxillary premolars and molars are placed to contact the opposing mandibular teeth, either regularly or in cross-bite with the usual overjet to prevent cheek-biting.

A "lingualized" occlusal scheme offers a convenient and accommodating arrangement with monoplane (0 degrees) mandibular premolars and molars opposing maxillary cusped (20 degrees to 33 degrees) teeth. This scheme requires that only the mandibular teeth need be adjusted: their occlusal surfaces are modified to create compensating curves, and their buccal "cusps" are beveled so as not to contact the upper buccal cusps. The mandibular teeth are adjusted to maintain multiple contacts bilaterally as the jaw moves eccentrically from the retruded (CR) position.

When the teeth are arranged appropriately in wax on the denture bases, each base is flasked again to replace the wax with acrylic resin.

THIRD CLINICAL SESSION

Remount and Occlusal Adjustment

The denture bases are reassessed clinically for comfort, stability, and retention, and adjustments made to the bases where needed, as the second processing of acrylic resin to attach the teeth might require this.

Clinical assessment of the occlusal contacts at this stage typically detects some imbalance that needs adjustment, which is made most efficiently by recording another occlusal record in CR and remounting the dentures on the articulator (Fig. 23-2, *M*). The remount procedure and occlusal adjustment can be completed quickly by: (1) recording the occlusal record as before; (2) placing the dentures with the new record (usually attached to the mandibular denture) on the casts; and (3) remounting the casts with a fast-setting mix of slurry water and plaster. This is practical and very efficient if the technician provides the casts, and if the articulator, plaster, and slurry water are readily at hand. Before adjusting the occlusal contacts, confirm that the contacts seen between the dentures in the mouth are the same as the contacts seen on the articulator. The adjustment in CR can proceed then on the articulator to produce an equivalent distribution of contacts bilaterally (Fig. 23-2, *N*), which is confirmed with occlusal indicator wax in the mouth (Fig 23-2, *O*).

Counseling the Patient

A discussion with the patient at the beginning or end of this session should reaffirm the benefits and limitations of complete dentures and will help to prepare the patient's expectations and tolerance needed to adapt to new dentures. It is also necessary to explain the significance of a sensible diet and choice of food to maintain health and comfort.[12] Detailed advice is needed also on denture hygiene, especially on prevention of fungal infections by storing dentures in a dry environment when they are not in the mouth.[13]

FOURTH CLINICAL SESSION

The fourth clinical session occurs typically a day or so after the dentures have been delivered. Additional sessions might be needed to achieve acceptable comfort; however, the denture bases have been adjusted for comfort on two occasions already, and the occlusal contacts equilibrated evenly during the previous clinical session. Therefore the patient should be reasonably comfortable with the dentures at this stage and should be content with the outcome (Fig. 23-2, *P* to *R*).

SUMMARY

The brief description of denture-making presented here complies fully with the MAP. Moreover, there is well-established evidence that a relatively uncomplicated clinical technique for making dentures is every bit as effective biologically and psychologically for patients as the more complicated techniques.[14]

REPRODUCING COMPLETE DENTURES

It is appropriate to reproduce or duplicate the good features of an "old and familiar" denture when it has been worn comfortably and healthily for a long while, but it is now

loose or structurally defective with, for example, excessive abrasion of the teeth or resin porosities. Reproduction of a denture is especially suitable when the denture-wearer does not want to change the appearance, and when the position of the teeth conforms in general to the MAP. This technique[15] essentially produces a replica of the old denture but with new teeth and other minor adjustments and corrections if needed (e.g., to increase the VDO when there is excessive tooth abrasion).

FIRST CLINICAL SESSION

The first clinical session follows the usual diagnostic and treatment-planning procedures, including if necessary an occlusal record at the optimal VDO and in CR (Fig. 23-3, *A*). Some patients request and can tolerate an increased VDO, perhaps to the original VDO before the occlusal surfaces were abraded. However, other patients—especially if elderly and frail—will not tolerate a change in the VDO and prefer a new denture that occludes familiarly at the acquired position.

Wax sprues (sticks of peripheral wax) are first attached to the hamular notch areas in the maxillary denture and the retromolar pad areas of the mandibular denture. Each denture is invested separately in a mold formed from irreversible hydrocolloid on the facial (polished) surfaces of the denture (Fig. 23-3, *B*), and laboratory putty reinforced with quick-setting plaster on the alveolar surfaces (Fig. 23-3, C and *D*). One half of the mold is formed by the alginate while the other is formed by the putty plaster. When the plaster

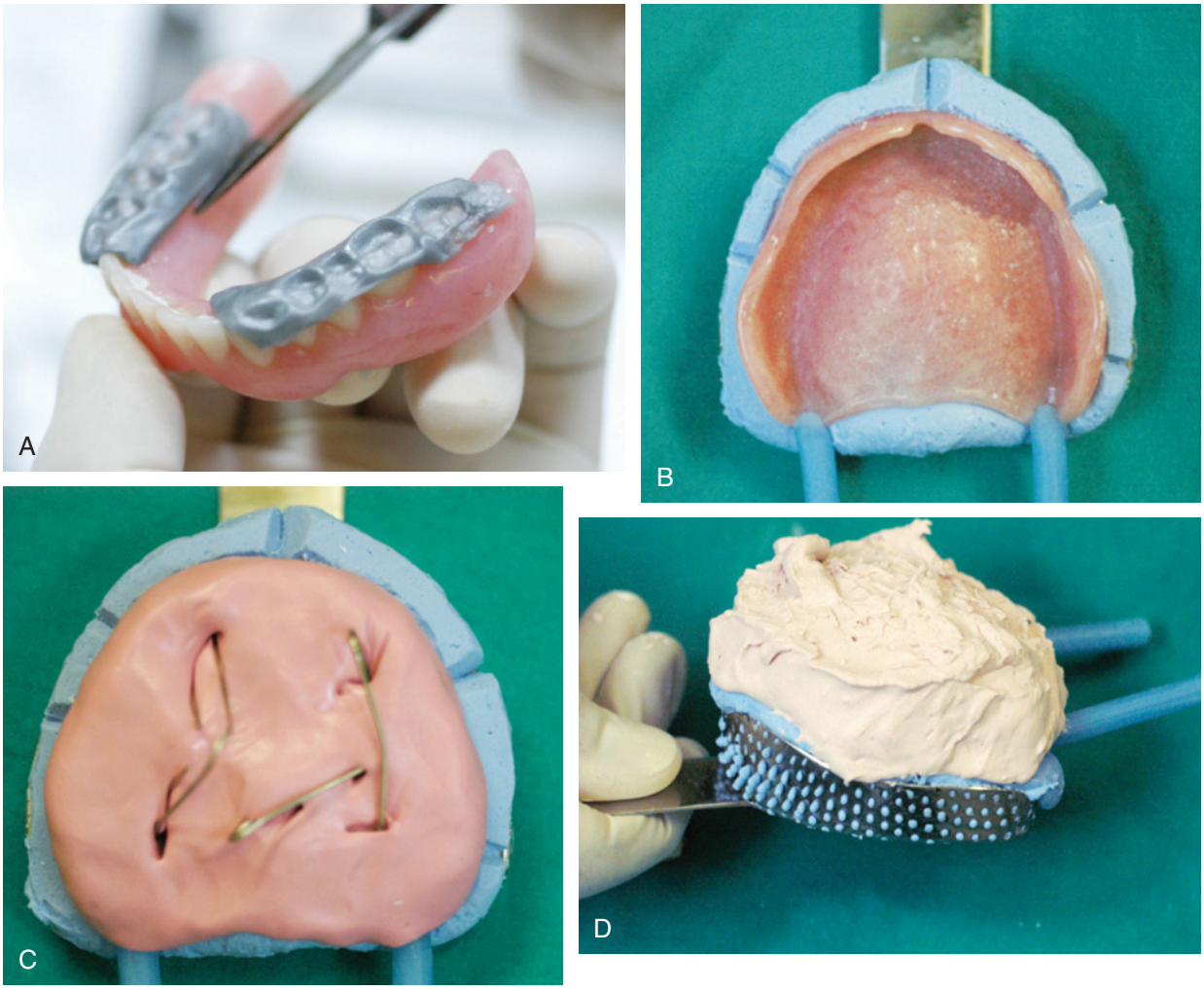


Figure 23-3 Some of the steps in the duplication technique. **A,** An occlusal record at a new vertical dimension on the existing denture. **B,** The polished surface of the denture is pressed into alginate in an oversized box tray to form one half of the mold. **C,** Laboratory putty is pressed into the alveolar surface of the denture and paper clips are used to retain the plaster that reinforces this half of the mold (as seen in **D**). *(**A, D, E, I,** from Owen CP: New dentures from old: a duplication method using "appropriatech," J Can Dent Assoc 72(5):393-397, 2006.)*

Continued









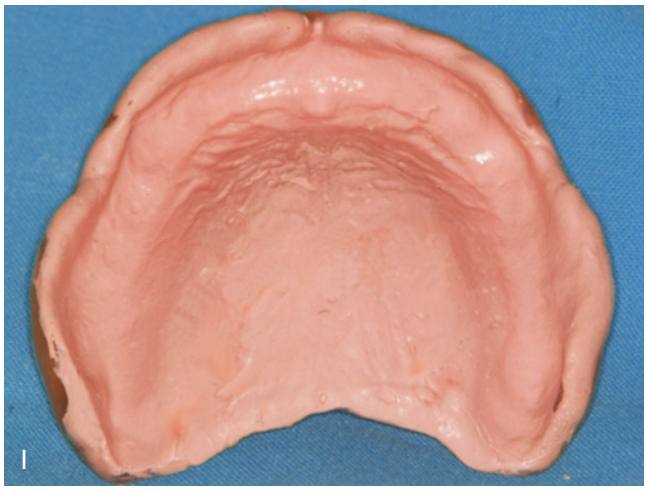


Figure 23-3, cont'd **E** and **F,** The wax replica is removed from the mold and mounted on an articulator. **G** and **H,** New acrylic resin teeth replace the wax "teeth" of the replica in the same positions. **I,** Zinc-oxide-eugenol paste has been used to reline the wax base.

has hardened, the mold is opened along the junction of the two materials, and the denture and sprues are removed. The denture is then returned to the patient.

FIRST LABORATORY SESSION

The mold is reassembled without the denture and the junction between the two parts is sealed with sticky wax. Baseplate wax is heated and when molten is poured into the mold through one sprue hole until it rises to the surface of the other hole. The mold and wax are allowed to cool then are chilled thoroughly and opened again to remove the wax "denture," which can be mounted on an articulator against the opposing denture or dentition (Fig. 23-3, *E* and *F*). New acrylic teeth are arranged on the base to replace the wax teeth at the optimal VDO, by replacing every alternate wax "tooth" to maintain the arch form and tooth positions (Fig. 23-3, G and *H*).

SECOND CLINICAL SESSION

The second clinical session confirms the acceptability of the occlusal and esthetic changes introduced and, if necessary, makes whatever additional changes are required to satisfy the patient's expectations and physical tolerance. The alveolar surface of the wax baseplate is now relined with a relatively nonviscous impression material (e.g., zinc-oxide-eugenol, or light-bodied polyvinyl siloxane) using a "closed mouth" technique to locate the two bases and conform to the functional shape of the supporting mucosa (Fig. 23-3, *I*).

SECOND LABORATORY SESSION

Master casts are made from the modified wax denture and flasked as usual to convert the wax into acrylic resin, and the denture is prepared for delivery.

Third Clinical Session

The denture is adjusted for comfort and function when assessed clinically, and an occlusal remount is performed as described above to refine the occlusal contacts if necessary. Finally, the patient is counseled on what to expect from the new prosthesis and how to maintain a healthy mouth with a denture.

ADAPTATION AND ADVANCING TECHNOLOGY

Adaptation is a remarkable attribute of successful aging.[16] People do of course struggle emotionally and physically to come to terms with the loss of their teeth, and the consequences of early tooth loss can be very disabling. Moreover, the difficulty of aging with a denture is compounded even further when it is made incorrectly, and this is more likely to occur when there is inadequate education in the art and science of complete dentures. Furthermore, it is unfortunate that we know little about the satisfaction of denture wearers in countries where the prevalence of edentulism remains high. Thus we can only speculate that satisfaction is much higher in countries where complete denture making is taught and practiced more widely.

Perhaps one day another new technique will save the day, and the digital world will provide appropriatech solutions to the challenges of artificial teeth. But, in the meantime, just imagine if private companies who profit from tooth loss directed their huge resources to produce affordable solutions for the least advantaged in society. Just imagine if a single computerized scan at very little cost could design, construct, and place implants and dentures. Just imagine if tissue-engineered tooth buds could replace the titanium implants and the plastic dentures. Then everyone, including our least advantaged communities, would benefit. Just imagine!

SUMMARY

A complete denture made by any technique should emerge from guidelines and principles that enable the wearer to adapt and cope with the disturbing consequences of tooth loss. It is a holistic and intimate service that encompasses counseling about tooth loss, nutrition, adaptation and coping, self-image, and chronic disability that demands frequent reassessment and continuous management. All of these factors are compounded by the need for mature and sensitive clinical judgment and skill. Such is the world of complete tooth loss and dentures. This is a challenging service. It serves a good purpose, it can be remarkably satisfying, and usually it is much appreciated. But above all, it offers the potential to better the lot of the least advantaged in many ways. These examples of "appropriatech" based on the MAP as contributions to the art and science of prosthodontics are offered in the hope that they will help the patients we serve, and especially those who have difficulty accessing our services.

References

1. Mojon P, Thomason JM, Walls AW: The impact of falling rates of edentulism, *Int J Prosthodont* 17:434-440, 2004.
2. Onozuka M, Watanabe K, Nagasaki S, et al: Impairment of spatial memory and changes in astroglial responsiveness following loss of molar teeth in aged SAMP8 mice, *Behav Brain Res* 108:145-155, 2000.
3. Fiske, J, Davis DM, Frances C, et al: The emotional effects of tooth loss in edentulous people, *Br Dent J* 184:90-93, 1998.
4. Dharamsi S, MacEntee M: Dentistry and distributive justice, *Soc Sci Med* 55:323-329, 2002.
5. Gilbert GH, Duncan RP, Shelton BJ: Social determinants of tooth loss, *Health Serv Res* 38: 1843-1862, 2003.
6. Feine JS, Carlsson GE, Awad MA, et al: The McGill consensus statement on overdentures. Mandibular two-implant overdentures as first choice standard of care for edentulous patients. Montreal, Quebec, May 24-25, 2002. *Int J Oral Maxillofac Implants* 17:601-602, 2002.
7. Fitzpatrick B: Evidence-based dentistry—it subdivided: accepted truths, once divided, may lack validity, *Int J Prosthodont* 21:358-363, 2008.
8. Owen CP: Standards of care: good or evil? *Int J Prosthodont* 22:328-330, 2009.
9. Owen PC: Appropriatech: prosthodontics for the many, not just for the few, *Int J Prosthodont* 17:261-262, 2004.
10. Owen CP: New dentures from old: a duplication method using "appropriatech," *J Can Dent Assoc* 72:393-397, 2006.
11. MacEntee MI, Walton JN: The economics of complete dentures and implant-related services: a framework for

analysis and preliminary outcomes, *J Prosthet Dent* 79:24-30, 1998.
12. Bradbury J, Thomason JM, Jepson NJ, et al: Nutrition counseling increases fruit and vegetable intake in the edentulous, *J Dent Res* 85:463-468, 2006.
13. Stafford GD, Arendorf T, Huggett R: The effect of overnight drying and water immersion on candidal colonization and properties of complete dentures, *J Dent* 14:52-56, 1986.
14. Ellinger CW, Wesley RC, Abadi BJ, et al: Patient response to variations in denture technique. Part VII: Twenty-year patient status, *J Prosthet Dent* 62:45-48, 1989.
15. Owen CP: Guidelines for a Minimum Acceptable Protocol for the construction of complete dentures, *Int J Prosthodont* 19:467-474, 2006.
16. Rowe JW, Kahn RL: Successful aging, *Gerontologist* 37:433-440, 1997.

Bibliography

Carlsson GR, Omar R: The future of complete dentures in oral rehabilitation, *J Oral Rehabil* 37:143-156, 2010.
Cune MS, dePutter C, Hoogstraten J: Characteristics of 5410 edentulous implant candidates and the treatment they receive, *Community Dent Oral Epidemiol* 23:110-113, 1995.
Felton DA: Edentulism and comorbid factors, *J Prosthodont* 18:88-96, 2009.
Lewis DW: Optimized therapy for the edentulous predicament: Cost-effectiveness considerations, *J Prosthet Dent* 79:93-99, 1998.
MacEntee MI: An existential model of oral health from evolving views on health, function and disability, *Community Dent Health* 23:5-14, 2006.
McMillan JR, Conlon C: The ethics of research related to health care in developing countries, *J Med Ethics* 30:204-206, 2004.
National Bioethics Advisory Commission: *Ethical and policy issues in international research: clinical trials in developing countries,* vol I, II:A1-E30, 2001.
Population Reference Bureau: 2010 World population data sheet, Population Reference Bureau, Washington, DC.
Treadwell HM, Northridge ME: Oral health is the measure of a just society, *J Health Care Poor Underserved* 18:12-20, 2007.
Thomas CJ: A double alginate mandibular impression technique, *J Dent Assoc S Afr* 34:781-782, 1979.
United Nations Department of Economic and Social Affairs/ Population Division: *World population aging 2009*, New York, 2009, United Nations.
Walton JN, MacEntee MI: Choosing or refusing oral implants: a prospective study of edentulous volunteers for a clinical trial, *Int J Prosthodont* 18:483-488, 2005.

Index

A

Abnormalities (identification), radiographic images (usage), 75f
Abrasive dentrifices, usage, 154
Abutments
  attachment, 343f-344f
  concept, extension, 110
  design features, 98f
  height, difficulty, 381
  loss, 112
  relationship, 380-381
  roots, selection, 109
  screw
    fracture, 384
    removal, 384
  teeth, gingival response, 295
  try-in, panoramic radiograph, 345f-347f
  usage, 24f-25f
Abutment teeth
  endodontic status, 109-110
  location, 109
  loss, 111-112
  periodontal/mobility status, 109
  selection, 109-110
Acantholysis, areas, 29f
Acoustic analysis, 320
Acquired immunodeficiency syndrome (AIDS), impact, 35
Acrylic composite teeth, wear resistance, 208
Acrylic denture bases, fracture, 312
Acrylic production, attempts, 311
Acrylic resin
  bases, usage, 111
  denture base, weakness, 107
  differentiation, 69-70
  dough, making, 263
  interim obturator, follow-up examination, 357f
  palatal flange, 382
  popularity, 208
  posterior projection, addition, 364-365
  processing, 263
  replacement, 277-278, 304
  teeth, usage, 260-263
  templates, usage, 90
  tray, projection, 364-365
  usage, 356
Acrylic show-through spots, indication, 268
Acrylic teeth, trimming, 250f
Adaptation, technology, 419
Adaptive complete denture experience, patient sign/symptoms, 98b
Adaptive denture experience, 330
Adaptive prosthodontic experience, oral-systemic conditions (impact), 29b
Adaptive responses, 21-22
Addition silicones, 129
  automatic mixing systems, 129
  base, 129b
  disinfection, 131
  hydrophilized addition silicones, 129
Adhesive promoters, usage, 142
Adjacent teeth, positions (reference), 288f
Adjunctive prosthodontic protocols, combination, 18
Adjunctive retention, denture adhesives (usage), 156
Adjustable condylar guidances, 198-199
Adjustable incisal guidance controls, 199
Adult dentition, dental adaptive mechanisms (restriction), 13
Adult occlusion, development, 9-13
Advanced residual ridge resorption
  mental foramina, placement, 85f
Advanced residual ridge resorption, evidence, 61f-62f
Affricative consonants, 316-317
Agar (reversible hydrocolloid), 125-126
  biocompatibility, 127
  composition, 125-126, 125b
  conditioning unit, usage, 126
  disinfection, 126
  hydrocolloids, strain-rate dependence, 127
  impressions, making, 126
  manipulation, 125-126
Age, concealment (Western preoccupation), 39
Age (increase), visual acuity (diminishment), 60
Age-related skin changes, 58f-59f
  impact, 188f
Aging population, 35
  edentulous mouth, age (impact), 36-37
  nutrition, impact, 37
  self-image, worry, 39
  taste/smell, 37
  teeth, impact, 38
Aging process, visual impact (modification), 59-60
Aging skin, 38
Aging teeth, 38
Aging woman, dentures (impact), 2f-3f
Air flow, adjustment, 315
Ala-tragus line, occlusal plane (relationship), 189-190
Alcohol consumption habit, dentist enquiry, 55
Alcohol torch, puffs, application, 228f
Alginate impressions, 126f
  extension, 170f
  making, 205
    errors, 127t
Alginates
  agar hydrocolloids, 127
  biocompatibility, 127
  composition/setting reaction, 126b
  dustless alginates, production, 126
  gypsum, usage, 127
  irreversible hydrocolloid material, 126-127
  manipulation, technical considerations, 126-127
  mixing bowl, usage, 127
  mixing time, 127
  sol-gel reaction, 126
  usage, 127, 336-338
  versatility, 126
Alkaline hypochlorite, avoidance, 154
Alkaline peroxides
  provision, 154
  solution, overnight immersion, 154
Alloplastic material
  asymptomatic rigid fixation, 101, 323
  functional loading, 323
  usage, 91f
Alloy restorations, 110
Alma gauge, usage, 233f
Aluminum oxides, short-term clinical results, 324
Aluwax contacts, tripod, 244f
Alveolar bone
  assessment, 345
  contrast, 12f-13f
  integrity, maintenance, 9
  loss
    excess, impact, 90
    response, 21-22
  maintenance, 94f-95f
  preservation, 110
    overdenture retained roots, presence, 293f
  progressive resorption, 42
Alveolar form, restoration, 355-356
Alveolar groove, 164f
Alveolar jawbone, demarcation (resorptive patterns), 402f

Page numbers followed by "f" denote figures, "b" denote boxes, and "t" denote tables.

