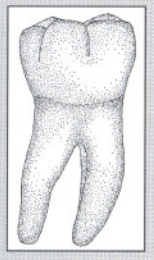
CHAPTER 2



DIAGNOSIS AND TREATMENT PLANNING

CHAPTER OUTLINE

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- Hepatitis
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Many excellent texts have been written on diagnosis and treatment planning. All emphasize that a thorough diagnosis, the determination of what is wrong, must be made before any definitive treatment may be considered. This chapter will deal with diagnosis and treatment planning as related to diseases of the pulp and periapical tissues. It will attempt to clarify the position of endodontics in an overall treatment plan.

IMPORTANCE OF A MEDICAL HISTORY

For many years the medical history was taken so that the patient could be treated in a manner most harmonious with maintenance of general health. Toward that end, it was important to know if a patient had a history of rheumatic fever so that antibiotics could be prescribed; if the patient were diabetic, appointments could be scheduled after meals; or medications already being taken by a patient would be considered when additional prescriptions were needed to prevent undesirable drug interactions.

At this time the dentist must consider not only the actions of treatment modalities on the patient's existing conditions, but also the potential impact of the patient's medical profile on the health of the entire dental operating team. Such conditions as hepatitis B, human immunodeficiency virus disease (HIV), and other sexually transmitted diseases (STDs), as well as active oral infections, may be passed from the patient to the dentist or auxiliary.

Dental personnel involved in a high number of surgical cases, such as oral surgeons, periodontists, some endodontists, general dentists with surgically oriented practices, and their surgical assistants, have been identified serologically as having a greater percentage of hepatitis B infections, even though some were unaware of actively having the disease.

Patients confined to hospitals, nursing homes, and other medical institutions may have the potential for infecting a healthy dental team. Institutionalized patients with Down's syndrome also have a higher incidence of positive hepatitis B antigen than do mentally handicapped people without Down's syndrome. There surely are other serious communicable diseases that have similar proclivities for occurring, along with conditions not normally considered dangerous.

Just as protecting patients from attacks of subacute endocarditis is extremely important, so must the dentist appreciate the seriousness of spread within the practice and self-protection when treating patients with these insidious conditions. Hepatitis is annoying and potentially debilitating; HIV is assumed to be fatal.

As stated in Chapter 1, virtually no medical contraindications exist to routine endodontic treatment. However, multiple situations might arise in which the patient's medical condition, past history, or regimen of medications may have implications that could alter the usual course of treatment. Therefore a complete medical history must be taken before any diagnosis, treatment planning, or even emergency treatment for pain relief is contemplated.

In addition to the patient's name, address, and business and home telephone numbers, the name of the physician of responsibility should always be included on each individual's record. Usually an internist or general practitioner is listed who is responsible for the patient's general well-being. Some patients have a number of physicians, including, among others, a surgeon, an allergist, an otolaryngologist, a urologist, an oncologist, and (for a woman) a gynecologist. After the patient's initial visit, the office receptionist should look up and record the telephone number of each physician listed. If an emergency arises and a physician must be swiftly contacted, the few minutes that would have to be wasted in looking up a telephone number are saved.

Patients should be asked if they have had or presently have any of the following diseases. Both the diseases and their significance in endodontic therapy are listed here.

Rheumatic Fever

Any patient with a history of rheumatic fever has the potential of suffering an attack of subacute bacterial endocarditis (SBE) after any bacteremia. Because almost every dental procedure, whether a simple prophylaxis, the extraction of a tooth, or certain phases of endodontic treatment, causes some degree of bacteremia, definite measures must be taken to avoid the possibility of SBE.

Bender et al's classic paper in 1963 on the degree of bacteremia after various dental procedures firmly established that many portions of endodontic treatment will induce no bacteremia. The authors reported that pulp extirpation and filing beyond the apex did produce a bacteremia, which dissipated after 10 minutes. However, when enlarging procedures were carried out within the confines of the canal, no bacteremia was produced in most cases. Even the placement of a rubber dam causes gingival impingement, and a bacteremia may result. Therefore it is best to use the standard prophylactic procedures before any endodontic appointment.

On the basis of this report, it is strongly suggested that antibiotic premedication be given to any patient with a history of rheumatic heart disease—at the initial appointment for endodontic treatment, at any subsequent appointment if the possibility of going past the apex exists, whenever a periapical lesion is present, and at any surgical appointment.

The preferred antibiotic management of such a patient was changed in 1990 by the American Heart Association's (AHA) Committee on Rheumatic Fever and Infective Endocarditis. The Council on Dental Therapeutics of the American Dental Association (ADA) had representation on that committee; thus these current guidelines have carefully considered dental procedures to be covered and appropriate action to be taken as part of the report. An update of that report by the AHA in 2002 follows.