Alveolar resorption, impact, 312
Alveolar ridges
  reduction, 184-186
  resorption, 9
    consequence, 44
    severity, 279f
  resorptive changes, 192
  undercuts, 85f
    presence, 63f-64f
Alveolar sounds
  controlling valve, 318
  production, 318
Alveolar speech sounds, 309
Alveolingual sulcus, position, 71
Alveolus
  controlling valve, 318
  sound production, 317-318
Alzheimer's disease, taste sensitivity (decline), 37
Amicrobial deposits, presence, 46f
Amorphous silica filler, 140-141
Amyotrophic lateral sclerosis, hypersalivation (association), 31
Anatomical posterior molds, interdigitation, 221
Anatomical slice, capture, 74-76
Anatomical structures, scouting, 332
Anatomical teeth
  cross-tooth/cross-arch articulation, 221f
  occlusal errors, elimination, 271-272
Angle class 2 division 1, 225-226
Angle class 3 (prognathic patients), 226
Angle class I occlusion, 68
Angle class II division 1, 225f-226f
Angle class II division 2, 225f-226f
Angle class III skeletal relationship, 248
Angled abutment, usage, 382
Angular cheilitis, 38f
  Candida-associated stomatitis, presence (correlation), 47
Ankylotic-like osseointegrated implant abutments, support, 330
Anterior anatomy, tray recordation, 285f-286f
Anterior angle class II division 2 smile prominence, 222f
Anterior bone resorption, result, 19f-20f
Anterior chin, thumb placement, 241-242
Anterior contact, assessment, 366
Anterior crossbite, 226f-227f
Anterior dorsum, groove (formation), 318-319
Anterior edentulous zones, sagittal views, 332f
Anterior excursion stability, balancing side ramp (usage), 223f
Anterior flanges (periphery), holes (drilling), 356
Anterior freedom, 210
Anterior labial maxillary frenum, 72f
Anterior landmarks, joining, 189
Anterior localized ridge resorption, occurrence, 61f-62f
Anterior mandibular coverage, 369
Anterior mandibular residual ridge reduction (RRR), impact, 87f
Anterior mandibular ridge, curvature/ovoid shape, 333-334
Anterior mandibular teeth, 48
Anterior maxilla, implant placement (limitation), 345
Anterior maxillary frenum, irritation, 277f
Anterior maxillary teeth extractions, impact, 187f
Anterior occlusal contacts, heaviness, 149
Anterior occlusal plane, measurement, 246-248
Anterior open bite, 245f
Anterior overlap, 223f
Anterior residual ridge shape, achievement, 333f
Anterior ridge undercut, impact, 113
Anterior right central, setting, 245f
Anterior segments, indexing, 282
Anterior teeth
  anteriors only try-in, 215
  anteroposterior (A-P) position, 317
  arrangement, 336
  chipping, 251f
  contact, posterior wax cones (registration tripod), 286f
  esthetic festooning, 258f
  horizontal overlap, 318
  horizontal relation, 319f
  inclination, 225f
    impact, 320
  labiolingual inclinations, 214f
  labiolingual position, 317-318
  length, modification, 60
  low incisal guide angle, 212f
  mesiodistal inclination, 214f
  overbite-overjet relations, 201
  positioning, 309
  positions, assessment, 238f, 336
  retention, 281
  single impression tray, usage, 282
  vertical length, 319f
Anterior tooth arrangement guide (ANTAG), 412, 413f-415f
Anterior tooth selection (ATS)
  clinical considerations, 208
  completion, 204
  implant dentures, 208
  importance, 204-205
  overdentures, 208
  patient input, 204-205
  patient preferences, 208
  technical considerations, 208
Anterior windows, denture teeth replacement, 392f
Anterior zone locations, selection, 403-404
Anteroposterior (A-P) compensating curves, 219
Anteroposterior (A-P) jaws, relationship, 76
Anteroposterior (A-P) tooth positions, simulation, 190-191
Antibacterial rinses, usage, 298
Antibiotic therapy, usage, 378
Antifungal agents, usage, 47
Antifungal therapy, prosthodontic management (combination), 46f
Antioxidant molecules, incorporation, 149
Apical lesions, 108-109
Aponeurosis, 165
Appetites, reduction, 50-51
Aramid fibers (Kevlar fibers), inclusion, 139
Arch form
  acceptance, confirmation, 287f
  contour, 182-184
  design, 182-188
  end result, 184-186
  optimum, 78
  position, 180
Arch relations, 68-69
Arcon-type articulator, 197f-198f
Articulated diagnostic casts, analysis, 107-108
Articulating ribbons, usage, 272
Articulation
  balance, anatomical teeth (arrangement), 221
  bilateral balance, evaluation, 221
  influence, 318
  usage, 198
Articulator, 197-198
  anterior (incisal) elements, programming, 200
  capability, 199
  condylar elements, 200-201
  dentures, remounting, 305
  example, 197f-198f
  facebow transfer, hinge-axis location, 196
  incisal elements, 201-202
  laboratory steps, 196-197
  mandibular member, remounting jig/index (positioning), 265
  master casts, mounting, 209
  maxilla, relationship, 196
  maxillary member, maxillary remount cast (attachment), 266f
  movement, accuracy, 198-199
  occlusion rims, transfer/preparation, 194b
  patient, relationship, 195-197
  plaster mountings, cast reattachment, 265f
  posterior (condylar) elements, programming, 200
  programming, 200-202
  remount, requirement, 183f-184f
  remount cast, mounting, 271f
  semiadjustable articulator, extremes, 200
  settings, arbitrariness, 202
  simplicity, 197
  structural control, 316f
  teeth, setting, 243-246
  upper base/model, 246-248
  usage, 316-317
Articulatory details, interindividual variation, 318
Artificial anterior teeth, anteroposterior positioning (indications), 211f

Artificial class I occlusion, 68
Artificial lower teeth, lower lip (relationship), 213f
Artificial stone
  mixture, 179
  pouring, 265
Artificial teeth
  arrangement, 13
  impact, 236f-237f
  setting, 184
Ascending mandibular ridge, occlusion (avoidance), 219-221
Ascending ramus, external oblique ridges (contact), 167-168
Astra Tech OsseoSpeed implant, 327f
Atrophic maxilla, 345f-347f
Attachment
  matrices, commercial production, 337f
  mechanism
    difference, 323
    failure, 100-101
  method, 333-334
Attachment system
  choice, 336
  maintenance, 338
  selection, guidelines, 335-336
Auditory feedbacks, 315-316
  impairment, 320
Autism, hypersalivation (association), 31
Auto-antibodies, presence, 30-31
Autoimmune type III hypersensitivity reaction, 28
Autologous bone grafting/implant placement, 91f
Autopolymerizing acrylic resin
  powder, usage, 310
  usage, 343f-344f
Autopolymerizing resins, 136
  base, composition, 180-182
  usage, 312, 390f-391f
Axial forces, establishment, 299

B

Backscatter, noble metals (impact), 373
Balanced articulation, 223-225
  presence, 221
Balancing contacts, 413f-415f
Balancing ramp, usage, 223
Balancing side posterior ramp, usage, 223
Balancing side ramp, usage, 223f
Ball abutments
  facilitation, 336-338
  type/size, 336
  usage, 333f
Ball attachments, indications, 336
Ball burnisher, usage, 165f
Ball magnets, usage, 333f
Bar attachments, indications, 336
Bar designs (retentive clips), matrices, 338
Bare tooth root preparation, usage, 110
Bar segments, engagement, 337f
Basal area, reduction, 63f-64f
Basal jawbone, demarcation (resorptive patterns), 402f
Basal seat area, inflammation, 61f-62f
Basal surface errors, elimination, 267
Base metal alloys
  advantages, 153b
  biocompatibility, 152
  chemical properties, 151
  clinical implications, 153b
  corrosion resistance, 151
  disadvantages, 153b
  elastic modulus, 151
  elongation, percentage, 151
  mechanical properties, 151
  physical properties, 151
  properties, 151-152
Baseplate obturator, usage, 357
Baseplate surgical obturator, modification, 357f
Baseplate wax, 180
  placement, 173-174
Bases
  movement, feeling, 242f
  stabilization, 241f
Base-tooth interface, porosities (presence), 142
Behavioral responses, 21-22
Bell's palsy, 188-189
Benign bony enlargements, 67
Bennett shift (direct lateral shift), variable controls, 199
Benzoyl peroxide, additives, 135
Bicortical implant placement, importance, 371f
Bidigital palpation, usage, 66
Bilabial sounds, 317
Bilabial stops, 321
Bilateral balance, 215
Bilateral balanced articulation, evaluation, 221
Bilateral balanced occlusion, establishment (difficulty), 299-301
Bilateral bony support, loss, 369-370
Bilaterally balanced occlusion, establishment, 301
Bilateral occlusal contact, 215
Bilateral posterior tooth contacts, creation, 299
Bilateral undercuts, interference, 267
Biocompatibility, requirement, 121
Biocompatible alloplastic material, usage, 100
Biologic price, 77
Biomaterials, requirements, 122b
Biomechanical support, 4-8
  mechanisms, 8-9
Biomet 3i Nanotite implant, 327f
Bisphosphonate-related osteonecrosis (BRON), 400
  development, 400-401
Bisphosphonates
  impact, 36
  therapy, 400-401
Bite examination, 413f-415f
Bite registration wax, 284-287
Biting forces, transmission, 8
Blockout material, removal, 266f
Blood clotting, interference, 378
Blood-thinning medications, usage, 28
Body
  image, changes, 55-56
  schema, emotional meaning, 55-56
Boley gauges
  try-in equipment, 232
  usage, 233-234
Bonding agents, addition, 148
Bonding resin, 296f
Bone
  anabolic processes, excess, 370
  augmentation, 340
  calcified ground substance, response, 325f
  contact, success, 324
  contour, alteration, 289
  dentures, fixed relationship (maintenance), 22
  formation, increase, 372-373
  grafting procedures, 403
  height
    measurement adjustments, 332f
    reference, 10f-11f
  homeostasis, hormonal influences, 400
  horizontal loss, continuation, 371f
  impact, 36
  implants, metallic implants (direct contact), 323-324
  maintenance levels, 97f
  mass
    maximum, 36
    reduction, 400
  maturation, 341-342
  metabolism, 36
  metallic implants, direct contact, 323-324
  morphology, changes, 305
  osseointegrated implant, bond, 324
  quality, 332, 402-403
    classification, 402
    sites, compromise, 335
  quantity, 332, 403
  reduction
    cause, 49
    generalization/unevenness, 10f-11f
  regenerative potential, 401
  responses, 324
    display, 328f
  ridge morphology, 66-67
  sequestration, 373-374
  sites
    compromise, 326
    improvement, 403
  stability, 388
  stage I surgical complication, 381
  structure
    loss, 308f
    positions, panoramic film (usage), 340
  support, two-dimensional quantity, 75f
  tissue
    continuous loss, 48
    pores, minimal size, 325f

Bone *(Continued)*
turnover, 36
increase, 372-373
vascularity, 401
vitality, cellular changes, 401
volume, questions, 340
Bone loss
occurrence, 184-186
penciling, 288f
risk, reduction, 12f-13f
Bone mineral density (BMD) scores, 400
Bone morphogenetic proteins (BMPs), 403
Bone resorption, 83-84
acceleration, 77-78
impact, 238f
increase, 398-399
Bone-to-implant contact, 324
Boney remodeling, necessity, 370
Bony margins, border molding, 354-355
Bony morphology, variations, 85f
Bony prominences, 80-83
removal, 80
Bony sinus walls, resection, 356
Bony support, absence, 368
Bony undercuts, 67-68
Border limits, 198-199
Border-molded impressions, making, 267
Border molded palatal seal, 178f
Border molding, 128, 353-355
material, usage, 282
peripheries, 354-355
process, usage, 177-178
stability/retention, maximization, 176
usage, 174-176
Border seal, creation, 176
Border tissues (trauma), flanges (impact), 63
Boxing, stone confinement, 179f
Boxing impressions, cast making, 178-179
Boxing rope wax, attachment, 178
Boxing wax
sealing, 178-179
sheet, attachment, 178
Brånemark, Per Ingvar, 95
osseointegration technique, 96f
Bruising, 378f
history, 378
Bruxism
hyperkinetic oral movement, 29-30
neurophysiological basis, 15
Bubble-free stone casts, pouring (simplification), 129
Buccal cusps, elevation, 223f-224f
Buccal fat pads
atrophy, 38
Fordyce's granules, 62
Buccal flange, 164f
Buccal forces, estimates, 8
Buccal frenulum (frenula)
examination, 71-72
labial sulci, relationship, 71
Buccal frenum
attachments, 177f
placement, 175f
posterior movement, 279f
Buccal inclination, presence, 380
Buccal mucosa
contact, 21-22
lesions, 276
tongue, suturing, 367f
Buccal muscle, sulcus deepening procedure (surgical detachment), 88f-89f
Buccal notch, 164f
left buccal border, 279f
Buccal pressure ulcer, development, 291f-292f
Buccal shelf, 165-166
cortical bone, 166f
Buccal upper and lingual lower (BU-LL), 264
Buccal vestibules
deepening, 93-94
location, 165
posterior extension, 167
Buccinator muscles, 167-168
attachment, 169f
contraction, 188-189
Built-in occlusal errors, 304-305
Bunsen burner
try-in equipment, 232
usage, 246
Burning mouth, tolerance, 176
Burning mouth syndrome (BMS), 28-29
causes, documentation, 29b
diagnosis, subjective reports (usage), 28-29
etiological factors, 29
management, 29
Sjögren's syndrome (SS), association, 28-29

C

Calcium carbonate, usage, 154
Calcium supplementation, 327
Calculus, excess, 283f
Camper's plane, parallelism, 301
Cancellous patterns, 402f
Candida albicans growth (inhibition), antifungal drugs (usage), 47
Candida albicans infections, suspicion, 63
Candida-associated denture stomatitis, 45
diagnosis, 45
etiology, 45-47
factors, 45b
local factors, 45
management, 47-48
predisposing factors, 45-47
preventive measures, 47-48
systemic factors, 45
Candida-associated stomatitis (presence), angular cheilitis (correlation), 47
Candida biofilms, role, 45
Candida infection, superimposition, 65f
Candida species, resistance, 47
Candidiasis, oral consequence, 31
Canines, anterior position, 215
Cantilevering, elimination, 342
Cap, placement, 360
Carbohydrate digestion, continuation, 14
Carborundum paste, usage, 272
Cardiovascular disease, history, 318
Care
continuum, MAP basis, 410
standards, 410
Caries
challenge, 108f
development, 107
extent, 74
level, impact, 3
susceptibility, 110
Cast copings, usage, 110
Cast Cr-Co mesh reinforcement, 299f
Cast irregularities, 289
Cast mesh, embedding, 299f
Cast metal alloys
denture base, 149-152
materials, choice, 149-151
technical considerations, 149-151
Cast metal superstructure fabrication, 107
Cast restoration technique, 110
Cast surgery
impact, 355-356
performing, 289
Cell cultures, cytotoxic effects, 149
Cellularity, loss, 370
Cementoenamel junction (CEJ), 257
display, 258f
Cements, addition, 148
Cement wax, usage, 313
Center screw, usage, 380
Central incisors
incisal edges, 192
midline setting, 209
sagittal view, 193f
Central looks, 206f
Central nervous system (CNS)
deficits, 352
sensory inputs, interpretation, 21
Centric occlusion (CO)
mandibular position, 16f-17f
position
contact, 368
patient-generated position, 368
Centric relation (CR)
concepts, 16-18
contacts, establishment, 271-272
definition, 18
employment, 18
horizontal mandibular reference position, 192
preliminary record, 192-195
verification, 269
Centric relation occlusion (CRO)
correction, 114
errors, correction, 271f
loss, 305
record, creation, 311
usage, 309
Centric relation (CR) position
static relationship, 198
understanding, 16f-17f
unlocking, 200

Centric relation (CR) record, 269
clinician material, usage, 284-287
endorsement, 194
inaccuracy, 353
marking, 182
obtaining, 270f
problem, 195
prostheses, luted position, 391f
Cephalometric films, usage, 332f
Cephalometric radiographs, faciolingual dimensions, 332
Ceramic mandibular prosthesis, construction, 342f
Ceramometal prosthesis, cement retention, 345f-347f
Cerebrovascular accidents, 352
Cerebrovascular disease, systemic consequence, 31
Chairside hard reline, placement, 291f-292f
Chairside technique, 311
Chamfer subgingival margins, 296f
Check-bite record, 192-194
Cheek biting
avoidance, 360
posterior denture teeth, impact, 44
traumatic ulcers, relationship, 44
Cheeks, 58-60
buccal mucosa, lesions, 276
external form, dependence, 58-59
lining mucosa, 61-62
movement, 352
muscles, training, 273
peak forces, estimates, 8
retraction, 169f
thickness, 59-60
Chemical bonding, usage, 142
Chemical denture cleansers, 154
Chemically activated methacrylate resins, usage, 147-148
Chemically activated methyl methacrylate monomer, usage, 142
Chemically activated resins, 136
properties, 138b
Chemically activated silicone liners, 148-149
Chemical staining, 69-70
Chewing
efficiency, decrease, 50
inability, 369
increase, importance, 32
initiation, 274
occurrence, 14
patterns, 273
performance, objective comparison, 156
Chlorhexidine acetate, usage, 126
Chlorhexidine mouthwashes, usage, 110, 335
Chlorhexidine rinses, 378
Chroma, deepening, 38
Chrome-cobalt alloy, 337f
Chromium-containing alloys, 151
Chronic denture-related mucosal irritation, oral cancer (relationship), 48
Cigarette smoking, association, 398-399
Cineradiography, 320
Circummandibular wires, 90
Circumoral changes, dentate woman, 2f-3f
Circumoral morphology, demands, 24f-25f
Circumoral muscle activity, maxillary gingival tissue (display), 382
Circumoral support, 58f-59f
consideration, 182-184
information, 76
maintenance, 113
Class I Kennedy removable partial denture, 333f
Class II malocclusion, 317-318
impact, 68
Class II mobility, 109
Class III malocclusion, impact, 68
Class III mobility, 109
Class III soft palate form, 177f
Clear overjet, 213f
Cleft palate, 364
congenital deficit, 352
Clinical crown length, reduction, 190
Clinical remount, 268-269
casts, fabrication, 265
Clinical sessions, 411-416
Closed-mouth recordation, 368f
Closed-mouth reline/rebase procedure, 309
preference, 309-310
Closed-mouth reline technique, 309b
Closing arcs, 242
Cobalt-chromium alloy, 151
usage, 149-151
Cobalt-chromium framework, 338
Cobalt-chromium-nickel alloy, 151
usage, 149-151
Cobalt-containing alloys, biocompatibility, 152
Cold compresses, usage, 378
Cold-curing acrylic resin, 180
Cold-curing resins, 136
Cold water bath, try-in equipment, 232
Collapsed class III profile, 240f
Color, characterization, 250f
Columella, anatomical landmark, 76
Commercially available attachment systems, diversity, 330
Commercially available implants, example, 325f
Commercially pure titanium (CP Ti)
alloys, 152
biocompatibility, 324
machined-surface CP Ti implants, 341
softness, 326f
superiority, 152
Communication, schema, 316f
Community-based nutrition programs, usage, 33
Compensating curves/ramps, usage, 215
Compensatory mechanism, 364
Compensatory pharyngeal constriction, increase, 365
Complete dentures
acceptance, 21
acrylic resin, usage, 94f-95f
Complete dentures *(Continued)*
adaptation, feedback mechanisms, 315-316
adaptive experience, 19f-20f
balanced occlusion, advantages, 272-273
biomechanical support mechanisms, 8-9
chairside technique, 311
clinical impression procedures, 309-312
clinical sessions, 417-419
construction, 16, 198-199
MAP guidelines, 411b
principles, 9, 295
creation, biomaterials (requirements), 122b
delivery, 267-275
dentogingival support, overdenture abutments (usage), 103f-105f
diagnosis, 304-306
direct sequelae, removable prostheses (impact), 43b
duplication, 313-314
usefulness, 313-314
examination, 332-333
fabrication, 1, 16-18, 200, 298
acrylic resin, usage, 312
clinical/laboratory protocol, 338
foundations, 80
functional impression technique, 310-311
functional stability, surfaces involvement, 256f
impact, 42
laboratory sessions, 418
making, articulator (selection), 200-202
metallic components, fractures, 312
method, 410-416
modification, 343f-344f
natural teeth, contrast, 14
neuromuscular pattern conformance, 315
occlusion, occlusal concepts, 215-225
patient selection, 340-342
preliminary treatment, 306-309
prosthetically maladaptive label, 22
prosthodontics
esthetic visual clues/decisions, 4f-5f
treatment methods, 1-3
repairs, 312-313
reproduction, 416-419
retention, 70-71
components, failures, 312-313
service
characterization, 13
requirement, 303
speech adaptation, 320
standard setup, 210
success, information, 313
support, amount, 68
surfaces, 180
design, 181f
temporary repair, 313
time-dependent changes, 42
tissue surface/teeth, calculus deposits, 153f
treatment, 20-21
completion, 58f-59f
objectives/methods, description, 23

Complete dentures *(Continued)*
options, 22-23
outcomes, 318
rationale, 303-304
usage, 8-9
sequelae, control, 42, 51
wearers, medial pterygoid muscles (atrophy), 50
wearing
prognosis, 28
time-dependent consequences, 51
Complete Dentures in Four Clinical Sessions (CD4)
basis, 410
technique, materials usage, 410
Complete denture teeth
landmarks, stone model location, 209
position, guidance, 209
provisional substitutes, wax occlusion rims (usage), 183f-184f
setup, landmarks (usage), 209
usage, 180
Complete edentulism, management, 99f
Completely edentulous patients, implant placement, 50
Complete upper denture, 48
Complications, 377-385
list, 377t
surgically related complications, 377-380
Component hardware fractures, occurrence, 384-385
Component loosening, incidence (increase), 380-381
Composite resin denture teeth, 134-139
Composite restorations, 110
Composites
improvements, 208
Compounds
impressions, usage, 365
placement, 175f
preliminary impressions, 172f
records, chilling/drying, 269
types, 124b
ZOE wash impression, combination, 123f
Compromised bone quality sites, 335
Compromised teeth, casting (requirement), 296f
Computer-guided technology, introduction, 405
Concave lingual polished surface, denture base accommodation, 259f
Condensation silicone, 128-129
base, 129b
components, 128-129
disinfection, 131
Condylar distances, variation, 199
Condylar elements, 200-201
setting, 201f
Condylar guidances, 198-199
adjustable incisal guidance controls, 199
split-axis condylar guidance controls, 199
Condylar housing, presence, 200
Condylar movements
joint sounds, 57-58
start/end points, 199f
Condyle rods, position, 196
Condyles, teeth (relationship), 197f-198f
Cone beam computed tomography (CBCT)
advantages, 401-402
scans, 340
usage, guidelines, 402
Cone-beam images, usage, 332
Connecting bar splints, usage, 333f
Connective tissue interface, differentiation (problem), 94f-95f
Consensus Conference on Treatment Outcome Criteria (University of Toronto), 101
Consonants
English consonants, valve positions/production modes, 317t
nasal consonants, production, 316-317
production, 316-317
Contact dermatitis, risk, 136
Contacting tissues, short-term/long-term health, 161
Controlling valve, 318
Conventional immediate denture (CID), 113-114
comparative indications, 115t
planning, 117f
Conversion prosthesis, insertion, 343f-344f
Cope (middle portion), 257-260
placement, 260
Coping
designs, 111f
prosthesis (relation), autopolymerizing acrylic resin (usage), 343f-344f
provision, 110
usage, 361f
Copolymers, formation, 133
Corner of the mouth-retromolar pad (CM-RMP), 222
Coronary artery disease, systemic consequence, 31
Coronoid bulge, 164f
Coronoid contour, 164f
Cortical bone
covering, 67
density, 334-335
lingual bilateral prominences, 166
Cortical information, synergy, 315
Cortical patterns, 402f
Cosmetic industry, profits, 39
Cover screw, protection, 380
Cracks, presence, 74
Craze
definition, 133
resistance, 133
Creep, definition, 133
Cross-arch articulation, 221f
Cross-arch stabilization, maintenance, 215
Cross-linking, 133
Cross-tooth articulation, 221f
Crown-and-sleeve coping retainer, requirement, 110
Crown preparations, subgingival margins, 406
Crown resection, 294
Crown to root ratio, reduction, 290
C-terminal telopeptide, serum levels (focus), 400
Cured PMMA, application, 133
Curved condylar movement, start/end points, 199f
Curved occlusal plane, nonanatomic teeth (setting), 223f-224f
Curve of Spee, 219
Curve of Wilson, 219
Cuspal anatomy, 208-209
Cuspid length, natural state (similarity), 258f
Cuspid teeth
compensating curve, 223f-224f
distal, 223f-224f
size/shape, blending, 209
Cuspless prosthetic teeth, setup, 202f
Cuspless teeth, selection, 215
Custom abutment, usage, 382
Custom-contoured wax occlusion rims, notching, 183f-184f
Customized acrylic resin templates, usage, 90
Custom tray
borders, determination, 173
impression, alginate (usage), 284f
seating, 177f
try-in, 390f-391f

D

Dead space, development, 295
Debridement/cleansing, 378
Deep anatomical space, creation, 367-368
Deep crypt formations, surgical elimination, 47
Deflasking, 134
stone mold, impact, 257-260
Degenerative skin changes, impact, 188f
Deglutition
facilitation, 355-356
occurrence, 8
Dehiscence
cover screw, 379-380
occurrence, 379f
osteopromotive membrane, usage, 380
Dehydration, impact, 31
Dekeratinized/desquamated filiform papillae, appearance, 29f
De novo bone, maintenance, 403
Dental adaptive mechanisms, restriction, 13
Dental arch, 205
midline determination, incisive papilla (usage), 210f
Dental caries, 390f
patient susceptibility, 293
risk, elimination, 298
Dental efficiency (impairment), partial tooth loss (impact), 18
Dental extraction, 362f-363f
resorptive remodeling, 161

Dental fabrication techniques, usage, 366
Dental floss, usage, 237f
Dental histories
  collection, 54
  knowledge, restriction, 54-55
Dental implants
  example, 345f-347f
  immediate load, 388
  macroscopic designs, proposal, 387
  placement, 344, 400
  usage, 294, 298
    dental caries, risk (elimination), 298
Dental impression compound, 123
  cast, pouring, 125
  disinfection, 125
  setting mechanism, 124
  softening, 124
  types, 124-125
  viscosity, 125
  water, incorporation, 124
Dental interventions, usage, 72
Dental materials
  advances, 113
  biodegradation, 121
  manufacturer provision, 121
  types, presence, 42
Dental midline, facial midline (relationship), 287
Dental needs, problems (focus), 56
Dental occlusion, checking, 239
Dental plaster, usage, 257-260
Dental procedures, modification, 351
Dental prostheses
  facial skeleton, linking, 23
  insertion, 44
Dental radiology, CBCT usage guidelines, 402
Dental restoration
  biocompatibility, 121
  defect, 390f
Dental retention, absence, 353
Dental sounds (creation), tongue tip (usage), 317-318
Dental speech, 309
Dental status, impact, 31-33
Dental stone
  improvement, 261f-262f
  usage, 257-260
Dental team, skills (impact), 55
Dental treatment, seeking, 20-21
Dentate
  edentulous state, transition, 6f-7f
  mandibular movement patterns, 14
  woman, facial/circumoral changes, 2f-3f
Dentate jaw, arch form, 301
Dentate mandibular dentition, 185f
Dentition
  development, characterization, 9-13
  opposing dentition, evaluation, 281
  replacement, 204
  resetting, 248
  restoration, 30f
  soft tissue behavior, impact, 184
Dentsply shade 102, 250f
Dentsply shade 114, 250f
Denture adhesives, 155-158
  adverse reactions, 158
  application, 158
  contraindications, 156-158
  indications, 156-158
  promoters, usage, 142
  removal, 158
  requirements, 158b, 357
  retention usage, 360
  summary, 158-159
  usage, 156, 353, 360
Denture bases
  acrylic, 221
  acrylic bases, fracture, 312
  adjustment, 267-268
  cast dental alloy, requirements, 151b
  cast metal alloys, usage, 149-152
  cross-arch stabilization, maintenance, 215
  excess, adjustment, 71-72
  extensions, 70
  impact, 236f-237f
  lingual surface, tongue position, 259f
  materials, 180
    classifications, 140t
    cytotoxicity, impact, 263
    requirements, 133b
  porosity, 134
  pressure transfer, 21-22
  radiopacity, 136
    improvement, 136
  resins
    chemical composition, 133b
    technical considerations/properties, 134-139
  retention, acrylic resin (usage), 338
  retentive elements, adjustability/replaceability, 293f
  shaping, 255
  sliding, 245f
  trial, 246
Denture-bearing area
  anatomic location, pencil outline, 126f
  creation, 162
  enlargement, 86-90, 330
  features, absence, 22
  firmness, 63f-64f
  impression, 123f
  tissue conditioner, distribution, 145f
Denture-bearing foundations, improvement, 77-90
Denture-bearing mucosa, 9
Denture-bearing support, compromise, 10f-11f
Denture-bearing surface, impact, 93-94
Denture-bearing tissues
  forces, transmission, 180
  optimal health, achievement, 78-79
Denture-bearing tissues, recovery, 78
Denture borders
  adjustment, 268
  outline, 170f
Denture borders *(Continued)*
  overextension/sharpness, 62-63
  polished surface shape/thickness, 58-59
  recess, 176
Denture cleansers, 152-155
  adverse reactions, 155
  dilute acids, usage, 155
  disadvantages, 156t
  enzymes, usage, 155
  materials, 154-155
  mechanical techniques, 154
  microwave radiation, 155
  requirements, 153b
  silicone polymers, usage, 155
  summary, 155
  techniques, 154-155
  ultrasonic units, 154-155
  usefulness, 310-311
Denture fabrication, 1
  light-activated materials, usage, 136
  materials, usage, 70f
  plastics, usage, 136
  success/failure, 55-56
  teeth, usage, 139
Denture flanges
  lateral turn, 169-170
  position, 44f
  reduction, 358
  support, 71
Denture hygiene
  absence, 44-45
  necessity, 47
  procedures, 69-70
Denture prosthesis, posterior extension (addition), 364
Denture-related problems, treatment (rarity), 35-36
Denture retention
  contributing factors, 157t
  devices, 333
  ensuring, implant abutment (availability), 330-331
  increase, muscular factors (usage), 9
  physical factors, involvement, 9
Dentures, 69-72
  adaptation, 21
    patient motivation, impact, 22
  age, 44-45
  alkaline peroxide solution, overnight immersion, 154
  anatomical borders, 358f
  anterior part, food collection, 383
  anterior segment, support, 186
  attention, requirement, 303-304
  axes, rotation, 303
  basal seat, mental foramina (relationship), 74
  bone, fixed relationship (maintenance), 22
  built-in occlusal errors, 304-305
  care, problem, 152
  cast, 253f
  centric relation occlusion (CRO), loss, 305

Dentures *(Continued)*
chemical denture cleansers, 154
cleansing, 153-154
comparison, 233-234
completion, delivery, 267-275
construction
facial tissues, tone (importance), 57
muscular control/coordination, impact, 57
control, optimum, 21
defects, 44-45
deposits, presence/accumulation rate, 152-153
design, interference, 67
diet, quality (factors), 33
disinfection, 153-154
displacement, reduction, 208-209
distal extension, 167-168
drying, 267-268
duplication, 313-314
usefulness, 313-314
effect, histologic studies, 162
facebow orientation, preservation, 269
facial aspect, 44
failure, 78-79
faults, self-reports, 37
finishing, 265
fit, intraoral evaluation, 70-71
flasks, partial filling, 261f-262f
foundation, morphological changes, 299
fracture, management, 312
functional stability, surfaces (involvement), 255
horizontal position, 305-306
hydration, 265
hygiene, maintenance, 153
impression, overextension, 170f
initial adjustment appointment, 277-278
initial placement, interference, 267
insertion
salivary flow rate, increase, 31
teeth removal, 289
instability, 60
problem, 61-62
intaglio surface, microbial plaque, 46f
irritation hyperplasia, 44
severity, 44f
lateral stability, 169
limitation, patient education, 273
lining materials, 144-149
clinical success, 144
summary, 149
usage, 144
luted transfer components, usage, 392f
maladaptive behavior, 93-95
malnutrition, risk factors, 32b
master cast, placement, 260
maximal bite force, 14
maximum distal extension, 71
metallic components, fractures, 312
nutrition
goals, 33
provision, 33
occlusal dentures, 192
Dentures *(Continued)*
opposing occlusal surfaces, 181f
oral environment, 42
oral hygiene, 274
oral-systemic conditions, supporting tissue vulnerability, 28
overextension, anterior maxillary frenum irritation, 277f
oxygenating cleansers, 154
palatal sounds, problem, 319-320
peripheral extensions, 72f
peripheral overextensions, traumatic lesions, 65f
peripheries, 336
periphery, border seal (achievement), 80
placement
timing, 373-374
tissue conditioner, usage, 295
polished surfaces
alginate pressing, 417f-418f
sloping, 208-209
polishing, 265
porcelain teeth, usage, 260-263
posterior border, 249-251
posterior lingual flanges, extension, 63f-64f
processing, 255-265
compression-molding technique, 142
relief, 67
remounting, 268-269
reorientation, 304
replacement, 50
rinsing, patient instruction, 274
sagittal diagrammatic view, 252f
seating, 158
problem, 267
spare set, patient request, 313
stabilization, 274
stomatitis, 44-48
etiological factors, 44-45
sequelae, 152
support, mucosa (mean area calculation), 8
surface
dry foods, adherence, 374
fitting, 47
time-dependent mechanical factors, 49
tissue-bearing surface, undercut (blocking), 266f
tissue surface, micropits/microporosities, 45-47
tissue surfaces, cleaning/drying, 158
try-in, water (provision), 255-257
visibility, absence, 238f
waxing, 255-265
Denture sore mouth (DSM) (development), palatal mucosal irritation/infection (impact), 43f
Denture stability
assessment, 23
increase, denture-bearing surface (impact), 93-94
occlusal contacts, impact, 289
Denture stability *(Continued)*
primary denture-bearing areas (enhancement), parallelism (impact), 68-69
provision, 23
ridge height reduction, impact, 67
Denture-supporting mucosa, variation, 267
Denture-supporting structures, 122
Denture-supporting tissues
occlusal forces, impact, 102
rest, achievement, 78
Denture teeth
acrylic resin, popularity, 208
adjustment, 300f
arrangement, 287
coating, avoidance, 261f-262f
fracture, 312
loss, 312
materials, 208
occlusal/incisal surfaces
partial exposure, 261f-262f
plaster engagement, 263
popularity, 140
porcelain-only shades, 205f
positions (determination), landmarks (usage), 210t
replacement, 392f
selection, 250f
description, 284
setup, landmarks, 209
shade guide, usage, 205f
shaping, 250f
try-in, accomplishment, 114
Denture wear
associations, 51b
chronic inability, 93-94
continuity, 44-45
discomfort, 15
gradual wear, 312
interference, 84f
psychological effect, 9
Denture-wearing habits, correction, 47
Deposit-free implant components, objective, 339f
Diabetes, 31
impact, 31
microvascular complications, 31
oral consequences, 31
systemic consequences, 31
Diabetes mellitus, control, 401
Diagnostic casts, 76
evaluation, 282
survey, 81-83
Diet
counseling, objective, 32-33
habits, improvement, 50-51
improvement, nutrition counseling (usage), 32
quality, factors, 33
questions, usage, 33
Diffuse atrophic glossitis, 46f
Dilute acids, usage, 155
Direct lateral shift (Bennett shift), variable controls, 199

Direct mucosal reactions, 42
Direct sequelae, 42-49
  removable prostheses, impact, 43b
Disclosing wax, application, 268
Discontinuity mandibulectomy
  defects, 367
  prostheses, 367-369
Displaceable hard palate, 164f
  retention, palatal seal (placement), 177f
Displaceable soft palate, 164f
Distal ridges, movement, 68-69
Distobuccal flange, thickness/interference, 278
Diver chambers, hyperbaric oxygen treatment, 328
Domed contour, restoration, 296f
Donath, Karl, 323-324
Double-base stabilization, 241-242
Double cross-linked (DCL) resins, 139-140
Dough formation, 134
Down's syndrome, hypersalivation (association), 31
Drag (bottom), 257-260
Drifted teeth, 74
Drill geometry, importance, 328
Dry eyes (xerophthalmia), subjective feeling, 30-31
Dry mouth (xerostomia)
  associations, 51b
  diagnosis, 30-31
  elderly, complaint, 31
  subjective feeling, 30-31
Dry mucosa, tolerance, 176
Dryness, objective oral/ocular signs, 30-31
Dual-viscosity technique (simultaneous technique), 128
Duct orifice, saliva expression, 66
Duplicate dentures, usefulness, 313-314
Duplication technique, steps, 417f-418f
Dustless alginates, production, 126
Dyskinesias, hyperkinetic oral movement, 29-30
Dystonia, hyperkinetic oral movement, 29-30

E

Early loading protocol, proposal, 404
Ear rods, distance, 196
Eccentric occlusions, occlusal disharmony, 284
Ectodermal dysplasia, control, 401
Edema, reduction, 80
Edentulism
  caries, level, impact, 3
  challenge, 208-209
  cure, request, 19f-20f
  decline, projections, 3
  distribution/impact, 35-36
  heterogeneous etiology, 3
  implications, 409
  longevity, impact, 3
  periodontal disease level, impact, 3
  treatment, 22
Edentulous anterior jawbone quantity/quality, Lekholm-Zarb classification, 402f
Edentulous cast, 187f
Edentulous jaws, abnormalities (presence), 74
Edentulous mandibles
  considerations, 342-344
  immediate load rehabilitation, 342-344
    procedures, 342-344
  implant placement, masticatory benefits, 370
  morphological outcomes, 63f-64f
  osseointegration, Brånemark technique, 96f
  treatment
    care standard, 410
    planning, 342
Edentulous mandibles, usage, 24f-25f
Edentulous mandibular arch, 185f
Edentulous mandibular morphological outcomes, 63f-64f
Edentulous mandibulectomy, prostheses (troubleshooting), 369
Edentulous maxilla, 345-347
  hammering, 307f
Edentulous maxillary arch, landmark position, 187f
Edentulous maxillofacial prosthesis, prosthetic considerations, 353
Edentulous mouth
  age, impact, 36-37
  bone, impact, 36
  mucosa, impact, 36
  neutral zone, 13
  nutrition, impact, 37
  perception, ease, 54
  saliva, impact, 37
  surgical preparation, 84
  teeth, impact, 38
Edentulous patients
  alternatives, 23
  assessment, 281
  attitude, 53-54
  behavioral information, 54-55
  bone ridge morphology, 66-67
  challenges, 22
  cheeks, observation, 58-60
  chewing, increase (impact), 32
  comfort, impairment, 274
  complete dentures
    acceptance/usage, 21
    impact, 42
  conditions/incidents, identification (primary objective), 56-57
  counseling, 416
  decisions, guidance, 205-207
  dental history, 54
  denture-bearing foundations, improvement, 77-90
  dentures
    absence, 274
    usage, 112-118
  education, 78f
Edentulous patients *(Continued)*
  expectations, 341
    meeting, 204-205
    probability, 340-342
  extraoral examination, 57-60
  financial implications, 77
  first visit, 53-54
  focused questions, responses, 54-55
  general health, 54
  graphic records, 199
  health questionnaire, information collection, 54
  hinge-axis records, 199-200
  history taking, 53-77
  humanitarian/compassionate management, 56
  immediate dentures, usage, 112-118
  individuality, 273
  infection, 63
  instructions, 273-275
  interocclusal records, 198-199
  involvement/trust, climate (creation), 56
  lips, observation, 58-60
  long-term systemic effects, 55
  management, 93
  maxillary cast framework, 150f
  maxillofacial defects
    implant placement, sequencing, 370-372
    prosthodontic rehabilitation, 369-370
  maxillofacial implant-assisted prostheses, 369-374
  measurements, 74-76
  medical history, exploration, 56-57
  medications, knowledge, 57
  motivation, 342
  movements, 353-355
  mucosal conditions, 28-29
  needs, treatment options (matching), 54
  observations, merits, 56-57
  obturator prosthesis, retention/stability, 361f
  oral manipulative skills, 55
  overdenture treatment, 102-112
  partially edentulous patient, restoration, 51
  patience, 56
  photographic images, 76
  photographs, usage, 74-76
  physical incapacity, 57
  positive-negative spectrum, problems, 55-56
  preliminary/final casts, fabrication, 122
  pretreatment expectations, 340
  problems
    dentist analysis, 56
    mutual trust/understanding, 53
    short-term resolution, 78
  prosthodontic treatment, success, 388
  psychological considerations, 55-56
  quality of life, enhancement, 330
  radiation, 340
  radiographs, usage, 74-76

Edentulous patients *(Continued)*
records
existence, 249
types, 198-200
rendering, 281
saliva, impact, 66
selection, 340-342
social environment, knowledge, 54
social information, 54-55
systemic health status, 56-57
temporomandibular joints (TMJs), 57-60
tongue, 64-66
tori, 67
vital signs, determination, 56-57
Why treatment plan, 77f
Edentulous patient treatment, 8
choice, 56
development, 77
medical emergency, occurrence, 56-57
options, 23t, 72b, 121
choice, information synthesis (facilitation), 54b
clinical examples, 73f
planning, 53-77
psychological preparation, 56
Edentulous predicament, management, 26f
Edentulous residual alveolar ridges, reduction, 10f-11f
Edentulous ridges
coverage, acrylic resin base (usage), 111
mobility/resiliency, 48
surface area, 9
Edentulous segments, residual ridge reduction, 102f
Edentulous state
historical context/considerations, 1-4
morphological changes, association, 20b
transition, 6f-7f
treatment, 94f-95f
Edentulous surgical obturator, retention, 356f
Elastic immersion materials, 125-127
cross-linked polymers, 125
Elastomeric bite registration materials, 284-287
Elastomeric impression materials, 127-131
advantages/disadvantages, comparison, 132t
condensation silicone, 128-129
disinfection, 131
elastomeric impressions, technique, 128
handling, 128
properties, comparison, 132t
usage, 176
Elastomeric impressions, boxing rope wax (attachment), 178
Elastomeric materials
availability, 122
types, 128
usage, 282
Elastomers
colored pastes, 128
disinfection, 131
dual-viscosity technique, 128
Elastomers *(Continued)*
handling, 128
monophase techniques, 128
putty-wash techniques, 128
setting, occurrence, 128
shrinkage, 128
surface quality, 131
two-component paste systems, 128
Elderly population/patients
community-based nutrition programs, usage, 33
denture-wearing problems, 336
dry mouth, complaint, 31
edentulous percentage, 3
health-related challenges, 53-54
long-standing maladaptive mandibular edentulism, annual recall examination appearance, 97f
malnutrition, risk, 37
nutrition, impact, 37
overt facial changes, 17f
percentage distribution/projected increase, 36t
self-image, worry, 39
teeth, impact, 38
treatment planning, 331
undernutrition, 51b
Electropalatography (EPG), 320
diagrams, 320f
Electrosurg, 296f
Embouchure, 58
Emergence profile, reduction, 381
Eminences, reproduction, 258f
Enamelplasty, agreement, 287f
Enamel wear, infliction, 12f-13f
Endocrine disorders, history, 318
Endosseous dental implants, 94-95
Endosseous implants, surgical placement, 343f-344f
End-to-end anterior occlusion, requirement, 248
End-to-end occlusion, avoidance, 360
End-to-end setting, 226
English consonants, valve positions/production modes, 317t
Enlarged maxillary tuberosities, 69
Envelope of motion, 16f-17f
impact, 18
Environmental conditions, changes, 43
Epidermal growths, impact, 38
Epstein-Barr virus (EBV), environmental trigger, 28
Epuli, removal, 355-356
Epulis, 80
result, 61f-62f
Epulis fissuratum, 80
cause, 81f
Erythema, occurrence, 342
Erythema multiforme (EM), impact, 28
Esthetic festooning, 258f
Esthetics, 190-191
changes, 18-21
clues/decisions, pretreatment/posttreatment, 4f-5f
Esthetics *(Continued)*
denture design, 331
expectations, 341
occlusal contact determinants, 193f
requirement, 201-202
try-ins, usage, 248-249
Estrogen replacement therapy, impact, 36
Ethyleneimine terminal group, addition, 130
Eugenol, 284-287
Excess monomer, plasticizing effect, 136
Exclusion criteria
implant overdentures, 331
implant prosthodontic treatment, 331b
Exclusive implant support, variations, 333
Exostoses
impact, 67-68
occurrence, 80
size/location, 84f
Expiration, air passage, 351
External auditory meatus, facebow (fitting), 195f
External carcinogens, impact, 36
External oblique line, buccinator muscle (attachment), 169f
External oblique ridge, 166f
sagittal cuts, 167f
Exteroceptors, impulses (interpretation), 21
Extractions, pencil notations, 286f
Extraoral close-mouthed appearance, 308f
Extraoral examination, 57-60
Extraoral measurements, 76