Conditions requiring the use of antibiotic coverage are as follows: prosthetic heart valves, including bioprosthetic and homograft valves; previous history of bacterial endocarditis, even without a history of heart disease; most congenital heart malformations; heart valves damaged or scarred by a history of rheumatic heart disease; congenital heart or heart valve defects and any other valvular dysfunction, even after intervening cardiac surgery; hypertrophic cardiomyopathy; and mitral valve prolapse with valvular regurgitation and mitral valve prolapse without valvular regurgitation but with thickening and/or redundancy of the valve leaflets in men ages 45 years and older.

Antibiotic coverage is not necessary for the following: isolated secundum atrial defects; surgical repair without residua 6 months after repair of atrial septal defect, ventricular septal defect, or patent ductus arteriosus; previous coronary bypass graft surgery; mitral prolapse without regurgitation; physiologic, functional, or innocent heart murmurs; previous Kawasaki disease or previous rheumatic fever without valvular dysfunction; and cardiac pacemakers and implanted defibrillators.

Dental procedures requiring antibiotic prophylaxis include any treatment known to induce gingival or mucosal bleeding, particularly professional cleaning in which any subgingival manipulation is involved. Procedures for which antibiotic coverage is not recommended include treatment not likely to induce gingival bleeding, such as

adjustment of orthodontic appliances or restorations completely supragingival, not requiring the use of a matrix retainer.

For many years the standard regimen for at-risk patients was to use intramuscular (IM) and, occasionally, intravenous (IV) injections of the antibiotics. Gradually, this was altered to make oral use acceptable for compliant patients. Now the oral route has become the preferred method, except for the few patients who are not reliable or cannot take antibiotics by the oral route. A huge proportion of patients would much rather take pills than utilize IM or IV coverage.

The standard regimen for patients of 60 pounds (27 kg) and greater is 2.0 g amoxicillin (four tablets or capsules of 500 mg each) orally 1 hour before the dental procedure. This is less than the 3.0 g formerly used and does not require the use of 1.5 g 6 hours after the procedure. For patients with allergy to amoxicillin, ampicillin, or penicillin, 600 mg clindamycin or 2.0 g cephalexin or cefadroxil is taken orally 1 hour before the procedure. Clindamycin is a powerful antibiotic that may cause severe, or even fatal, colitis if taken for 1 week or more, which is very unlikely when being used for endocarditis prophylaxis. Azithromycin or clarithromycin may be substituted for cephalosporins for patients with intermediate hypersensitivity to penicillins, 500 mg orally 1 hour before the procedure.

For children, amoxicillin may be taken as a syrup, using 50 mg/kg of weight or, for those sensitive to amoxicillin, clindamycin at 20 mg/kg; or for those using azithromycin or clarithromycin at 15 mg/kg. The total child's dose should not exceed the adult dose.

For those patients who are unable to take oral prophylaxis or who may not follow the oral dosage regimen who are allergic to amoxicillin, ampicillin, or penicillin, adults are administered 600 mg clindamycin IV within 30 minutes before the procedure or cefazolin 1.0 g IM or IV within 30 minutes before the procedure. For children, clindamycin is administered at 20 mg/kg or cefazolin at 25 mg/kg, with total dose not to exceed the adult dose.

Some time ago the suggested method was to start the antibiotic therapy 1 day before the procedure. This schedule has been discarded because it was found to allow more time for producing organisms resistant to the antibiotic.

Because the production of SBE is one of the most hazardous possibilities that may occur from any dental treatment, the regimen described must be followed whenever a prior episode of rheumatic fever is established in the taking of a medical history. In addition to merely asking a patient about the history of rheumatic fever, further questioning should be pursued with a patient who mentions having had any of the symptoms. These symptoms, usually appearing in childhood or early adolescence, include red, tender, and painful joints; small fibrous nodules on the extensor surfaces of the wrists or ankles; recurrent tonsillitis or other streptococcal diseases; and chorea, acute carditis, or rheumatic arthritis. If any question exists as to the possibility of this disease, it is much safer to prescribe the suggested antibiotic medication than to chance SBE. Consultation with the patient's physician is recommended in any cases of doubt.

Wahl published an excellent paper on the pros, cons, and "in-betweens" for the use of deterrents for SBE, describing some of the myths and truths that exist in relation to these procedures. Among the problems he discussed were that compliance by U.S. dentists and physicians to the AHA guidelines has been very poor and that attempting to err on the positive side of antibiotic use may cause serious conditions, including anaphylaxis (rare), allergy, buildup of resistant strains, fungal overgrowth, gastrointestinal (GI) tract upset, and interference with oral contraceptives.