F

Face
appearance, occlusion (vertical dimension) impact, 39f
height, maintenance, 113
Facebows, 195-196
design, 196
fitting, 195f
fork, attachment, 195-196
orientation, preservation, 269
record, requirement (absence), 246-248
support, 196-197
usage, 197, 300f
Facebow transfer
hinge-axis location, 196
importance, 196
jig
fabrication, 263, 265f
usage, 266f, 269
Facial aesthetics, alteration, 48
Facial appearance, 368
result, 308f
Facial asymmetries, 57
Facial changes, 17f
dentate woman, 2f-3f
Facial collapse, 358
Facial contours
alteration, 353
extraoral examination, impact, 57
modification, 20-21
Facial contracture, 358f
Facial esthetic needs, determination, 336

Facial form, 353
Facial landmarks/lines, identification, 237f
Facial midline, dental midline (relationship), 287
Facial muscles
  optimal activities, 57
  orbicularis oris muscle, connection, 255
Facial nerve, marginal mandibular branch (damage), 368
Facial skeleton, dental prostheses (linking), 23
Facial support
  maintenance, muscles (involvement), 236f-237f
Facial support, consideration, 182-184
Facial surfaces, augmentation, 190
Facial symmetries, extraoral examination (impact), 57
Facial tissues, tone (importance), 57
Facial undercuts, 294
Faciolingual dimensions, information, 332
Fast motor pattern, 315
Fast-setting plaster, 265f
  pouring, 265
Fat
  presymphysial pad support, disappearance, 38
  subcutaneous/buccal pads, atrophy, 38
Feedback
  mechanisms, 315-316
  sensorimotor feedback, 330
Festooning, 257
  completion, 257
    denture flange periphery, sealing, 259f
  details, subtlety, 257
Fibrous connective tissue, composition, 69
Fibrous scar band, creation, 356
Fibrous tissue, wedge (removal), 82f
Fibula contour, sagittal cone beam reformations, 371f
Fibula flap, 371f
Final casts, fabrication, 122
Final elastomeric impressions, technique, 128
Final impressions, 282
  border molding, usage, 178f
  materials, 173-179
    availability, 176
    selection, 176
  soft regular set alginate final impressions, 283f
  trays/technique, 173-179
  usage, 411
Final upper impression, 413f-415f
First alginate impression, 413f-415f
First premolar region, implant placement limitation, 345
Fish, Wilfred, 180
  attention, 184
Fitting denture surface, *Candida* species colonization, 47
Fixed full-arch design, 395
Fixed full-arch prescriptions, 318
Fixed full-arch prostheses, comparison, 338
Fixed implant solutions, 396f-398f
Fixed implant-supported prostheses, edentulous patient planning, 347f-348f
Fixed implant supported prosthesis, usage, 96
Fixed implant-support prosthesis, conversion, 383
Fixed maxillary prosthesis, 321
Fixed partial prostheses, polyvinyl siloxane impressions, 130f
Fixed prosthesis
  cementing, 384
  failure, 297f
  support, implants (usage), 388
  weakness, 297f
Fixed restoration, usage, 345
Flabby ridge tuberosities, 48
Flanges, thickness/contours, 70
Flask
  closure, 263
  cooling, 263
  cope, placement, 260
  coverage, tin foil substitute (usage), 261f-262f
  heating, 261f-262f
  placement, 261f-262f
  plaster mix, pouring, 260
  transfer, 263
Flat posteriors
  hiding, soft tissue (impact), 222f
  masking, anterior angle class II division 2 smile prominence (impact), 222f
Flat teeth, flat plane setting, 222f
Floor, soft tissue necrosis, 372
Floor-of-mouth tissues
  resection, 367f
  suturing, 366-367
Fluoride gel application
  impact, 110
  usage, 105f-106f
Fluoride preparations, 112
Fluoride remineralization, 112
Fluoride supplementation, 327
Fluoro-substituted monomers, incorporation, 139
Flush resin technique, 136-137
Follow-up appointments, 275-280
Follow-up requirement, 379
Food
  comminution, 14
  crushing, premolars/molars (usage), 188-189
  frictional contact, 21-22
  intake, nutrition/dental status (impact), 31-33
  mass, formation, 352
  selection
    dentition, role, 37
    range, broadness, 50
  test, reduction capacity (direct measurement), 50
  trituration, masticatory apparatus (involvement), 5
Food bolus
  manipulation, 370
  penetration/chewing, 208-209
  position, 272-273
  prevention, 368
  transportation, 257f
Fordyce's granules, 62
Forearm, microvascular flaps, 366-367
Fossa (shape alteration), muscle contraction (impact), 71
4-methacryloxyethyl trimellitic anhydride (META), usage, 142
Foveae palatinae, 164f
  observation, 283f
Fractured denture, management, 312
Fractured surfaces, trimming, 313
Fracture reinforced single denture, parafunctional patient, 300f
Framework try-in, 382
Frankfort plane, 196-197
Free skin grafts, resiliency (loss), 89
Free soft tissue flap, presence, 367f
Freestanding design, ball abutments/magnets (usage), 333f
Frenectomy, requirement, 300f
Frenula, accommodation, 72f
Frenular attachments, 80
Fricative sounds, 316-317
  distortion, 255-257
Frictional retention, usage, 111
Friction fit, 335-336
Fulcrum line, rotation, 294
Full-mouth radiographs, analysis, 107-108
Full peripheral extension, establishment, 282
Full sulcus extension, 128
Full wax-up, agreement, 287f
Functional contact movements, 310f
Functional cusp tips, reduction (absence), 271
Functional deficiencies, 57
Functional fixed prosthodontic results, achievement, 382
Functional impressions
  impression wax, usage, 178
  removal, 146
Functional impression technique, 310-311
  acceptance, 311
  simplicity/practicality, 310
Functional loading, de novo bone maintenance, 403
Functional morphology, changes (indirect sequelae), 50-51
Functional occlusal contact determinants, 193f
Functional teeth contact movement, frange, 299
Functional tooth contacts, mandibular position, 16-18

G

Gagging
  management, effectiveness, 71
  occurrence, 277-278

Gelation, 125
tissue conditioners, 145
Generalized stomatitis, 65f
Genial tubercles
cortical prominence, 166
enlargement, 84f
prominence, 80
sagittal cuts, 167f
Geniohyoid muscle, genioglossus muscle (suture), 80
Geographic tongue, 29f
Gingiva
display, 208
interarch space, 236f-237f
lamina propria, 5-7
rolls, creation, 257
Gingival bleeding, 384f
Gingival color, 205
Gingival contours, impact, 250f
Gingival disease, prevention, 107
Gingival finish line, making, 227-229
Gingival irritation, 295, 384f
Gingival margin
importance, 295
smoothness, 228f
Gingival-mucosal grafting procedures, 331-332
Gingival outline, tapering, 258f
Gingival shade, denture-base shade tabs (usage), 114-115
Glandular tissue destruction, 66
Glass transition temperature (Tg), 144
reduction, plasticizers (usage), 147
Glossectomy, 366
Glutaraldehyde, usage, 126
Glycerin, incorporation, 126
Gold alloy-retaining screw, exit, 382
Gold copings
impact, 111
retainer, requirement, 110
usage, 105f-106f
Gold inlay, 251f
Graft copolymer resins (production), chemical modification (usage), 139
Graphic records, 199
obtaining, difficulty, 200
Grinding
characterization, 250f
techniques, 323-324
Gross occlusal plane discrepancies, 108-109
Gross recurrent caries, 108-109
Growth factors, administration, 327
Gypsum mold, differences, 134

H

Habituation, process, 21
HA ceramics, short-term clinical results, 324
Hamular notches, 71, 164f
depth (assessment), mirror (usage), 252f
distal limit, 165
mucous membrane, components, 165
obliteration, 90
Hamular notches *(Continued)*
soft tissue pressure, 176-177
wax sprues, attachment, 417-418
Hand mirrors, try-in equipment, 232
Hard bristle brushes, usage, 154
Hard calculus deposits, removal, 154
Hard connective tissues, 5-7
Hard palate
anatomic defect (prosthetic closure), liquid drinking (test), 355
contours (change), tumor mass (impact), 355-356
defects
border molding, 354-355
impact, 355
oral cavity, superior aspect, 351
papillary hyperplasia, 48
prosthesis, seating, 391f
restoration, obturator prosthesis (impact), 355
soft palate right/left muscles (attachment), 351
static structure, 354-355
Hard reline, curing, 291f-292f
Hard tissues
bone, complete denture dependence, 60
surface quality/contours, 60
Harmonious labial support, neutral zone determination (balance), 186
Head
cancer, radiotherapy (primary/surgical adjuvant treatment), 370
injuries, 352
radiation fields, 369
radiation therapy, 373-374
tumor recurrences, occurrence, 372
Healed interface, outcome, 326f
Healing
abutment, 380-381
interface, trauma avoidance, 376
Healing implant bone interface, biomechanics, 405
Health questionnaire, information collection, 54
Hearing loss, 315
Heat-activated methacrylate resins, physical/mechanical limitations, 139
Heat-activated PMMA, 134
application, 133
curing cycles, 134
dough technique, 134
polymerization cycle, 134
polymerization exothermic reaction, 134
processing, injection molding technique (usage), 136
surface/subsurface voids, presence, 134
Heat-activated resilient liners, usage, 147
Heat-activated resins, physical/biological considerations (clinical implications), 137t
Heat-activated silicone rubbers, 148
availability, 148
Heat-cured denture bases, resin denture teeth (bond), 135
Heat-cured methacrylate resin processing errors, 135f
Heat-cured resin bases, advantages, 135-136
Hemostat, usage, 356f
High lip line, position (evaluation), 115-116
High smile line, gingiva (display), 208
High-speed handpiece, usage, 383
Hinge articulator, reliance, 200
Hinge axis
approximation, 196
determination, 333f
ear rods, 196-197
location, 199-200
records, 199-200
Hinge type articulator, 197f-198f
History taking, 53-77
Homologous graft, usage, 91f
Horizontal bone loss, 109
Horizontal bony shelving, presence, 86-87
Horizontal jaw relationship, recording, 412-416
Hormone balance, 66
Horseshoe-shaped maxillary overdentures, composition, 337f
Host bed, 327-328
Host bone
response, 395-401
sites, potential (radiograph requirements), 332f
Host response, 341-342
Hot spatula, usage, 248
Household bleach
cleanser component, 274
usage, 127
Huntington's disease, 29
Hydrated silica, usage, 154
Hydrocolloids, 125-127
Hydrophilized addition silicone, 129
Hygiene protocol, age-related inability, 107
Hyperbaric oxygen (HBO)
advocacy, 372-373
therapy, 372-373
treatment, 328
usage, 371f
Hyperkeratosis
areas, 29f
oral cancer, relationship, 48
Hyperkinetic oral movement, 29-30
Hypernasality, 362, 365
correction, 363f
Hyperplasia
cause, 77-78
denture irritation hyperplasia, 44
papillary hyperplasia, 63
soft tissue hyperplasia, 63
Hyperplastic ridge, 80
replacement, 81f
Hyperplastic tissue
changes, 46f
replacement, 61f-62f
surgical excision, 44

Hypersalivation, 31
Parkinson's disease, association, 31
Hypochlorite denture cleansers, usage, 148
Hypochlorite solutions, 154
Hypokinetic oral movement, 29-30
Hyponasality, test, 355
Hypophosphatasia, control, 401
Hyposalivation, 31
difficulties, 31
effects, 30f
oral consequence, 31
Hypothyroidism, control, 401
Hysterectomies, 98

I

Iatrosedative interview, components, 56
Ice packs, usage, 378
Idiopathic osteoporosis (type II osteoporosis), 36
Iliac cortex, veneer grafting/sinus augmentation, 345f-347f
Ill-fitting dentures, long-term wear, 79-80
Imaging protocol, 401-402
Immediate complete dentures, treatment, 284f
Immediate complete upper/lower partial dentures, 291f-292f
Immediate dentures, 112-118, 281-290
centric relation position, recordation (problem), 113
clinical/laboratory procedures, 295-298
clinical technique/protocol, selection, 114-118
consideration, 282
creation, clinical protocols, 113
critical consult, 287f
custom tray
impression, alginate (usage), 284f
perforation, 284f
execution, challenges, 113
final impression, 282
impression
readiness, 284f
trays, removal, 285f-286f
informed consent, example, 116b
initial treatment, 281
laboratory procedures, 287-289
occlusal analysis, 117
occlusion, plane location, 117
one-tray immediate denture impression, wax relief/design, 284f
opposing dentition, evaluation, 281
oral examination, 114-116
oral prophylaxis, 118
patient explanation, 114
list, 116b
periodontal therapy, 118
permanent prosthesis, 281
postoperative care, 289-290
postoperative pain, reduction, 113
preexisting conditions, acceptability, 113
preextraction records, 117f
preliminary impressions, 282
Immediate dentures *(Continued)*
prognosis, 117-118
referrals/adjunctive care, 118
removal, patient instruction, 289
surgical consultation visit, 118
tooth/teeth modifications, 116-117
treatment
advantages, 113-114
contraindications, 114
disadvantages, 113-114
needs, 118
planning, 114-118
understanding/application, problem, 281
Immediate implant placement, 362f-363f
Immediate load, allowance, 389b
Immediate load complete denture technique, 389-393
Immediate loading, 388
choice, 341
protocol, proposal, 404
Immediate load rehabilitation, 342-344
Immediate overdenture, insertion readiness, 297f
Immediate tooth-supported complete dentures, procedures, 295
Immersion cleanser, requirement, 154
Immune hypersensitivity reactions, MMA (association), 135
Implant abutments
availability, 330-331
number, reduction, 334
snap attachments, usage, 24f-25f
Implant analogues, placement, 391f
Implant dentures, 208
Implantology, advances, 410
Implant overdentures
attachment systems
choice, 336
selection, guidelines, 348
bar attachments, indications, 336
cleaning, 338
clinical/laboratory protocol, 338
commercially available attachment systems, diversity, 319
connected elements (splinted), usage, 336
design, 336
fabrication, 336
faciolingual dimensions, 332
inclusion/exclusion criteria, 331
maintenance, 338
number/distribution, 333
one-stage surgical approach, 335
osseointegration phase, 334-335
panoramic radiographs, usage, 332
philosophies, usage, 336b
presurgical evaluation, 331-334
prosthodontic approaches, 336b
prosthodontic procedures, 338b
prosthodontic protocol, 335-338
single elements (unsplinted), usage, 336
surgical procedure, 317
treatment planning, 331-334
two-stage surgical approach, 321
Implant prosthodontics
considerations, 321
patient considerations, 98-101
PL support, absence, 100
quasiscientific anarchy, risk, 98
scientific era, 95-98
treatment
exclusion criteria, 331b
inclusion criteria, 331b
treatment outcomes patient-related factors (summary), 399t
Implant prosthodontic treatment
consideration, 93-101
options, 23-25
determinants, 101b
validity, demonstration, 23
Implant-retained fixed prostheses, treatment (usage), 19f-20f
Implant-retained prostheses
effectiveness, 321
wearing, 362f-363f
Implant-retained prosthetic ocular prosthesis, treatment, 396f-398f
Implant-retained restorations, 342
Implant-retained system, components, 383
Implants
analogs, connection, 389-393
attachment mechanisms, differences, 406t
biocompatibility, 324
biological complications, 383
chemistry, compensation, 328f
cleaning, 338
concept, extension, 293f
connection, transfer components (usage), 390f-391f
cover screw, dehiscence, 379-380
crowding, 377f
design, 324-326
modification, rationale, 387-388
distribution, 333
drill geometry, importance, 328
failure, risk (increase), 398-399, 401
force, moment (transmission), 389
fracture, 384
functional benefits, 370
gingivitis, peri-implantitis, 43f
host bone site, availability, 24f-25f
insertion torque, 328
internal threads, protection, 380
irradiation, 373
irregularities, micrometer range, 325f
labial/lingual inclination, 381
length, 341
loading
conditions, 329
suitability, 340-342
long-term success, 370
macrodesign, 341
macroscopic design, proposal, 387
macroscopic/microscopic structure, combination, 388
macroscopic/microscopic surface designs/materials, impact, 96
manufacture, 326f

Implants *(Continued)*
mechanical complications, 383-385
microdesign, 341
micromovement, 342
microroughness, 326
microscopic design
discussion, 388
nanopatterns, 326
display, 327f
number, 333, 341
minimum, notion (challenge), 347
overdenture security, 293f
perpendicular placement, 342
placement, 50
masticatory benefits, 370
occurrence, 372
platform, full seating (prevention), 381
postinsertion, 383-385
primary stability, 388
prosthodontic complications, 383-385
prosthodontic procedures, preoperative planning, 401
prosthodontic treatment, long-term outcome studies, 395-398
provision, 186
proximity, restoration difficulty, 381
resonance frequency, analysis, 344
retention, enhancement/diversification, 337f
risks/benefits assessment, 370-373
secondary stability, 388
site, osseointegration (relation), 327-328
splinting, 342
submerging, 396f-398f
surgical protocol, 334-335
surgical technique, 328-329
titanium alloy manufacture, 326f
topography, 328f
unloaded healing, 100
Implant stability quotient (ISQ), 344
Implant-supported fixed option, patient selection, 340
Implant-supported fixed prosthesis, 382-383
complications, 382
Implant-supported maxillary overdenture, 308f
Implant-supported overdentures, 383
annual follow-up, requirement, 298
insertion, 383
polyether final impression, 131f-132f
treatment planning, objectives, 331b
Implant-supported prostheses, 180
benefits, 51
cost-effective version, 330
effectiveness, 321
impression, accuracy, 381
provisional substitutes, wax occlusion rims (usage), 183f-184f
wearing, 362f-363f
Implant-supported prosthodontics, scope (expansion), 396f-398f
Implant-supported restorations, 342
Implant-supported therapy, patient acceptance (increase), 341
Implant surfaces, 326-327
characterization, 326
chemistry, alteration, 327
doping, 327
modification, 326
physics, manipulation, 326-327
Implant treatments
decisions, 331
irradiation, contraindication, 328
outcomes, 330
Impression compound, 123f
considerations, 124-125
disinfection, 125
modeling plastic, 124
softening, 124
stress-induced distortion, 124
Impression materials, 122-133
alginates, usage, 126
classification, 122
composition/manipulation, 124b
selection, 122
summary, 133
support, 356
Impression plaster, 123
component, 123
mechanical limitations, 123
usage, 313
Impressions, 411-412
baseplate wax, placement, 173-174
border molding tray, 172f
cake compound, thermoplastic material, 172-173
compound, usage, 173
concepts, 171
copings, 381
cutback, 178f
final impressions, trays/materials/technique, 173-179
making, principles/objectives, 170-172
preliminary impressions, 172-173
procedures, 171-172
relationship, 381-382
relief, 163b
silicone putty impression material, 172
stick compound, addition, 172-173
surfaces, 182f, 256f
tray, insertion, 282
wax, usage, 178, 178f
Incisal edges
approach, failure, 318
incisive papilla intaglio (vertical/horizontal distance measurement), Alma gauge (usage), 233f
relative position, 318
Incisal elements, 201-202
Incisal guidance angle, 301f
Incisal guidance controls, adjustment, 199
Incisal guide tables, 197f-198f
Incision line, tension, 378
Incisive canal nerve, relief (requirement), 267
Incisive foramen, location, 163-164
Incisive fossa, 164f
Incisive papilla, 164f
intaglio, incisal edge (vertical/horizontal distance), 233f
location, 209
lower ridge crest, 238-239
mandibular incisors, relationship, 192
pressure, 277
space, 186
usage, 210f
Inclusion criteria
implant overdentures, 331
implant prosthodontic treatment, 331b
Incremental dried denture border, disclosing wax (application), 268
Indirect sequelae, 50-51
Individual tooth colors/position, characterization, 248-249
Infection, 63
occurrence, 378
Infection-related complications, reduction, 377-378
Inferior alveolar canals, challenge, 403-404
Inferior alveolar nerve, damage, 379
Inflammation
cause, 77-78
microscopic evidence, 78-79
Inflammatory papillomatosis, presence, 187f
Inflammatory process, management, 383
Information
collection, logical sequence, 54
storage, difficulty, 21
synthesis, 54b
Initial occlusal contacts, adjustment, 264
Injection molding technique, 136
Innate motor acts, 315
Insertion torque, 328
stabilization, equivalence, 344
Intaglio surface
microbial plaque, 46f
support area, 67f
Interappointment laboratory procedure, 246-248
Interarch distance, reduction, 273
Interarch space, 236f-237f
amount, 190
deficiency, 69
setting, 221
Interarch tooth relationships, 76
Intercuspation, maximum, 310
Interfacial osteogenesis, induction, 95-96
Interim denture (ID) approach, 114
Interim immediate dentures (IIDs), 113
choice, 114
comparative indications, 115t
prosthesis, examination, 116
Interim lining material, conformance, 357
Interim obturator prosthesis, 356-358
Interimplant distance, excess, 334f
Interim prostheses, fabrication, 353
Interim soft lining materials, availability, 113
Interim treatment liner, removal, 311
Interior cancellous bone, exposure, 67
Interlanguage quality variation, 318

Internal oblique ridge, sharpness, 167-168
Interocclusal airway space, 235
Interocclusal CR record, 192-194
Interocclusal distance
  creation, 299
  existence, 190
  rest position, 190
Interocclusal records, 198-199, 268-269
  description, 192-194
  shortcoming, 199
  wax tripod, usage, 246f-247f
Interocclusal space, limitation, 208
Interpenetrating network (IPN), 139
  teeth, popularity, 140
Interpupillary distance, comparison, 76
Interpupillary line, 189
Intraoral anatomical landmarks, reconciliation, 180
Intraoral examination, 60-69
  pattern, 66
Intraoral radiography, usage, 74-76
Intrinsic musculature, spreading, 66f
Iodophors, immersion, 125
Iodopors, usage, 126
Irradiated bone, vascular supply (increase), 372-373
Irradiated edentulous patients
  prosthodontic treatment considerations, 373-374
  salivary consideration, 374
Irradiated jaws, ORN (usage), 372
Irradiated tissues, implants (risks/benefits assessment), 370-373
Irradiation
  contraindication, 328
  implant healing, 370-372
  therapy, 401
Irreversible alginate material, usage, 411
Irreversible hydrocolloids, 172
  impression material
    mixture, 70-71
    usage, 176

J

Jawbone density, systemic treatments (impact), 36
Jaw movements
  facial/masticatory muscles, impact, 57
  old age, 37
  range, 198
    reproduction, 197
Jaw relationships, 76
  maintenance, 113
  records, 359f
    registration, TMJ complication, 58
  records, deviation, 368f
  unobtrusive observation, 57
Jaws
  bisphosphonate-related osteonecrosis (BRON), 400
  closure
    rehearsal, 239-241
    relaxation, 239-241, 244f
  concentricity, disparities, 57
Jaws *(Continued)*
  excursions, 222
  exostoses, occurrence, 80
  horizontal relations, 192
  opening, 199-200
    axis, upper jaw (relationship), 195-196
  posture, relaxation, 239-241
  relation record, 413f-415f
  separation, amount, 192
  size
    discrepancies, 90
    disparities, 57
  three-dimensional images, generation capacity, 76
  three-dimensional reconstruction, 163f
  TMJ, anatomical relationship (absence), 195-196
  vertical dimension, decrease, 63
  vertical relations, 192
Joints, functional capacity, 18

K

Kelly's syndrome, 69f
  evidence, 48
Kennedy class I partially edentulous mandible, 185f
Kennedy class I removable partial denture (RPD), impact, 48
Keratinized mucosa, quality (variation), 162
Keratinized stratified squamous epithelium, 162
Kingsley scraper, usefulness, 264

L

Labial curvature, impact, 207
Labial flange, 164f
  integrity/strength, frenectomy (restoration), 300f
  thickness, 60, 71
Labial frenulum, examination, 71-72
Labial frenum, 164f
  prominence, 175f
  tray, 172
Labial margin, bulk (increase), 60
Labial muscle, sulcus deepening procedure (surgical detachment), 88f-89f
Labial notch, 164f
Labial sulci, buccal frenula (relationship), 71
Labial vestibules, 164f
  alignment, 416
  deepening, 93-94
  division, 164-165
Labiodental fricatives, 321
Labiodental sounds, 317
Labiolingual center, 317
Labiolingual tooth position, change, 60
Laboratory equilibration, 263-264
Laboratory implant/abutment analogs, prosthetic cylinders (relationship), 344
Laboratory pins, 381
Laboratory putty, pressing, 417f-418f
Laboratory remount, 263-264
  example, 265f
Laboratory sessions, 412, 416
Lamnia propria, 5-7
Landmarks, 209
  stone model location, 209
  usage, 210t
La/SSB, 30-31
Lateral excursions, errors (correction), 272f
Lateral flanges (periphery), holes (drilling), 356
Lateral jaw movement, impact, 71
Lateral jaw relationships, 76
Lateral mandibulectomy, proprioception, 368
Lateral posterior maxillary undercuts, 67-68
Learned motor acts, 315
Left buccal border, 279f
Left buccal vestibules, 164
Left mandible, movement, 342f
Left tuberosity, pendulousness/mobility, 61f-62f
Lekholm-Zarb classification, 402f
Lesion intraoral marking, Thompson color transfer stick (usage), 44
Light-activated (VLC) material, requirement, 310
Light-activated (VLC) resins, 138
  properties, 138b
Light-cured acrylic resin, 180
Lingual anatomy, occlusal contacts, 215-219
Lingual bony prominence, mucosa relief, 267
Lingual borders
  compound, presence, 169f
  defining, 169
Lingual flanges, distal regions, 64-66
Lingual forces, estimates, 8
Lingual inclination, presence, 380
Lingualized articulation, 215-221
  arrangement, 219-221
  usage, 219
Lingualized occlusal scheme, 416
Lingualized occlusion, selection, 272
Lingual Look test, 227f
Lingual look test, 226
Lingual musculature, functional balance, 13
Lingual occlusion, buccal cusps, 219f-220f
Lingual polished surface contour, proper form, 259f
Linguoalveolar sounds, 318-319
  acoustic characteristics, 318
  articulatory characteristics, 318
  auditory characteristics, 318-319
Linguoalveolar stops/fricatives, error rate, 321
Linguodental sounds, 317-318
Linguopalatal sounds, 319-320
Linguopalatal stops/fricatives, error rate, 321
Linguovelar sounds, 319-320
Lining mucosa, 61-62
Lip fullness
  confusion, 60
  problem, 60
  teeth presence/absence, impact, 58f-59f

Lips, 58-60
anterior teeth, relationship, 70
appearance, 209
biting, 360
closure, 368
collapse, 273
competence, assessment, 368
contour, 190-191
restoration, 236f-237f
external form, dependence, 58-59
length, complication, 60
lining mucosa, 61-62
minor salivary glands, lymphocytic infiltration, 30-31
muscles, training, 273
peak forces, estimates, 8
phonetic issues, 59-60
positions, relationship, 58
repose, 57
rolled-in vermilion border, 59-60
support, 58f-59f, 205
evaluation, 115-116
Lips apart/mouth breathing posture, 210-211
Liquids, loss (prevention), 368
Living bone, titanium (relationship), 95-96
Loading protocol, 332-333
Local bone disease/anatomy, factors, 74
Local mucosal morphology (changes), direct sequelae (impact), 42-49
Long-term cortical bone resorption, support/absence, 167-168
Long-term implant success/survival, 341b
Long-term soft liners, 144, 147-149
biocompatibility, 149
chemically activated methacrylate resins, usage, 147-148
force dispersion, 147
glass transition temperature (Tg) reduction, plasticizers (usage), 139
heat-activated resilient liners, usage, 147
methacrylate resin, usage, 147
prescribing, 149
requirements, 147b
resiliency, loss, 147
silicone-based soft liners, usage, 148-149
therapeutic measure, 147
usage, 147
challenge, 148
Lost-wax casting techniques, 149
Lower anterior teeth
labial surfaces, imprints, 317
setting, 213f
tongue tip extension, 317-318
Lower base, stabilization, 241f
Lower cast, distal ends, 260
Lower cuspids, distal contact, 215
Lower dentures
base, approach, 242
midline, cross section (problem), 312
placement, 270f
removal, 266f
Lower face height, reduction, 49
Lower incisors, approach, 318
Lower jaws, centric relation (concepts), 16-18
Lower labial contour, 209
Lower lingual cusps, length, 272f
Lower lip
artificial lower teeth, relationship, 213f
incisal edges, relationship, 317
posterior third, labiodental sounds, 317
Lower molar ramp, 223f
Lower mounting ring
fast-setting plaster, 265f
plaster, 263
Lower prostheses, 240f
Lower ridge crest, 238-239
Lower teeth
antero-posterior (A-P) relation, 222
length, check, 318
resetting, 238f
visibility, 235-236
wear, 300f
Lower wax rim height, 209
Lower wax-up, reorganization, 240f
Low-fusing modeling compound (ISO)
placement, 269, 270f
softening, 270f
usage, 269
Low molecular-weight polyether, ethyleneimine terminal group (usage), 130
Low palatal contour, palatal contours (checking), 361-362
Low-viscosity VLC resin, application, 313
Luted transfer components, usage, 392f
Lymphocytic infiltration, 30-31

M

Machined-surface commercially pure titanium implants, 341
Macrothread design, definition, 387
Magnesium supplementation, 327
Magnetic abutments, facilitation, 336-338
Magnetic attachments
indications, 336
usage, 361f
Maladaptive denture behavior, 93-95
solution, osseointegration technique (usage), 96
Maladaptive denture patients, preprosthetic surgical techniques, 330
Maladaptive edentulous patients, treatment success, 19f-20f
Malnutrition, risk factors, 32b
Mandible, 165-170
alloplastic only graft, presence, 75f
anterior position, 248
anterior rotation, 49
anterior zone, immediate/early loading protocol alternatives, 404
bone resorption, 83-84
contralateral coronoid process, lateral jaw movement (impact), 71
denture irritation hyperplasia, severity, 44f
edge-to-edge position, 271f
external oblique line, 71
Mandible *(Continued)*
floor, soft tissue (absence), 367f
forward movement, 309
guidance, 241-242
sloped platform, usage, 369
horizontal overlap, 368
horizontal reference position, 192
implant placement, 12f-13f, 362f-363f
irradiated sites, implants (loss), 372-373
lateral aspect, 367
lateral cephalomeric radiograph, 163f
lingual aspect, 67
maxillae, vertical relation, 190-191
maxillofacial prostheses, requirement, 366
morphological changes, 15
movement, 215, 318
multidirectional contact movements, occlusal surfaces (impact), 13
occlusal view, 343f-344f
outward positioning, 162
physiological rest position dimension, 190
position, 165
posterior bone loss, 48
primary stress-bearing areas, 161
prominence, 226f-227f
residual ridge reduction, 49f
severity, 48
resorption, problems, 209
retromolar pad, 165
rotation, lateral excursions, 200
secondary stress-bearing areas, 161
side-to-side movement, 353-354
squamous cell carcinoma, resection, 364f
undercutting, 169-170
upward movement, 308f
Mandibular antagonists, vertical/horizontal overlap, 212f
Mandibular anterior occlusion, vertical dimension, 210-211
Mandibular anterior teeth
arrangement, 210-212
extrusion, labio-incisal direction, 48
lips apart/mouth breathing posture, 210-211
mesial drift, 210-211
modification, 117f
positioning, 368-369
Mandibular arch, 184-186
Mandibular border molding, 174t
Mandibular border movements
centric relation position, 16f-17f
motion, envelope (sagittal plane), 16f-17f
Mandibular buccal cusps, 271
Mandibular buccal frenum, 165-166
Mandibular buccal sulcus, buccal boundary, 71
Mandibular canals, location/size, 67
Mandibular canines, 212
eminences, reproduction, 258f
inclination, 214f
Mandibular cast, 184-186
framework, usage, 150f
Mandibular central fossae, occlusal contacts, 215-219

Mandibular central incisors
incisal edges, 193f
inclination, 214f
positions, 211
Mandibular complete denture, silicone liner (*Candida* growth), 50f
Mandibular dental arch, dental structures (association), 276
Mandibular dentition, maxillary palatal cusps (full contact), 227f
Mandibular dentures
area, 215
buccal surface, 255
instability, 369
lingual/buccal polished surfaces, 256f
lingual flange, 255
thickness, 320
lingual surface, concavity, 257
objectives, 308-309
positioning, 269
reinsertion, 269
remounting, 269
repositioning, 306f
seating, tongue (interaction), 257f
stability, teeth contact, 215
tissue-conditioning material, inclusion, 146f
traumatic ulceration, peripheral overextension (impact), 44f
wearing, 64
difficulty, 365-366
Mandibular deviation, 369
Mandibular discontinuity resections, 367
Mandibular fixed prosthesis, insertion, 32
Mandibular frenula, impact, 82f
Mandibular hammer overloading risk, status, 109
Mandibular implants
fracture, 384f
healing period, 321
Mandibular impression, distal end (importance), 178
Mandibular incisors
accentuation, upper lip droop (impact), 38f
incisive papilla, relationship, 192
labial surfaces, alignment, 416
Mandibular interforaminal implants, splinting, 372
Mandibular jaws, size/form harmony, 68
Mandibular lateral incisors, 212
Mandibular midline implant, application, 335f
Mandibular molar, height (reduction), 82f
Mandibular movements, 14
alteration, 353
limitations, 57-58
performing, 357
range, requirement, 195
Mandibular occlusal plane, landmarks, 223f-224f
Mandibular occlusal position, functional assessment, 236-238
Mandibular occlusion rim
occlusal plane level/height, determination, 182
opposing areas, box-shaped areas, 194
trimming, 194
Mandibular osseointegrated fixed complete prosthesis, edentulous patient planning, 343f-344f
Mandibular osteotomy, 90
Mandibular overdentures
loading protocol, 335
performance, 333f
retention/support, 98f
stabilization, 294f
success, 330
Mandibular position, deviation, 367
Mandibular posterior partial edentulism, fixed/removable implant solutions, 396f-398f
Mandibular posterior teeth, 219f
curved plate, 219f
RMP middle, 219f
set, 219f
Mandibular processed bases, usage, 360
Mandibular resection, 371f
prostheses, 366-369
Mandibular residual ridge resorption, advancement, 333-334
Mandibular ridge, 306-308
maxillary ridge, parallelism (absence), 84
occlusal surface resorption, 68-69
Mandibular rotation, impact, 305
Mandibular single denture, resilient liner (requirement), 299f
Mandibular stress-bearing areas, 162b
Mandibular symphysis region, sequential cephalometric tracings, 306f
Mandibular teeth
buccal cusps, realism, 215-219
neutral zone setting, 218f
positioning, 215
positions, 218f
setting, 222
priority, 221
Mandibular tori
occurrence, 67
size/location, 83f
Mandibulectomy, class II appearance, 368
Manual skills, impairment, 338
Marginal bone heights, maintenance, 324-326
Marginal bone loss
explanation/reason, 324
monitoring, 338
Marginal bone resorption, 326f
Marginal mandibular branch, damage, 368
Marginal mandibulectomy
forearm, placement, 367f
prostheses, 366-367
resection, 367f
Marking pencil, usage, 276-277
Marrow
space, 371f
veneer grafting/sinus augmentation, 345f-347f
Masseter, computed tomography studies, 50
Masseter muscle
activation, 167
anterior edge, 165-166
contraction, 165
vertical fibers, border, 167
Mastectomies, 98
Master casts
fitting, 260f
placement, 260
processed dentures, removal, 264
soaking, 259f
teeth, preparation, 298
wax excess, removal, 258f
Master model, separation, 246f-247f
Mastication
biting forces, transmission, 8
components, 14
compromise, 113
dentition, role, 37
dentures, movement, 14
function, 14
impairment, 274
impossibility, 365-366
muscles, involvement (pain/tenderness), 57-58
new dentures, 273-274
occurrence, problem, 113
oral motor function, 315
pressure, spreading, 161
stresses, 275
tongue/cheeks movement, 352
Masticatory apparatus, involvement, 5
Masticatory efficiency, level, 14
Masticatory forces
complete dentures, usage, 8-9
heaviness, 149
Masticatory function
enhancement, 51
impairment, 42
associations, 51b
nutritional status, relationship, 50-51
reduction, 31
restoration, importance (limitation), 31
Masticatory loads, mucosal support, 8-9
Masticatory movements, tongue/cheek muscles (impact), 14
Masticatory muscles
atrophy, 50
optimal activities, 57
strain, 382
Masticatory performance
improvement, 370
prosthetic service quality, relationship, 14
Masticatory system
integrity, loss, 4
neuromuscular mechanisms, 7
operation, ability, 9
resiliency, 15
treatment, 4-5

Matrix, 294-295
Maxilla, 163-165
articulator, relationship, 196
components, 164f
compound preliminary impression, 172f
implant placement, 362f-363f
inward positioning, 162
irradiated sites, implants (loss), 372-373
lateral cephalometric radiograph, 163f
mandible, vertical relation, 190-191
morphological changes, 15
osseointegrated implants, paralleled abutments, 345f-347f
primary/secondary stress-bearing areas, 161
retrusion, 226f-227f
ridge contour, reflection, 335f
Maxillary alginate impression, making, 356
Maxillary anterior alveolar ridge, proclination, 162
Maxillary anterior teeth, 219f
clear overjet, 213f
overbite, minimum, 213f
position, 412
salvageability, absence, 284f
set, 219f
setting, 212-215
dimensions, 213f
vertical/horizontal overlap, 212f
visibility, 235
Maxillary anvil occlusal overloading risk, 109
Maxillary arch, 186-188
CID planning, 117f
Maxillary arch (implant placement), tipped posterior implants (usage), 390f-391f
Maxillary bone
removal, 80
resorption, 305
Maxillary border molding, 174t
Maxillary buccal corridors, 369
Maxillary buccal undercuts, exostoses (impact), 67-68
Maxillary canines, 214-215
eminences, reproduction, 258f
tips, location, 187f
Maxillary cast
framework, 150f
occlusion rim support, 197
Maxillary central incisors
Dentsply shade 102, 250f
inclination, 214f
incisal edges, 192
Maxillary ceramometal fixed prosthesis, intaglio surface, 345f-347f
Maxillary complete dentures
open anterior windows, lateral incisor position, 391f
relining efforts, 307f
rotation, 69f
Maxillary complete dentures, posterior limit (establishment), 282
Maxillary custom impression tray, extension, 358-359
Maxillary defects
border molding, 353-355
custom tray displacement, 359f
viscous alginate, impact, 358f
Maxillary dentures
base, contraction, 267
distobuccal flange
border thickness, 279f
thickness/interference, 278
fitting, problem, 65f
flasking, 260f
landmarks, 164f
loosening, 279f
mounting, 268
objectives, 308-309
palatal festooning, impact, 257
palatal section, provision, 304
posterior border, 71
speech, impairment, 255-257
support, increase, 281-282
weight, reduction, 150f
Maxillary edentulous ridge, integrity, 308f
Maxillary fixed implant prostheses, impact, 309
Maxillary fixed prosthesis, failure, 345f-347f
Maxillary frenula, impact, 82f
Maxillary gingival tissue, display, 382
Maxillary horizontal overlap, 368
Maxillary implants
placement, determination, 332
strategic placement, 347f-348f
surgery, bruising, 378f
Maxillary interim obturator, baseplate obturator (usage), 357
Maxillary irreversible hydrocolloid material, usage, 175f
Maxillary jaws, size/form harmony, 68
Maxillary lateral incisors, 214
inclination, 214f
Maxillary left gingival cancer, 362f-363f
Maxillary lingual cusps, 271
Maxillary mirror image, 283f
Maxillary mucosa, 242
Maxillary obturator prosthesis, 355-362
Maxillary occlusion rim
anterior position, 189
facebow fork, attachment, 195-196
first molar-second premolar region, V-shaped grooves (bilateral placement), 194
Maxillary overdenture
abutment support, gold copings (usage), 105f-106f
horseshoe-shaped maxillary overdentures, components, 337f
provision, 90
treatment option, 334
Maxillary palatal cusps
full contact, confirmation, 227f
occlusal contacts, 215-219
pulling, 226
Maxillary posterior teeth
arrangement, 219-221
setting, 218f
Maxillary premolars, placement, 416
Maxillary processed bases, usage, 360
Maxillary remount cast, attachment, 265
Maxillary resection, 361f
peripheries
blockage, 354f
border molding, 354-355
Maxillary resection, phases, 355
Maxillary residual ridge, height (loss), 68
Maxillary ridges, mandibular ridges, parallelism (absence), 84
Maxillary right central, identification, 250f
Maxillary rim, modification, 182
Maxillary single denture stability, posterior crossbite (impact), 300f
Maxillary sinuses, enlargement, 67
Maxillary stress-bearing areas, 162b
Maxillary surgical stent, fabrication, 401f
Maxillary teeth
buccal cusps, realism, 215-219
congenital loss, 105f-106f
interarch space setting, 221
loss, 298
residual edentulous ridge, relationship, 186
selection, considerations, 109t
Maxillary tori
removal, indications, 80
size/location, 83f
Maxillary tuberosities, 71, 164f
appearance, panoramic radiographs (usage), 74-76
enlargement, 69
hypertrophy/downgrowth, 48
Maxillectomy, 358, 362f-363f
defects, 370
velar movement, absence, 363f
Maxillofacial defects
implant placement, sequencing, 370-372
retention problem, 360-361
Maxillofacial implant-assisted prostheses, usage, 369-374
Maxillofacial prosthodontics
anatomic/physiologic considerations, 351-352
form/function, 351-352
Maxillofacial radiology, CBCT usage guidelines, 402
Maxillomandibular registration, 180
vertical dimension, establishment, 321
Maxillomandibular relationship, 345
determination, basis, 190
progressive changes, 14
records, 284-287
obtaining, 368
Maximal bite forces, decrease, 50
Maximum hinge-opening position, 16f-17f
Maximum intercuspation position (MIP), 113
Measurements, usage, 74-76
Medial CT imaging, usage, 402
Medial mandibular rotation, 368-369
Medial pterygoid muscles, atrophy, 50

Medial upper and distal lower (MU-DL), 264
Median palatine groove, 164f
Median palatine raphe, 164f
Medical histories
  collection, 54
  exploration, 56-57
  mental health assessment, 55-56
Medications, knowledge, 57
Mediolateral compensating curves, 219
Mediolateral curve, formation, 223f-224f
Medium-to-high viscosity elastomeric material, usage, 128
Medium-viscosity polysulfides, 128
Meeting place, 188-189
MELISA, 327-328
Mental foramen
  bony margins, density/resorption resistance, 83-84
  mental nerve exit, 166
Mental foramina, 74
  location, 49f
  location, radiographic markers (panoramic radiograph), 343f-344f
  placement, 85f
  pressure, 83-84
  superficial location, 67f
  superficial position, identification, 75f
Mental health, assessment, 55-56
Mentalis muscle
  displacement, 89
  region, horizontal bony shelving (presence), 86-87
Mentalis nerve, relief (requirement), 267
Mental nerve, exit, 166
Mentolabial fold, support (excess), 60
Menton, anatomical landmark, 76
Mesial drift, 210-211
Mesiodistal relationship, errors (correction), 272f
Metal inserts, usage, 139
Metallic implants
  bone implants, direct contact, 323-324
  soft tissue coatings, absence, 323-324
Metallic markers, template (usage), 332f
Metal occlusal plane, usage, 257
Metal stock trays, alginate (usage), 336-338
Methacrylate-based resins
  biocompatibility, 135
  teeth, 139-143
  water sorption, 139
Methacrylate resins
  base, adhesion (loss), 148
  chemical bonding, 143
  properties, comparison, 144t
  usage, 147, 149
  water sorption, reduction, 139
Methacrylate resin teeth
  advantages, 141-143
  detachment, factors, 142
  disadvantages, 142-143
  esthetics, 142
  technical considerations, 142
Methacrylates, mechanical reinforcement, 139
Methacrylic acid, 135
Methylene chloride, usage, 142
Methyl methacrylate (MMA)
  adverse reactions, 135f
  immune hypersensitivity reactions, associations, 135
  monomer, 135
    tertiary amine initiator, 136
Microbial colonization, prevention, 47
Microorganisms (death), electromagnetic waves (impact), 155
Microthread design, definition, 387
Microwave-activated resins, 138
Microwave-cured denture resins, properties, 138b
Microwave radiation, 155
Midline
  pencil notations, 286f
  smile, confirmation, 245f
Midpalate, seating, 358-359
Minimum Acceptable Protocols (MAP), 410
  guidelines, 411b
  protocol-based guidelines, conformance, 412f
Missing dentition, replacement, 204
Missing teeth, replacement, 2f-3f
  treatment, 340
Mobile mucosa, virtual continuity, 63f-64f
Mobile tissues, interference, 80
Mobile tuberosity, excision, 82f
Modeling compound
  acrylic resin replacement, 277-278
  addition, 364-365
  painting, 354
Modeling plastic, 124
Modified impression technique, 61f-62f
Modified resin base materials, 139
Modiolus, 189f
  action, interference, 255
Molar regions
  chewing, occurrence, 14
  cross-section shrinkage, 68-69
Molars
  food crushing, 188-189
  placement, 416
Mold
  formation/preparation, 257-263
  packing, 263
Molten wax
  flow, 227-229
  removal, 246-248
Monomer
  allergy/sensitivity, 136
  amount, impact, 263
  diffusion, facilitation, 134
Monoplane articulations, 215
  arrangement, 222
Monoplane occlusion, recommendation, 368-369
Morphological face height, changes, 15-18
Morphological tissue health variables, diagnosis, 61f-62f
Motor cortex, 315
Motor skills
  acquisition, 21
  compromise, 330
Mouth
  age, impact, 36-37
  body, interaction, 28
  bone, impact, 36
  corner, nasolabial fold (virtual community creation), 188f
  dentures, sagittal diagrammatic view, 252f
  lower anteriors, 213f
  mirror, 165f
  mucosa, impact, 36
  opening/closure, 353-354
  posterior impression, replacement (accuracy), 285f-286f
  saliva, impact, 37
  soft tissues, floor (attachment abnormality), 365
  tolerance, limits, 14
Mouth floor
  raising, 64
  soft tissue
    absence, 367f
    necrosis, 372
  varicosities, 62
Movement analysis, kinematic methods, 320
Mucoperiosteum
  soft tissue, support, 60
  tenderness, 67
Mucosa, 61-63
  abnormalities, diagnosis, 62
  bases, shift, 239
  color, 62-63
  dentures, displacement reduction, 208-209
  erythema, 45f
  graft, placement, 88f-89f
  health, 291f-292f
    appearance, 311
  impact, 36
  lower wax-up, clamping, 241f
  lubrication, 66
  mean area, calculation, 8
  mobile mucosa, virtual continuity, 63f-64f
  removal, 82f
  retention, 66
  stability, 291f-292f
Mucosa-borne dentures, obtaining, 409
Mucosal-and-implant support, variations, 333
Mucosal conditions, 28-29
Mucosal folds, depths (exposure), 64
Mucosal hyperplasia (development), chronic low-grade trauma (impact), 44
Mucosal impression, posterior tray, 285f-286f
Mucosal lesions, presence, 36
Mucosal mechanism, support, 14
Mucosal support, 8-9
Mucosal surface, error correction, 305

Mucosal vulnerability, 330
Mucositis, oral consequence, 31
Mucostatic impression, 171
  impression plaster, usage, 123
Mucous membrane, 162
  composition, 162
  soreness, 15
Mucous membrane pemphigoid (MMP), impact, 28
Mucous salvia, impact, 37
Multiple implants, splinting, 342
Multiplex polymer matrix (MPM) resin teeth, 139-140
Muscles
  attachment, displacement, 49
  function, maintenance, 42
  tension, 273
Muscular control, observation, 57
Muscular denervation, 352
Musical activities, knowledge, 58
Mylohyoid muscles
  contraction, 64
  insertion, lingual bony prominence (mucosal relief), 267
Mylohyoid ridge
  bony prominence, 166
  sharpness, 167-168

N

Nanofilled composite resin teeth, 143
Nano Tite PREVAIL implant, 326f
Nasal cavities
  oral cavity, separation, 351
  prosthetic seal, testing, 355
  structural controls, 316f
Nasal consonants, production, 316-317
Nasal reflux, 361-362
Nasal sounds, 351
Nasogastric feeding tube
  requirement, 364
  usage, preclusion, 355
Nasolabial fold, virtual community (creation), 188f
Nasolabial grooves, deepening, 38
Nasopalatine nerve, pressure, 277
Nasopharynx
  air, passage, 351
  closure, 315
Native mandible, implant placement, 372f
Natural anterior tooth inclination, 309
Natural dental arch, shapes (variation), 219f-220f
Natural dental occlusion, functional/parafunctional considerations, 9-15
Natural dentition, 187f, 334
  biomechanical support, 4-8
  differences, 99f
  occlusal philosophies, 271
  opposition, 294f
  overdenture, opposition, 107-108
  transition, 281
  visibility/accessibility, 4-5
Natural-looking gingival outline form/contour, display, 258f
Natural mandibular dentition, opposition, 308f
Natural papilla contour, shape, 228f
Natural teeth
  absence, 16-18
  abutments, 330
  chewing efficiency, decrease, 50
  complete dentures, contrast, 14
  contact, centric occlusion, 68-69
  loss, 35
  number, reduction, 50
  opposing natural teeth, 208
  retention, 298
  roots
    retention, 290, 294
    support, 330
  support, 289
  usage, 102
Natural upper anterior teeth, prominence (questions), 60
Neck
  cancer, radiotherapy (primary/surgical adjuvant treatment), 370
  radiation fields, 369
  radiation therapy, 373-374
  radiotherapy, impact, 31
  tumor recurrence, occurrences, 372
Neoplastic disease, surgery, 352
Nephropathy, predisposition, 31
Neuromuscular control
  regressive/degenerative changes, 22
  system, 309
Neuropathy, predisposition, 31
Neurosis, chronic anxiety state, 56
Neutral zone, 13
  concept
    attention, 184
    posterior denture teeth violation, 44
  denotation, 181f
  design, 182-188
  determination, 78
  determination, harmonious labial support (balance), 186
  establishment, 182
  example, 254f
  identification, lingualized articulation (usage), 219
  position, 180
New dentures
  appearance, 273
  mastication, 273-274
  speaking, 274
Nickel-chromium alloy, 151
  usage, 149-151
Nickel-containing alloys, biocompatibility, 152
Nobel BiocareTiUnite implant, 327f
Nonanatomical articulations, 215
Nonanatomical flat-plane teeth, usage, 272
Nonanatomical teeth
  arrangement, 222
    balanced articulation, 223-225
    balancing ramp, usage, 223
  occlusal errors, elimination, 272
Nonelastic impression materials, 123-125
Nonfunctional habits, occlusal contacts, 14
Non-healing wounds, risk (absence), 369
Nonionic surfactant wetting agent, addition, 129
Nonperforated trays, alginate adhesive coating, 126f
Nonresected mandible, CR position (balance), 368
Nonvital teeth, 297f
Nonworking side condyle, rotation arc, 196
Nose, anatomical landmarks, 76
Nuisance crinkling, 89
Nutrition
  counseling, usage, 32
  impact, 31-33
  intake, amelioration, 50
  status
    maintenance, 42
    masticatory function, relationship, 50-51

O

Obturator
  addition, 364f
  contours, finalization, 364-365
  periphery, silk sutures (placement), 356f
  tolerance, improvement, 356
  trial base, blockage, 354f
Obturator prosthesis, 358-360
  defect, clinical blocking, 358
  palatal contour, evaluation, 360
  relining, 358f
  retention
    absence, 360-361
    improvement, 361f
    increase, 370
  stability
    improvement, 361f
    increase, 370
  troubleshooting, 360-362
  vertical opening, decrease, 358
Occlusal adjustment, 416
  facilitation, 79
Occlusal anatomy, impact, 207
Occlusal buccal/lingual alignment, impact, 369
Occlusal concepts, 215-225
  tooth molds, 216t-217t
Occlusal contacts, impact, 289
Occlusal correction steps, performing, 272
Occlusal crossbite, indication, 76
Occlusal discrepancies, 44-45
Occlusal disharmonies
  cause, 306
  final correction, 271
Occlusal equilibration, 268-269
Occlusal errors, 134-135
  displacing forces, excess, 304-305
  elimination, 271-272
  grinding, 271
  observation, 279
Occlusal impressions, 256f
Occlusal indicator wax, usage, 413f-415f

Occlusal loading, excess, 48
Occlusal plane, 205
  ala-tragus line, relationship, 189-190
  determination, approaches, 189-190
  level/height, 188-190
    determination, 182
  lowering, 60
  orientation, improvement, 310
  posterior height, 185f
Occlusal plans, 226
Occlusal record, vertical dimension, 417f-418f
Occlusal rims, adaptation, 368
Occlusal scheme, stability, 336
Occlusal stability, loss, 104-107
Occlusal stress, 107-108
  distribution, adversity, 12f-13f
  optimum, 100
Occlusal support
  edentulous ridges, usage, 406
  vertical dimension, 58f-59f
Occlusal surface, 182f
  articulating surfaces, 180
  design, 24f-25f
Occlusal table
  food bolus, transportation, 257f
  narrowing, 208-209
Occlusal teeth contact, simulation, 197f-198f
Occlusal vertical dimension
  change/reduction, 190
  loss, suspicion, 305
Occlusion
  achievement, 245f
  adjustments, 276
  concepts, 215
  development/adaptation, 13t
  errors, 268
    visibility, 268-269
  incorrectness, 62-63
  plane, 235
  posterior plane, height, 215
Occlusion rims
  arch form, contour, 182-184
  attachment, 180
  curvatures, 184-186
  design, 184-186
  lingual extent, establishment, 184-186
  usage, 182, 190
Old age
  edentulism
    distribution, 35-36
    impact, 35-36
  jaw movements, 37
  personal appearance, concerns, 39-40
  self-satisfaction, appearance (impact), 40
Old dentures, facial surfaces (augmentation), 190
Older face, upper lip droop, 38f
Older populations
  cumulative survival rates, 97f
  health-related challenges, 53-54
Older populations *(Continued)*
  percentage distribution/projected increase, 36t
  undernutrition, 51b
Old prostheses
  examination, 70
  occlusal correction, 79
1-1-1 trichloroethane, usage, 310
One-tray immediate denture impression, wax relief/design, 284f
Open anterior windows, lateral incisor position, 391f
Opening arcs, 242
Open-mouth method, 309
Open-mouth reline/rebase procedure, 309
Opposing dentition, evaluation, 281
Opposing natural teeth, 208
Opposing occlusion, 300f
Opposing teeth, lubrication, 246
Opposing undercuts, requirement, 67-68
Optimal prosthetic function, preclusion (surgical correction), 80-84
Optoelectronic articulatory movement tracking, 320
Oral biofilms, 153
Oral biological/functional environment, 181f
Oral biomechanics, management, 1
Oral cancer
  chronic denture-related mucosal irritation, relationship (absence), 48
  development, 48
  hyperkeratosis, relationship, 48
  rarity, 36
Oral cavity
  dental materials, types (presence), 42
  epithelial lesions, 367
  health, oral hygiene, 274
  infection, spread, 47
  inferior aspect, 351-352
    resection, 352
  nasal cavity, separation, 351
  posterior portion, impression tray (usage), 282
  presurgical anatomy, consideration, 289
  prosthetic seal, testing, 355
  removable prosthesis, placement, 42
  structural controls, 316f
  superior aspect, 351
Oral commensal bacteria, interactions, 47
Oral dyskinesias, 29-30
Oral ecological concerns, 406-407
Oral environment, prosthetic materials (interaction), 43b
Oral examination, 275-278
  continuation, 278-280
  periodic recall, 280
  procedures, 276
Oral function, facial/masticatory muscles (impact), 57
Oral fungal infections, 63
Oral hygiene
  absence, 44-45
  dentures, involvement, 274
Oral hygiene *(Continued)*
  measures, 342
  necessity, 47
  problem, 47
Oral lichen planus (OLP)
  consequence, 31
  impact, 28
Oral manipulative skills, 55
Oral motor function, features, 315
Oral movement disorders, 29-30
Oral mucosa
  burning sensations, 47
  external carcinogens, impact, 36
  resilience, 222
  subepithelial inflammation, 28
Oral rehabilitation, 315
Oral sounds, 351
Oral stereognosis, 21
Oral structures, speech production role, 316-320
Oral-systemic conditions, impact, 29b
Oral-systemic vulnerability, 28
Oral tissues
  health, 338
  polyether, wettability, 130
  volume, loss, 209
Oral treatment, 275-278
  continuation, 278-280
Orbicularis oris muscle, 236f-237f
  facial muscles, connection, 255
Orofacial changes, production, 18-20
Orofacial examination, 54
Orofacial musculature, functional balance, 13
Oropharynx, usage, 315
Orosensory feedbacks, 315-316
Orthodontic wire, usage, 390f-391f
Osseointegrated, implant-retained fixed prostheses, usage, 19f-20f
Osseointegrated dental implants
  mandibular fixed prosthesis, insertion, 32
  usage, 90
Osseointegrated implants
  bone, bond, 324
  experimental approach, 324
  usage, 23
Osseointegrated interface, 323-324
  periodontal ligament, contrast, 407f
Osseointegrated oral implants, introduction, 323
Osseointegrated prostheses, indication, 28
Osseointegrated response, strength, 325f
Osseointegrated teeth root analogues, provision, 19f-20f
Osseointegration (OI)
  achievement, 329
  achievement, occurrence, 387
  biological failure, 376-377
  Brånemark technique, 96f
  description, 95-96, 387
  failure, 324
  impairment, 370
  implant macroscopic/microscopic surface designs/materials, impact, 96

Osseointegration (OI) *(Continued)*
influence, 395
long-term prospective clinical studies, clinical yield, 396b
loss, 100-101
maintenance, 401
patient considerations, 98-101
phase, surgical protocol, 334-335
physical adaptation, occurrence, 387
problems, 376-377
promotion, requirements, 388b
requirements, modifications, 389b
research base, 25
research developments, 396b
result, 99f
success
determinants, 396b
norms, 101
technique
introduction, 26f
usage, abbreviated form, 24f-25f
time-dependent healing process, 101
treatment outcome considerations, 101
Osseous structures, imaging (accuracy), 401f
Osteoblastic/osteoclastic activity, balance, 15
Osteoporosis, 399-400
clinical diagnosis, 400
history, 318
impact, 36
manifestation, 48
types, 36
Osteopromotive membrane, usage, 380
Osteoradionecrosis (ORN)
morbidity, 370
risk, 372-374
absence, 369
Overbite, 223f-226f
space, 246
Overbite-overjet relations, 200
Overdenture abutments
endodontic treatment, 294
maxillary teeth selection, considerations, 109t
preparation/restoration, 110
Overdentured abutment teeth, prolongation, 108f
Overdentured teeth abutments, longevity, 102
Overdentures, 208, 290-295
abutments, impact, 103f-105f
ankylotic-like osseointegrated implant abutment support, 330
application, usage, 24f-25f
cast Cr-Co mesh reinforcement, 296f
casting, 296f
checking, 338
cleaning, 338
clinical/laboratory procedures, 295-298
clinical preparation, 293
concept, consideration, 290
design, 395
fluoride gel, usage, 298f
function, impact, 371f
Overdentures *(Continued)*
implant support, 410
indications, 107-109
insertion, 295
example, 297f
long-term monitoring, 112
maintenance, 298
natural tooth/root abutments, 319
natural tooth roots support, 330
recall maintenance, 298f
retained roots, 293f
retainers, distribution, 294
retention, 294-295
improvement, gold copings/telescopic crowns (usage), 111
retentive elements, space (requirement), 295f
retentive role, enhancement methods/techniques, 110-111
service, 104-107
versatility, 107
short-term/long-term treatment outcomes, 330
solution, 297f
support, 96, 102
abutment teeth, usage, 111-112
dental implants, usage, 294
teeth support, 294f
therapy, 293f
treatment
considerations, 330-331
planning, 293-294
Overdenture technique
advantages, 107, 107b
development, 103f-105f
disadvantages, 107
introduction, 102-104
Overdenture treatment, 102-112
abutments, 74
outcome studies, 112
planning, 107-109
success, 111-112
Overextension
patient complaint, 171f
requirement, 176
Overjet, 223f-226f
excess, 245f
space, 246
Overt facial changes, 17f
Oxygenating cleansers, 154

P

Palatal augmentation prosthesis, 365-366
clinical examination, 365
patient, information, 365-366
try-in stage, 366
Palatal bone screw, usage, 356f
Palatal configuration, alterations (influence), 321
Palatal contour, evaluation, 360
Palatal coverage, 336
acceptance, confirmation, 287f
Palatal cusps, upper setup, 219f-220f
Palatal festooning, restoration, 257
Palatal form, restoration, 355-356
Palatal hyperplasia, restriction, 81f
Palatal movement, degree, 71
Palatal mucosal irritation/infection, 43f
Palatal rugae, realism, 228f
Palatal seal
area, wax-up extension (confirmation), 251f
identification, 251f
Palatal sounds, problems, 319-320
Palatal trauma
clinical examples, 65f
interactions, 47
Palate
augmentation, 366
covering, 163
incisive papilla, interaction, 186
petechiae, 173f
tongue contact, 365
alteration, 369
Palatectomy defects, 370
Panoramic dental radiography, survey, 74-76
Panoramic radiographs
creation, 332
projection, 74-76
Papilla
contour, shape, 228f
wax-up measurement, 234f
Papillary hyperplasia, 45f
appearance, 63
impact, 48
Papillomatosis, 80
presence, 187f
Parafunction, forces generation (direction/duration/magnitude), 15t
Parafunctional considerations, 14-15
Parafunctional contact movements, 310f
Parafunctional habits
consideration, 55
occlusal contacts, 14
Parakeratosis, problems, 89
Parasympathetic drugs, impact, 31
Parkinson's disease
hypersalivation, association, 31
hypokinetic oral movement, 29-30
neurological function, compromise, 188-189
Partial dentures, removable prostheses (direct sequelae impact), 43b
Partial edentulism
management, 99f
result, 168f
Partial glossectomy defect, closure, 352f
Partially dentate patient
considerations, 72-74
posterior alveolar ridge crest, resorption, 166f
Partially edentulous jaws, abnormalities (presence), 74
Partially edentulous patient, restoration, 51
Partial posterior mandibular dentition, presence, 66f
Partial prosthesis, removal, 380

Partial teeth, loss (impact), 18
Partial wax occlusion rim, usage, 183f-184f
Passavant's ridge
  observation, 363f
  presence, 364
Paste/markers, combination (usage), 276-277
Pathoses (identification), radiographic images (usage), 75f
Patient-centered treatment approach, 412f
Patient records, types, 198-200
Patrix, 294-295
  designs, form, 335-336
Pear-shaped pad, 167-168
Pendulous fibrous maxillary tuberosities, occurrence, 80
Pendulous maxillary tuberosities, 48, 80
Pendulous tuberosities, reduction, 355-356
Percarbonates, provision, 154
Perceptual analysis, 320
Periimplant bone resorption, failure, 324
Peri-implantitis, 43f
Periimplant tissues
  health, 338
  stimulation/brushing, 339f
Periodontal care, hygienic phase (maintenance), 112
Periodontal disease, 362f-363f
  advancement, 291f-292f
  impact, 12f-13f, 318
  level, impact, 3
  long-standing severity, 396f-398f
  loss, 100-101
  preoperative/radiographic images, 390f
  prevention, 107
Periodontal ligament (PL), 5-7
  absence, 94f-95f
  analogous attachment mechanism, 100
  natural dentition, support/retention, 6f-7f
  osseointegrated interface, contrast, 407f
  presence, 9
  qualitative/quantitative determinants, 100
  result, 100-101
Periodontal microorganisms (inhibition), stannous fluoride preparation (usage), 112
Periodontal pathogens, presence, 406
Periodontal pockets, depth (determination), 74
Periodontal support
  factor, 74
  loss, 9
Periodontal tissues, direct functional occlusal force application (total time calculation), 8t
Periodontitis-like pathogenesis, 406
Periodontium
  attachment, 5-7
  support, 7
Perioral muscles, anatomy/activities, 68
Periosteum, cellularity/vascularity loss, 370
Peripheral borders
  overextension, 172
  tissues/contours, 164-165, 167-170
Peripheral overextension, impact, 44f
Peripheral seal, maintenance, 249-251
Peripheral vascular disease, systemic consequence, 31
Peripheral wax, softening, 411
Permanent prosthesis, 287
Peroxide denture cleansers, usage, 148
Peroxide-sensitive patients, resins (usage/benefits), 136
Personal appearance, concerns, 39-40
Pharyngeal constriction, pronouncement, 365
Pharyngeal extension
  addition, 364
    example, 363f
  reduction, 365
Pharyngeal sphincter, movement, 364
Pharyngeal wall
  contact, intimacy, 315
  elevation, 352f
  squeezing, 365
Pharynx
  air, passage, 351
  impression, support, 358f
  infection, spread, 47
  movement, inadequacy, 352
  obturation, 363f
  superior constrictor muscle, 71
    presence, 236f-237f
  valves/articulators, 316f
Phenolic glutaraldehydes, immersion, 125
Philtrum
  flattening, 38
  obliteration, 60
  shape, evaluation, 115-116
Phonation, 351
  evidence, 364f
Phonetics, 191-192
  assessment, 235-236
  considerations, 59-60
  overlapping, 201-202
  palate contour, assistance, 259f
Photographic images, 76
Photographs, usage, 74-76
Phthalate esters, 135
Physical incapacity, 57
Physiological rest position dimension, 190
Pink acrylic resin, 337f
Pink baseplate wax, excess, 228f
Pinpoint hyperemia, 45f
Plaque
  accumulation, 43
    enhancement, 338
  objective, 339f
  removal, 154
    facilitation, chlorhexidine mouthwash (usage), 335
Plaque formation (inhibition), stannous fluoride preparation, 112
Plaster
  mountings, cast reattachment, 265f
  notching, 246f-247f
  separating medium, application, 260-263
Plasticized methacrylates, biodegradation, 147
Plasticizers, usage, 147
Plastic material, production attempts, 311
Platelet-derived growth factor (PDGF), 403
Plosive consonants, 316-317
Pocketing, cast preparation, 289
Polished surfaces, 182f
  design, 24f-25f
  development, clinical steps (requirement), 194b
  involvement, 256f
  proper forms, development, 255-257
    basis, 255
Polydimethylsiloxane, 128-129
Polyether
  final impressions
    implant supported overdenture usage, 131f-132f
  final impressions, custom trays (usage), 131f-132f
  impressions, 131f-132f
  pick-up impression, 131f-132f
  usage, 128, 176
  wettability, 130
Polyether elastomer, 130b
Polyether impression materials, 130-131
  base paste, low molecular-weight polyether, 130
  stiffness, 130-131
Polymeric denture base materials, 133-139
Polymerization
  cycle, 134
    processing variable, 142
  process, activation, 136
  shrinkage, occurrence, 134
    countering, 176
Polymer matrix, amorphous silica filler, 140-141
Polymers
  creep, 133
  cross-linking, 133
  improvement, 208
  structure, cross-linking (effectiveness), 129
Polymethyl methacrylate (PMMA)
  cast mesh, embedding, 299f
  IPN dispersal, 139
  polymerization process, 133
  popularity, 149
  resin-based dentures, usage, 135
  resins, 133
  rubber reinforcement, 139
  securing, 242
Polysulfide impression, detail reproduction, 129f
Polysulfide rubber, 128
  base, 128b
  condensation reaction, 128
  detail reproduction, 128
Polysulfides, disinfection, 131
Polyvinyl siloxanes (PVS), 129
  impressions, 130f

Porcelain denture teeth
ceramic composition, 143
esthetics, 143
manufacture/supply, 143
triaxial composition, 143
Porcelain-only shades, 205f
Porcelain teeth
advantages, 143-144
chemical bonding, 143
contact, sound (production), 143
differentiation, 69-70
disadvantages, 143-144
esthetics, 143
grinding, difficulty, 143
heat distortion temperatures, 143
mechanical attachment, 135
mechanical retention, loss, 208
properties, comparison, 144t
reality, 208
Porosities, presence, 142
Positioned mandibular cuspid, guide, 223f-224f
Postdam area, marking, 413f-415f
Posterior alveolar ridge crest, resorption, 166f
Posterior bone loss, 48
Posterior border path, reproducibility, 18
Posterior buccal flange, length, 167f
Posterior contact, assessment, 366
Posterior crossbite
impact, 300f
setup, 226f-227f
Posterior denture height, 368-369
Posterior denture teeth
impact, 44
lingual contour, establishment, 259f
Posterior extension, addition, 364
Posterior impression, replacement (accuracy), 285f-286f
Posterior landmarks, joining, 189
Posterior lingual flanges
extension, 63f-64f
length, 167f
Posterior mandible
implant placement, 342
partial resection, impact, 353
Posterior mandibular dentition, presence, 66f
Posterior mandibular prosthetic teeth (replacement), partial wax occlusion rim (usage), 183f-184f
Posterior mandibular teeth, loss, 21-22
Posterior maxilla, implant placement (enablement), 345
Posterior mold, variation, 207
Posterior mucosal border molded impression, 285f-286f
Posterior mylohyoid area
extension, achievement, 171f
mirror, usage, 170f
Posterior occlusal plane, anterior reference, 213f
Posterior occlusion relationship, problem, 183f-184f
Posterior-only contact, 245f
Posterior palatal seal (PPS), 176-178, 282
achievement, scoring (concept), 178
chronic response, 65f
creation, 176-177
border molding process, usage, 177-178
impression wax, usage, 178f
depth, 253f
confirmation, 251
enhancement, 284f
establishment, 249-252
extent, confirmation, 251
importance, 90
location/confirmation, 251
maintenance, 249-251
midline, ulceration, 277f
position, 253f
pressure, 173f
region, 164f
tissue displacement, 176
tuberosity area, 177f
verification, 252f
vibrating line/width, 252f
Posterior retromylohyoid ridge, boney undercut (mucosa), 373-374
Posterior segments, indexing, 282
Posterior teeth
arrangement, 215
guidelines, 336
problem, 268
buccal cusps, elevation, 223f-224f
central grooves, position, 223f-224f
color selection, 209
cuspal anatomy, 208-209
end-to-end occlusion, avoidance, 360
molds, 208-209
selection, 200
occlusal anatomy, 284
presence, 114
removal, 281-282
set, number, 215
single impression tray, usage, 282
usage, 287
Posterior wax cones, registration tripod, 286f
Posterolateral margins, tissue adaptation (checking), 361-362
Posterolingual mandibular undercuts, 67-68
Posteromedial margin, tissue adaptation (checking), 361-362
Postinsertion speech adaptation, 309
Postmenopausal osteoporosis (type I osteoporosis), 36
Postoperative pain, reduction, 113
Postoperative speech, facilitation, 355-356
Posture movements, performing, 353-354
Pour resin technique, 136-137
Precancerous lesions, rarity, 36
Preextraction photographs, usefulness, 76
Preextraction vertical measurements, 190
Preferred smiles, 205
Preliminary casts, fabrication, 122
Preliminary centric relation record, 192-195
Preliminary centric relation (CR) record, making, 182
Preliminary impressions, 172-173, 282
making, 172
purposes, 282
trays/materials/technique, 172-173
Preliminary maxillomandibular relation records, 182
Premaxilla
area, implant placement, 361f
bone resorption, 48
Premolar length, natural state (similarity), 258f
Premolar regions
chewing, occurrence, 14
ridge, 184-186
Premolars
food crushing, 188-189
positioning, 221
Premotor cortex, 315
Preprocessed VDO, 264
Preprocessing VDO, re-establishment, 268
Preprosthetic nonsurgical methods, 77-79
Preprosthetic surgery
decision making, 76
epuli removal, 355-356
Preprosthetic surgical initiatives, 49
Preprosthetic surgical methods, 79-90
Preprosthetic surgical procedure
prescription, objectives, 79-80
replacement, 88f-89f
Preprosthetic surgical techniques, prescription, 330
Preprosthodontic intervention, requirement, 107-108
Preprosthodontic surgical prescriptions, objectives, 79b
Pressure-indicating pastes, 70-71
Pressure indicator paste (PIP)
application, 267-268, 267f
evaluation usage, 276-277
patterns, 267-268
bead depth/sharpness, 277f
indications, 268f
usage, 291f-292f
biting, avoidance, 267-268
importance, 267
Pressure packs, application, 378
Pressure ulcer, adjustment, 291f-292f
Presurgical dental examination, 355-356
Presymphysial pad support, disappearance, 38
Primary denture support, checking, 66
Primary stability, 388
Problems, 376-377
iatrosedative interview components, 56
list, 377t
Processed acrylic, shrinkage, 249-251
Processed bases, 353
mounting, 368-369
stability, 369
Processed dentures
base, strains (release), 311-312
removal, 264
Processed upper denture, attachment, 265f
Prognathic appearance, increase, 49

Prognathic facial skeletons, setup, 225-229
Prognathic patients (angle class 3), 226
  Angle class III skeletal relationship, 248
  complete anterior/posterior crossbite, 226f-227f
Prognathic profiles, tooth setup requirement, 225f
Progressive alveolar bone resorption, 42
Progressive bone resorption, failure, 324
Progressive endarteritis, 370
Proprioceptive mechanosensitive afferents, impact, 315
Proprioceptors, impulses (interpretation), 21
Prostheses
  attachment, 344
  clinical images, 392f
  coping (relation), autopolymerizing acrylic resin (usage), 343f-344f
  design, 21
    posterior ridges, 12f-13f
  examination, 70, 116
  fabrication, 21
    complete denture success, information (usage), 313
  fixed full-arch design, 395
  frontal occlusal view, 347f-348f
  insertion, 382-383
    frontal view, 345f-347f
    path, 81-83
  integration, panoramic radiograph, 347f-348f
  intraoral/extraoral perspectives, frontal views, 345f-347f
  irritation, 42
  length, problem, 365
  modification, 357
  overdenture design, 395
  performance, improvement, 340-342
  periphery, air, escape, 355
  plaque formation, 42
  postinsertion, 383-385
  presence, 66f
  radiographic images, 392f
  retention
    enhancement/diversification, 337f
    mandibular/maxillary frenula, impact, 82f
  rotation, 333f
  soft palate, junction, 361-362
  speech production, prosthetic considerations, 320-321
  stabilization, 102
  supporting/surrounding tissues, interfaces, 42
  tissue support, 281
  troubleshooting, 369
  try-in, panoramic radiograph, 345f-347f
  wearing, adaptive potential, 22
  withdrawal path, 81-83
Prostheses, muscular stabilization, 9
Prosthetic cylinders, laboratory implant/abutment analogs (relationship), 344
Prosthetic dental occlusion, functional/parafunctional considerations, 9-15
Prosthetic dentition, visibility/accessibility, 4-5
Prosthetic denture teeth
  fabrication, materials (usage), 139-144
  requirements, 141b
Prosthetic envelope, consideration, 58-59
Prosthetic material
  chemical degradation/corrosion, 42
  integrity, time-dependent wear/tear, 385f
  interaction, oral environment (impact), 43b
  surface properties, 42
Prosthetic occlusions, design/fabrication, 13
Prosthetic rehabilitation, treatment time (reduction), 370-372
Prosthetic services quality, masticatory performance (relationship), 14
Prosthetic smile, creation, 251f
Prosthetic teeth
  design, 195
  labial surface, gold alloy-retaining screw (exit), 382
  placement
    reconciliation, 377f
    skin tone, combination, 191f
  positioning, 181f
  retention, 150f
  selective recontouring, 44
  summary, 144
  wear, time-determined/behavior-determined basis, 208
Prosthetic teeth surfaces, nonarticulating buccal/lingual parts, 180
Prosthodontic care
  diet, counseling (objective), 32-33
  local bone disease/anatomy, factors, 74
  patient decision, 54
Prosthodontic design objectives, 334-335
Prosthodontic impression materials, qualities, 122b
Prosthodontic interventions, oral ecological responses, 406
Prosthodontic loading, 403-406
Prosthodontic management, 54
  antifungal therapy, combination, 46f
Prosthodontic procedures, 338b
Prosthodontic rehabilitation
  initiation, 320
  treatment prognosis, improvement, 367
Prosthodontic-related complications, 380-382
  list, 380t
Prosthodontic services
  anatomy, relationship, 13
  success, 267
Prosthodontic therapy, focus, 1
Prosthodontic treatment
  dietary counseling, 32-33
  success, 388
Protective gag reflex, elicitation, 71
Protective reflexes, learning, 13
Protocol-based guidelines, MAP conformance, 412f
Protocols, acceptance, 410
Protrusion, mesiodistal relationship (error correction), 272f
Protrusive closure, 16f-17f
Protrusive record
  option, 269-272
  patient instruction, 271f
  usage, 201f
Protrusive upper teeth, male prominent midface, 225f-226f
Provisional copings, attachment, 343f-344f
Provisional prosthesis
  absence, 341
  choice, 341
  esthetic/functional verification, 347f-348f
  interarch distance, constraint, 347f-348f
  radiographic survey, 343f-344f
Psychological inventories, proposal/usage, 56
Pterygoid plates, obturator contact, 359f
Pterygomandibular raphe
  composition, 167-168
  notch, 177f
  presence, 236f-237f
Pterygomaxillary seal, 164f
Pulpal recession, 109-110
Pulpless teeth, apices, 74
Putty-wash techniques, 128
Pyramidal motor system, role, 315

Q

Quaternary ammonium, usage, 126

R

Radiation cellular damages, impact, 370
Radical alveolectomies, performing, 373-374
Radiographic images, 74-76
  usage, 75f
Radiographs
  film size, impact, 74-76
  usage, 74-76
Radiotherapy
  primary/surgical adjuvant treatment, 370
  significance, 370
  usage, example, 371f
Rag wheel, usage, 265
Rapid-cure type resins, 134-135
  deflasking, 134
  occlusal errors, 134-135
  thermal contraction, differences, 134
Rebasing, 303
  materials, 311-312
Reconstructed mandibles, prostheses (usage), 369
Record bases, removal, 261f-262f
Redox potential, 47
Redundant lips, collapsed class III profile, 240f
Reflex mechanisms, receptors (inclusion), 7
Reflux, 355
Registration bases, formation, 230
Rehabilitation, promise, 340
Reinforced denture base resins, limitations, 139b

Relining, 303
achievement, 304
materials, 311-312
Remaining teeth
examination, 74
number/location, examination, 74
Remodeling process, importance, 48
Remote anchorage, usage, 347
Remount casts
fabrication, 266f
lower dentures, removal, 266f
mandibular denture, articulator mounting, 271f
processed bases, mounting, 368-369
Remounting
bite examination, 413f-415f
jib/index, positioning, 265
Remounting casts
impact, 265
usage, 412
Remounts
adjustment, 416
necessity, 242-248
occlusal index, usage, 269
usage, 243t
Removable dentures
replacement set, insertion, 31
support, problem, 31
Removable implant solutions, 396f-398f
Removable partial denture (RPD)
design, 185f
impact, 48
Removable prostheses
base metal alloys, usage, 151-152
dependence, 98-100
placement, 42
soft tissue support, 342
teeth, usage, 246
wearing, biologic price, 77
Removable prosthodontics
patient problems, short-term resolution, 78
treatment, nutrition guidelines, 32b
Removable restoration, usage, 345
Removal torques, measurement, 324
Reorganized upper wax-up, arch (change), 240f
Residual alveolar processes, formation, 9
Residual alveolar ridges, 164f
alveolingual sulcus, position, 71
atrophic nature, 345f-347f
cross-sectional contour, change, 68
functional stresses, distribution, 310f
occlusal plane, parallelism, 189
resorption, continuation, 35-36
shape/size, dependence, 162
undercuts, excision, 81-83
Residual bone loss, 9
Residual dentition, crowding, 105f-106f
Residual implant material, soft tissue (relationship), 384f
Residual mandibular bone, lingual aspect, 332
Residual maxillary ridge, occlusal loading (excess), 48
Residual monomer content, 135-136
Residual palate, custom tray support, 359f
Residual ridge curvature, implants (placement), 334f
Residual ridge morphology
changes, 49
classifications, 87b
variations, 67
Residual ridge reduction (RRR), 48-49
acceleration, 307f
anterior mandibular RRR, 87f
avoidance, 9
consequences, 49
edentulous segments, 102f
etiological factors, 48b
functional efficiency, 51
oral morphological problem, 102
pathogenesis, understanding, 48
presence, 49f
retardation, 51
severity, 330
stability/retardation, 110-111
time-dependent patterns, 403
Residual ridge resorption (RRR), 15-16, 61f-62f
advanced status, 61f-62f
degree, 336
mental foramina placement, 85f
progression, rapidity, 281-282
result, 303
time-dependent residual ridge resorption, 67f
Residual ridges, 9, 162
anterior part, resorption, 84
augmentation, 90
alloplastic material, usage, 91f
procedures, 49
bilateral undercuts, interference, 267
crest
mental foramen, relationship, 168f
migration, 86-87
denture-bearing mucosa, 9
dimensions, time-dependent reduction, 102
height, reduction, 48
horizontal/vertical relationships, 331-332
hyperplastic replacement, 63f-64f
knife edge, 163f
preservation, 275
Residual tooth structure, amount, 110
Resin denture teeth
bases, bond (ensuring), 142f
heat-cured denture bases, bond, 135
Resin-dough time, processing variable, 142
Resinous complete denture bases, 153b
Resins
dimensional change, 311-312
overdenture area, hollowing, 295
processing, 136
Resin teeth
bonding, 142
esthetic qualities, 142
wear resistance, increase, 140-141
Resorbable sutures, wound healing process (supplementation), 335
Restorations, fracture/ditching, 74
Restorative resins, in vitro degradation, 135
Rest vertical dimension (RVD), clinical determination, 76
Retained roots
identification, 74
periapical health, 294
periodontal support, 293-294
Retained teeth abutments, 102
Retainers, distribution, 294
Retaining screws, access, 390f-391f
Retention, 294-295
components, failures, 312-313
denture adhesive, 291f-292f
hardware, blocking, 383
Retentive attachments, milled edges, 337f
Retentive clips
bar designs, matrices (processing), 338
milled edges, 337f
Retentive components, accommodation, 333-334
Retentive elements
durability, 295
usage, 295
Retentive prosthesis, evaluation, 305
Retinopathy, predisposition, 31
Retrognathic facial skeletons, setup, 225-229
Retrognathic profile, tooth setup requirement, 225f
Retromolar pad (RMP), 167-168, 185f
center, posterior references, 215
circling, 189
mandibular teeth, setting, 218f
middle, curve, 219f
positioned mandibular cuspid, guidance, 223f-224f
Retromylohyoid fossa, 71
alginate impressions, extension, 170f
denture engagement, avoidance, 373-374
extension, avoidance, 169f
presence, 169f
relationship, 169-170
Reversible hydrocolloid (agar), 125-126
composition, 125-126, 125b
manipulation, 125-126
setting (gelation), 125
Rheumatoid arthritis, impact, 31
Ridge-lap areas, tin-foil substitute contamination, 142
Ridges
augmentation, 90
alloplastic material, usage, 91f
height reduction, impact, 67
morphology, compromise, 75f
parallelism, 84, 192
reduction, 189
support, loss, 63

Right buccal vestibules, 164
Right mandible, movement, 342f
Room temperature vulcanized (RTV) silicone rubbers, 148-149
  availability, 148
Root analogues, impact, 290-293
Root projection, 257
Root stabilized overdentures, 296f
Root surface
  caries, studies, 112
  preparation, 110
Ro/SSA, 30-31
Rubber, IPN dispersal, 139
Rugae, 164f
  alveolus, tongue tip (contact), 318-319
  secondary stress areas, relief, 174f

S

Sagittal cone beam reformations, 371f
Sagittal Posselt's diagram, posterior border, 241-242
Saliva
  absence, 156-158
  absorption, 268
  dysfunction, 30-31
  flow rate
    decrease, 66
    increase, 31
  function, importance, 30
  glands, enlargement, 30-31
  impact, 37
  role, 37
  secretion rate, 42
Salivary flow, reduction, 330
Salivary glands
  accommodation, 274
  disease, 156-158
Scar band, identification, 359-360
Scleroderma, control, 401
Scoring, concept (achievement), 178
Screw fragment, removal, 383
Screw retained ceramometal prostheses, occlusal views, 347f-348f
Screw-retained prostheses, 384
Secondary denture support, checking, 66
Secondary osseointegration failure, occurrence, 324
Secondary preprosthetic surgical procedures, necessity, 369
Secondary stability, 388
Secondary stress areas, relief, 174f
Second mandibular left gingival cancer, 362f-363f
Second premolar region, implant placement limitation, 345
Sectional casts, posterior view, 193f
Sectional impression method, diagram, 285f-286f
Selective grinding, usage, 264
Selective pressure impression technique, 67
Self-administered home relines, 146-147
Self-curing resins, 136
Self-satisfaction, appearance (impact), 40
Self-tapped implants, 334-335
Semiadjustable articulator
  condylar elements, programming, 200-201
  extremes, 200
  incisal guide, ability, 201f
Senile osteoporosis (type II osteoporosis), 36
Sensorimotor feedback, 330
Sensory inputs, interpretation, 21
Sensory mechanisms, relationship/dependence, 37
Sensory perception, secondary/dependent function, 7
Separating medium, application, 260-263
Sequelae (control), complete dentures (usage), 42, 51
Sequential cephalometric tracings, 306f
Serum calcium levels, 398-399
17-β estradiol, administration, 399-400
Sharp anterior ridges, panoramic image, 86f
Shear thinning (monophase technique), 128
Sheet boxing wax, usage, 179f
Short bar segments, 334
Short-term edentulous period, avoidance, 113
Short-term soft liners, 144
  composition, 145b
  indications, 145, 145b
  temporariness, 145
  tissue conditioners, 145-146
  usage, challenge, 148
Sialoliths, identification, 66
Sibilant sounds, 235-236, 316-317
  alveolar sounds, 318
  generation, 318-319
  production, anterior teeth
    horizontal relation, 319f
    vertical length, 319f
  teeth, air jet (contact), 318-319
Sickle scaler, usage, 248
Silicone adhesion, loss, 148
Silicone-based liners, 144
Silicone-based soft liners, usage, 148-149
Silicone liner, *Candida* growth, 50f
Silicone materials, usage, 176
Silicone paste, nonionic surfactant wetting agent (addition), 129
Silicone polymers, usage, 155
Silicone putty
  impression material, 172
  usage, 173
Silicone rubbers, availability, 148
Silicones
  disadvantages, 129, 148
  elasticity, 129
  impression materials, formulations, 70-71
Silk sutures, placement, 356f
Silver amalgam restorations, 251f
Single-base stabilization, 241
Single dentures, 298-301
  biologic factors, 298
  diagnosis, 298-299
  management, 298
  mandibular single denture, resilient liner (usage), 299f
  planning treatment, 301
Single dentures *(Continued)*
  teeth arrangement, 299-301
  treatment planning, 298-299
Single implant replacements, host locations (immediate/early loading protocol alternatives), 404
Single impression tray, usage, 282
Single posterior interference, 245f
Single prostheses
  balanced articulation, 301f
  teeth, matching, 300f
Sinus augmentation, 345f-347f
Sinus enlargement, sequela, 345
Sjögren's syndrome (SS), 30-31
  burning mouth syndrome (BMS), association, 28-29
  diagnosis, 30-31
  hyposalivation, effects, 30f
  implant failure, risk (increase), 401
Skin
  aging, 38
    effects, 58f-59f
  creases, presence, 59-60
  graft, 362f-363f
    placement, 88f-89f
  points, measurement, 233f
  tone, prosthetic teeth placement (combination), 191f
Skin-grafted mandible, radiotherapy response, 366-367
Slow-speed handpiece, usage, 383
Smell, 37
Smile
  bicuspids, impact, 204
  confirmation, second try-in (usage), 245f
  Dentsply shade 114, 250f
  facial landmarks/lines, blending, 237f
  gold inlay, 251f
  improvement, 206
  lines
    accident example, 345f-347f
    usage, 76
  maxillary anterior teeth, visibility, 235
  midline shift, 283f
  natural appearance, occlusal arrangement (impact), 223-225
  patient recognition, 235f
  restoration, 297f
  silver amalgam restorations, 251f
Smiling lips, image frame, 236f-237f
Smoking
  cessation, 399
  impact, 398-399
Social confidence, loss, 340
Social environment, knowledge, 54
Socioeconomic status, usage, 54
Sodium hypochlorite
  diluted household bleaches, usage, 154
  immersion, 125-126
Soft connective tissues, 5-7
Soft denture liners, glass transition temperature (Tg), 144
Soft diet, chewing inability, 369

Soft liners
application, 379
cleaning, 148-149
condition, quality (maintenance), 310
molding/excess, trimming, 291f-292f
phthalate esters, 135
presence, 291f-292f
removal, 381
usage, 310f
Soft-lining materials, usage, 78
Softone (tissue conditioning material), 353-354
Soft palate
air, passage, 351
anatomic defect (prosthetic closure), liquid drinking (test), 355
at-rest position, lateral videofluoroscopic frames, 352f
border molding, 353-355
defect, Passavant's ridge (observation), 363f
elevation, 352f
form/mobility, classification, 251-252
movement
inadequacy, 352
range, judgment, 251-252
obturator prosthesis, 362-365
troubleshooting, 365
oral cavity, superior aspect, 351
prosthesis, junction, 361-362
remnant, prosthesis extension, 363f
right/left muscles, attachment, 351
squamous cell carcinoma, resection, 364f
tray extension, 358f
upward lift, 315
Soft plaster mix, 246f-247f
Soft regular set alginate final impressions, 283f
Soft tissue
behavior, impact, 184
coatings, absence, 323-324
conditioner, 47
coverage, 163
growth, 380-381
healing, time-dependent completion, 113
health, 55
ensuring, manual/electric adjuncts (usage), 339f
hyperplasia, 63
impression, implant analogues (placement), 391f
irritation, provocation, 50f
loss, 336
material, application, 391f
morbidity, development (preclusion/minimization), 51
mucoperiosteum, 60
necrosis, 372
overgrowth/collapse, 384
pressure, 176-177
pulling, 171-172
reaction, 380-381
Soft tissue *(Continued)*
reduction, 337f
support, 342
dependence, 60
surface quality/contours, 60
Solar lentigines, thickening, 38
Sol-gel reaction, 126
Sounds
changes, fixed prosthesis (impact), 309
energy, 318
concentration, 318
tabular presentation, 316-317
Spatula, usage, 248
Speaking
assessment, 235-236
new dentures, involvement, 265
practice, 274
Speech
adaptation, 320
analysis, methods, 320
articulation, 58
occurrence, 315
assessments, helpfulness, 236-238
communication, schema, 316f
compromise, 113
dentist knowledge, 58
functional deficits, 352
impairment, 255-257
pathology problems, 320
patterns, 273
problems
incidence (increase), circumoral muscle activity (impact), 382
maxillary fixed implant prostheses, usage, 321
prosthetic considerations, 320-321
slurring, 365
upper/lower teeth, resetting, 238f
Speech production, 315-316
actions/sequences, 315
distortion, complete dentures (impact), 316
oral motor function, 315
schema, 316f
teeth/oral structures, role, 316-320
Speech-related palatal contour, development, 257
Speech sounds
deterioration, 320
emission, 315
listening, 355
oral/nasal cavities, structural controls, 316f
Sphincter
closure, problem, 352
formation, 352f
Spiny ridges, 80-83
removal, 80
Splinted implants, impression material flow, 390f-391f
Splinting bar, encroachment, 334f
Split-axis condylar guidance controls, 199
Split-thickness skin graft, 367f
Spring clamp, flask transfer, 263
Squamous cell carcinoma, resection, 364f
Stage I surgery, 377-379
imaging techniques, usage, 379
interval, 379-380
Stage II surgery, 377, 380
complications, 380-381
cover screw, impact, 380
interval, 379-380
tissue conditioner/soft liner, removal, 381
Stains, removal, 154
Stair-step, elimination, 176
Standard anterior arrangement, 209-215
Stannous fluoride preparations, impact, 112
Staphylococcus aureus (secondary infection), 47
Static centric occlusion contact, closed-mouth recordation, 368f
Static impression technique, 309-310
acceptance, 311
usage, 309-310
Static prostheses, creation, 351
Sticky wax, usage, 269
Stock compound, addition, 172-173
Stock metal tray, compound preliminary impression, 125f
Stock trays
alginate impressions, 126f
characteristics, 172
modification, 413f-415f
usage, 176
Stomatitis, 38f
classification, 44
dentures, 44-48
mucosal lesions, presence, 36
presence, 81f
Stone model, surgery template (construction), 289f
Stone mold, impact, 257-260
Stone removal, 264
Stone teeth, removal, 288f
Stone trimming, estimation, 288f
Stress distribution, implant design, 100
Strip rope wax, usage, 179f
Study casts, 76
Styrene-type monomers, incorporation, 139
Subcutaneous fat pads, atrophy, 38
Subgingival margins, crown preparations, 406
Sublingual glands, 166f
mylohyoid muscle, relationship, 169
Submandibular ducts
patency, checking, 66
sialoliths, identification, 66
Submandibular glands, 166f
pharmacological side effects, 37
Submucosa, formation, 162
Submucosal conditions, evaluation, 74
Sulci (sulcus)
depth, 86
expansion cord, placement, 296f
frenula traversal, 71-72
low wound margin, 89

Sulci (sulcus) *(Continued)*
sulcus-deepening procedure, 87f, 330
surgical detachment, requirement, 88f-89f
width/depth, loss, 49
Super hydrophilic design, 326-327
Superimposed *Candida* infection, generalized stomatitis, 65f
Superior constrictor muscles, 167-168
Superstructure, boundaries (defining), 68-69
Supporting bone
form/size, factors, 161
morphology, stabilization, 113
Supporting denture bases, design, 195
Supporting implants, number/distribution, 336
Supporting occlusal contacts, 264
Supporting structures, anatomy, 161-162
Supporting tissues
displacement, 14
health, 309
oral-systemic vulnerability, 28
prostheses, interfaces, 42
regressive/degenerative changes, 22
Surgery template, construction, 289f
Surgical closure, 367-368
Surgical labial sulcus, deepening, 186
Surgically prepared bony interface, self-repairing ability, 323
Surgically related complications, 377-380
Surgical obturator
goals, 355
prosthesis, 355-356
retention, mechanism, 356
Surgical procedures, time interval, 380
Surgical protocols, 402-403
Surgical scarring, 352
Surgical template, usage, 84
Sutures
adjustments, example, 291f-292f
loosening, 378
removal, 378-380
example, 291f-292f
Swallowing
contacts, formation, 366
functional deficits, 352
soft palate elevation, 352f
Swallow reflex, initiation, 365
Swelling, peak, 378
Syringe material, tempering (nonrequirement), 126
Systemic antibiotics, 378
Systemic conditions, 401
Systemic disorders, 61-62
Systemic health
host bone response, 395-401
oral surgical procedure, impact, 100
status, 56-57
Systemic lupus erythematosus (SLE), 28
prosthodontic management, 28
women, frequency, 28
Systemic mycotic infections, risk (increase), 47

T

Tapered molds, 208
Taste, 37
sensations (impairment), cranial nerves (impact), 37
sensitivity, decline, 37
Teeth
aging teeth, 38
air jet, contact, 309
anterior sectional tray, coverage, 285f-286f
anterior tray, usage, 285f-286f
anteroposterior positions, 190-191
arrangement, 70, 299-301
impact, 205
try-in, 382
assessment, 72-74
attachment mechanisms, differences, 406t
avulsion (compromise), RRR process (usage), 102f
buccal position, 255
calculus deposits, 153f
centric occlusion, 193f
chipping, 69-70
condyles, relationship, 197f-198f
contacts
creation, 271
maximum protrusion, 16f-17f
pressure, spreading, 161
coronal portion, reduction (objective), 110
drift, 74
esthetics, arrangement, 316-317
exchange, 290f
exposure, amount, 115-116
extraction, 69, 289
denture replacement, 74
example, 290f
necessity, clinical conditions, 72b
sequela, enlargement, 345
finishing touch, 207
first contact, patient cessation, 243
forces, production, 8
forms, change, 208-209
grinding (bruxism), 15
facilitation, chemical bonding (usage), 142
implants, differences, 100b
inclination, dissimilarities, 245f
inclined planes, contacts, 18
lingual position, 255
lubrication, 246
measurement charts, 204
millimeter measurements, 205
modifications, IID impact, 116-117
natural inclinations, variation, 212-214
occlusal surfaces (modification), selective grinding (usage), 264
pair, comparison, 207f
palatal surface, restoration, 257
patient satisfaction, 230
Teeth *(Continued)*
periodontium
attachment, 5-7
support/positional adjustment, 7
physiological occlusal forces, exertion, 7
positioning
effects, 318f
functional criteria, 59-60
identification, importance, 282
preparation, 110
copings/magnetic attachments, usage, 361f
problems, awareness, 60
provisional substitutes, wax occlusion rims (usage), 183f-184f
removal, 112
decision, 281
denture insertion, 289
periodontal disease, impact, 396f-398f
simulation, 289
restoration, 396f-398f
retained roots, identification, 74
retention, 50
role, 316-320
rotation, dissimilarities, 245f
setup, 183f-184f
sequence, 209
space, estimation, 288f
shades
comparison, 207f
guides, 204
patient decision, avoidance, 207
shape, 205
size, 205
determination, 205f
information, 76
selection, 207
sockets attachment, 5
speech production role, 316-320
stabilization, muscles (usage), 254f
surfaces
chemical/mechanical preparation, problem, 142
cleanliness, creation, 228f
sutures, example, 290f
touching
absence, 244f
observation, 242f
wax surfaces, 257
wear, impact, 238f
Telescopic crowns, impact, 111
Temporomandibular disorders (TMDs)
diagnosis, 58
management, 58
outcome, prosthodontic treatment (impact), 18
suspicion, 57-58
Temporomandibular joints (TMJs), 57-60
articular surfaces, involvement, 15
changes, 15-18
function, descriptions, 18
jaws, anatomical relationship (absence), 195-196

Temporomandibular joints (TMJs) *(Continued)*
morphological changes, 18
movements, variation, 198
muscles, pain/tenderness, 57-58
palpation, 57
state, change, 268
Tensor veli palatini muscle, 165
Terminal dentition, result, 111-112
Terminal hinge movement, 16f-17f
Tertiary amine initiator, 136
Therapeutic medication, impact, 31
Thermal contraction, differences, 134
Thermal shrinkage, 134
Thermoplastic wax
addition, 364-365
advantage, 359-360
Thin plaster remounting, space (creation), 246f-247f
Thompson color transfer stick, intraoral marking, 44
Thread designs, range, 324-326
Three-dimensional reconstruction, 163f
Three-dimensional stabilization, 324
Tilted implants, usage, 347
Time-dependent aging, 324
Time-dependent denture-wearing problems, 330
Time-dependent functional wear and tear, 69-70
Time-dependent residual ridge resorption, 67f
Tin foil substitute
contamination, 142
teeth, contact, 260-263
usage, 261f-262f
Tipped posterior implants, usage, 390f-391f
Tissue
adaptation, checking, 361-362
behavior, constant pressure load, 79f
blanching, 289
conditioning, 173f
liners, composition, 145
contact, brush line indication, 268
coverage, 240f
displacement, 76
distortion problems, minimization, 267
impressions, accuracy, 255
inflammation, 62-63
intactness, 352
irritation, 275
loss, 352
mobility, impact, 366-367
morphological health variables, diagnosis, 61f-62f
reactions, 324
recordation, impressions (usage), 171
reflection, 282
replacement, 274
responses, comparison, 79f
surface, calculus deposits, 153f
surgical excision, 80
Tissue *(Continued)*
trauma, 44-45, 62-63
impact, 70
severity, 46f
traumatized tissues, management, 78-79
treatment/conditioning materials, usage, 78
treatment liners, physical stages, 310f
undercuts, impact, 282
Tissue-bearing surface, metal base (contact), 149
Tissue changes
continuation, 357-358
occurrence, 304f
periodontal disease, impact, 291f-292f
Tissue conditioners, 145-146
application, 379
cyclic/intermittent loading, 146
distribution, evenness, 145f
durability, 55
effectiveness, 146
elastic recovery, 146
functional impressions, removal, 146
gelation, 145
liners, physical stages, 310f
material
addition, 364-365
placement, 366
removal, 381
rheological properties, 146
usage, 78-79, 173, 295
impact, 309
varnish, recipe, 379b
viscoelastic behavior, maintenance, 146
viscoelastic properties, 146
viscous behavior, 146
Tissue-conditioning material
inclusion, 146f
incremental additions, 357f
physical properties, impact, 311
Tissue-ward movements, 111
Titanium
casting, expense, 152
implants, backscatter, 373
living bone, spatial relationship, 95-96
Titanium alloys, 152
usage, 149-151
Titanium-based dental technology, results, 152
Tobacco smoking habit, dentist enquiry, 55
Tomographic images, usage, 332
Tongue, 64-66
alveolingual sulcus, position, 71
attachments, abnormality, 365
controlling valve, 318
coordination, 64-66
cracking, 30f
cramped space, 320
curling, 352
dorsal surface, opening formation, 320
dorsum
erythematous patches, dekeratinized/desquamated filiform papillae, 29f
flatness, 318
Tongue *(Continued)*
function, impairment, 367
intrinsic musculature, spreading, 66f
lateral border, air control, 255-257
lateralization, loss, 352
mobility, deficiency, 352f
movement, 352
limitation, 174-176
muscles, training, 273
oral examination, depressor (usage), 30-31
palate, contact, 320f, 365
alteration, 369
inhibition, 352
peak forces, estimates, 8
placement, 318
polished surfaces, relationship, 256f
positions
relationship, 58
significance, 64-66
resection, 352
sagittal groove, creation, 320f
seating, 257f
space
cramp, 309
splinting bar, encroachment, 334f
suturing, 366-367
example, 367f
tactile stimuli, replacement, 21-22
upper front part, sagittal groove, 318
upper front teeth, contact, 319
volume, resection, 370
Tongue tip
centering, 366
movement, 169
placement, 318
Tooth color, 205
characterization, 248-249
example, 250f
making, 206
range, 38
selection, 206
Tooth loss, 9
approach, 410
causes, patient perceptions, 54-55
denture origin, 312
dissatisfaction, 90
history, 54-55
impact, 18-20
presence, 13
psychological/biomechanical consequences, 3-4
Tooth molds
guides, 204
occlusal concepts, 216t-217t
selection/agreement, 207
Tooth-on-the-ridge teeth arrangement philosophy, 184-186
Tooth positions, 60
characterization, 248-249
determination, 205f
dissimilarities, 245f
problems, 114
relationship, 58

Tooth roots
abutments, caries/periodontal disease (impact), 318
direct reline, preparation, 297f
preparation, 110
replacement, osseointegrated dental implants (usage), 90
Tooth selection
edentulous patient expectations, meeting, 204-205
factors, 68
patient desires, 205
Tooth-supported complete denture, 295
Tooth-supported immediate complete denture, 295-298
Tooth-supported overdentures, creation, 111
Tooth-supported single overdenture, 297f
Tooth-to-ridge relationship, 70
Tooth-to-tooth relationship, 70
Topical fluoride, usage, 298
Tori (torus), 67, 80-83
extension, 67
palatinus, presence, 67
removal, 80
Tori mandibular, lingual bilateral prominences, 166
Torus palatinus, bony enlargement, 164
Total anteroposterior length, 215
Tourette's syndrome, 29
Trabecular bone, loss (acceleration), 36
Transfer components, usage, 390f-391f
Transforming growth factor-β (TGF-β), 403
Transient ecchymosis, appearance (delay), 378
Transitional prosthesis, usage, 380
Transitional removable partial denture, retention, 282
Transmucosal abutment, usage, 380
Trauma avoidance, 376
Traumatic lesions, 65f
Traumatic occlusal loading, 100-101
Traumatic teeth avulsion, compromise, 102f
Traumatic ulceration, peripheral overextension (impact), 44f
Traumatic ulcers, cheek biting (relationship), 44
Traumatized tissues
conditioning, 146
management, 78-79
Treatment options (choice), information synthesis (facilitation), 54b
Trial denture base (TDB)
creation, wax (usage), 180-182
hard TDB material, usage (alternative), 180-182
occlusion rims, attachment, 180
Trial dentures
movement, 195
waxing, 257-260
Trusoft (tissue conditioning material), 353-354
Try-in
dentition, resetting, 248
esthetics, 248-249
Try-in appointments, 180, 232-234
anterior teeth, resetting, 191f
chairside comparison, 232-233
conclusions, 230
conformative approach, 233f
equipment, 232
explanation, 232
information, determination (priority), 230
interappointment laboratory procedure, 246-248
laboratory prescription, 253-254
preparedness, 230-232
priority, order, 234
reality, 234-249
reorganized approach, 233f
sessions, 230
speaking/phonetic assessment, 235-236
usage, 183f-184f
wax-up
completion, 227-229
readiness, 244f
Try-in assessment
double-base stabilization, 241-242
single-base stabilization, 241
Trying-in appointments, wax-up, 223f-224f
Tuberosities
area, posterior palatal seal, 177f
characteristics, 164
enlargement, 69f
implant placement, 361f
Tumor mass, impact, 355-356
Two-tray impression method, diagram, 285f-286f
Type I dental impression compound, 124-125
Type I denture stomatitis, pinpoint hyperemia, 45f
Type I osteoporosis (postmenopausal osteoporosis), 36
Type I stomatitis, 44
Type II dental impression compound, 124-125
Type II osteoporosis (senile/idiopathic osteoporosis), 36
Type II stomatitis, 44
Type III denture stomatitis, deep crypt formations (surgical elimination), 47
Type III stomatitis, 44

U

Ulcerations, elimination, 379
Ultra-high modulus polyethylene (UHMWPE) polymers, inclusion, 139
Ultrasonics, 320
Ultraviolet (UV) radiation, exposure (impact), 48
Unconscious swallow, 18
Undercuts, 80-83
blocking, 266f, 353
bony undercuts, 67-68
impact, 282
management, 294
removal, 80
surgical removal, 63f-64f
Undernutrition, associations, 51b
Undisturbed healing, description, 388
Unlinked polymer chains, availability, 141
Unsplinted design, ball abutments/magnets (usage), 333f
Unstimulated saliva, absence, 31
Upper anterior artificial teeth, setting, 209
Upper anterior teeth
end-to-end setting, 226
positions (measurements), ANTAG (usage), 413f-415f
problems, 235
shortness, 317
tongue tip extension, 317-318
Upper buccal cusps, length, 272f
Upper cast
attachment, 263
postdam area, scoring, 412
Upper central incisor, palate contour (establishment), 259f
Upper dentures
action, 236f-237f
grasping, 241
limiting structures, 164
Upper front teeth, 236f-237f
Upper front teeth, tongue (contact), 319
Upper incisors, approach, 318
Upper jaws
jaw opening axis, relationship, 195-196
Upper jaws, centric relation (concepts), 16-18
Upper labial contour, 209
Upper lip, droop, 38f
Upper model, holding, 248
Upper molar, flat setup (anterior overlap), 223f
Upper prostheses, 240f
Upper right central incisor, prominence (illusion), 250f
Upper second molar, deletion, 219f-220f
Upper setup, palatal cusps, 219f-220f
Upper teeth
anteroposterior (A-P) relation, 222
dimensions (measurement), Boley gauge (usage), 233-234
length, check, 318
loss, 283f
posterior crossbite setup, 226f-227f
resetting, 238f
visibility, 235-236
Upper wax rim height, 209
Upper wax-up, reorganization, 240f
Urine pyridinoline levels, 398-399

V

Valves, structural controls, 316f
Vanadium alloy, usage, 324
Van der Waals forces, 139
Variable intercondylar distances, 199
Vascularity, loss, 370
Velar movement, absence, 363f
Velopharyngeal area, border molding, 353-354

Velopharyngeal closure, 351
disruption, 352
re-establishment, 353-354
Velopharyngeal inadequacy, 352
Velopharyngeal musculature, activation, 354
Velum, occurrence, 363f
Veneer grafting, 345f-347f
Vent holes, usage, 174f
Vertical dimension
establishment, 366
increase, 381
Vertical dimension of occlusion (VDO), 182, 236-239
accompaniment, 48
aging, 307f
alterations, influence, 321
assessment, 309
change, 79, 268
impact, 303
clinical determination, 76
collapse, 307f
contact, 368f
correction, 114, 245f
correctness, problem, 317
decrease, 360
determination, 368
methods, 192
establishment, 190-192, 321, 368, 412
occlusion rims, usage, 190
esthetics, 190-191
excess, 279
extraoral measurement, 233
increase, 190-191, 238f, 243, 263-264
remount, usage, 243
loss, 49, 305
presence, 332-333
maintenance, 113
mechanics, 192
number, yield, 192
overt loss, 310
phonetic tests, 191-192
preferred VDO, determination, 189
recordation, skin point measurement, 233f
reduction, 271, 284, 307f
remount, usage, 243-246
restoration, 238-239
soft liners, usage, 18
sacrifice, 271
selection, 200
usage, 16-18
Vertical facial support, amount (prediction), 79
Vertical height, increase, 240f
Vertical maxillomandibular relations, establishment, 190
Vertical opening, loss, 353
Vesiculoerosive conditions (VECs), 28
Vestibular depth
recovery, 90
reduction/elimination, 380
Vestibuloplasties, 49, 86-90
indication, 89
Vibrating line, 164
location, 165f
soft palate motion, 165
Vinyl acrylics, 136
Viscoelastic soft liner, advantage, 147
Visible light-cured (VLC) resin
application, 312-313
relining materials, usage, 311
systems, usage, 311
Vision
data-gathering sense, 60
magnification, impact, 60
Visual acuity, diminishment, 60
Visual capacity, reduction, 338
Vitamin D-dependents rickets, 401
Vomer, palatal bone screw (usage), 356f
Vowels, voiced sounds, 316-317

W

Wall mirrors, try-in equipment, 232
Warm water bath, try-in equipment, 232
Water absorption, 268
Water diffusion coefficients, 139
Water sorption, 139
reduction, 139
Wax base, removal, 261f-262f
Wax dentures, fitting, 260f
Waxed-up trial denture, 134
Wax excess
land area removal, 258f
removal, 257
Wax occlusion rims, 180
occlusal plane, alignment, 196
provisional substitutes, usage, 183f-184f
Wax preference, 246
Wax records, handling (care), 246
Wax registration, 245f
Wax relief/design, 284f
Wax replica, removal, 417f-418f
Wax rims
horizontal relationship, 412-416
support, 180
Wax spacer, removal, 173-174, 176
Wax spatula, try-in equipment, 232
Wax sprues, attachment, 417-418
Wax tripod, 246f-247f
Wax try-in appointment, checklist, 231t
Wax try-in remount, interappointment laboratory procedure, 246-248
Wax-up
completion, 227-229, 257
measurements, comparison, 234f
occlusion, 246
pattern, 252
readiness, confirmation, 232
try-in
anterior open bite, 245f
tooth occlusion, 243
visibility, 238f
Wharton duct, patency, 66
Why treatment plan, 77f
Witch's chin, 86-87
appearance, 48
Women, SLE (report), 28
Working side contacts, nonworking side contact, 219-221
Wound healing
detrimental effects, 55
process, supplementation, 335
Wrinkles, elimination, 59-60

X

Xerophthalmia (dry eyes), subjective feeling, 30-31
Xerostomia (dry mouth)
associations, 51b
diagnosis, 30-31
elderly, complaint, 31
subjective feeling, 30-31
X-ray mapping, 320

Z

Zero condylar inclination, usage, 202f
Zinc oxide, 284-287
Zinc oxide eugenol (ZOE)
impression paste, 123-124
applications, 124b
paste, application, 123f
wash impression, compound (combination), 123f
Zirconia, biocompatibility, 324
Zygoma, root, 165
Zygomatic wires, removal, 356