Wahl also discussed the fact that the British Society of Antimicrobial Chemotherapy, a body similar to the AHA in promoting guidelines for endocarditis prophylaxis, only recommends antibiotic coverage for the dental procedures of extractions, scalings, or surgery involving gingival tissues. Endodontic treatment, most crown and bridge procedures, and periodontal examinations are excluded from coverages.

The latest AHA recommendations are the most simple and logical ever proposed in the United States, and compliance should be higher than accorded previously published guidelines. However, if studies currently underway and the experiences of health care workers in Great Britain indicate that some facets of prophylaxis are not necessary, further modifications may be forthcoming.

Artificial Heart Valves

Insertion of an artificial valve in the heart to replace a valve damaged by congenital defect or by systemic or local disease is no longer a rare surgical procedure. Artificial valves currently used are composed chiefly of Teflon or Teflon-like materials to diminish the possibility of adhesions. The danger of clumps of bacterial colonies collecting on these valves increases greatly after a bacteremia. Therefore any patient with artificial heart valves should receive the same prophylactic antibiotic administration as a patient with a history of rheumatic fever.

Coronary Artery Disease

The tremendous increase in life expectancy secured in the twentieth century has caused more people of advanced age to require dental treatment. Coronary occlusion and other cardiovascular diseases are most common after middle age (i.e., past 50 years), although they may be seen frequently in the 40s as well. Associated factors may include hypertension, angina pectoris, arteriosclerosis, stressful occupations, and smoking. Patients exhibiting these conditions may be suspected of a tendency toward cardiovascular disease and should be treated accordingly.

Cardiovascular disease does not contraindicate endodontic therapy, but certain precautions should be observed when treating patients with such a history. Often the patient with a previous episode of coronary occlusion is receiving anticoagulant therapy. Nonsurgical endodontic treatment, including vital pulp extirpation, requires no alteration in the administration of anticoagulants. If surgery becomes mandatory, the patient's physician should be advised. It is up to the physician and not the dentist to alter the administration of the drug to secure a blood level compatible with the clotting required for a surgical procedure.

Because it is necessary to either remove or reduce the anticoagulant cover for a patient undergoing surgery, nonsurgical treatment is much preferred if a choice exists. Conditions such as the presence of a large radiolucency, failure to reach the apex, persistent postoperative tenderness, and other possible indications for endodontic surgery should be given every opportunity to heal without surgical intervention. Only when there is no other choice should surgery be considered. However, because endodontic surgery usually ends with the areas of incision apposed and sutured, it is still preferable to the extraction of an involved tooth.

Pain from any source may cause excitation and resultant heart strain in patients with a history of coronary occlusion. Therefore, during therapy, these patients should be given prescriptions for mild to moderate analgesics to diminish the effects of postoperative pain. As with any analgesic, the initial dose should be given while the local anesthetic (if one has been used) is still effective so that the drug's pain-relieving qualities have ample time to work before the anesthetic is dissipated. If a local anesthetic has not been used, the analgesic should be taken immediately at the conclusion of the appointment. If postoperative pain is anticipated and no local anesthetic is to be used, it is wise to have the patient take an analgesic before the placement of the rubber dam so that much of the drug's effect will be gained right at the conclusion of the appointment.

Most patients with a history of coronary occlusion require no premedication during therapy. If any doubt exists, the patient's physician should be consulted. When more than one tooth is to receive endodontic care at one appointment, a brief recess should be granted between applications of the rubber dam unless the time required for one of the treatments is brief. The use of multiple isolation and treatment of two or more teeth simultaneously, even when adjacent, should be avoided.

If the patient complains of substernal pain during an appointment, a dressing should be placed and the treatment terminated for that day. The patient should be sent to the physician for further investigation. The most common reasons for this symptom are GI disturbance or angina pectoris, but a mild coronary attack may be occurring.

Hypertension

High blood pressure may occur either as a separate disease entity or in conjunction with cardiovascular-renal disease or arteriosclerosis. Among the causative factors are an occupation involving stress, familial tendency, overweight, unbalanced diet, and abnormal stimulation of the sympathetic nervous system, often on an emotional basis. Symptoms include shortness of breath, frequent and persistent headaches, poor vision, ringing ears, nosebleeds, and dizziness. Some patients, particularly in the earlier phases, have no symptoms at all. Treatment is based on reduction of the symptoms, usually by means of various drugs to lower the blood pressure.

The ADA has made a strong effort to organize dentists to aid in the detection of hypertension by routinely taking blood pressure of their patients. Many people visit the dentist at least once yearly but do not see their physician during that period. Screening of all dental patients may locate individuals with hypertension and allow for treatment before the occurrence of serious cardiovascular disease.

For many years, physicians advised dentists who were treating patients with hypertension to avoid the use of epinephrine in local anesthetic administrations. On occasion, patients with a history of coronary attack were also included. Unfortunately, the local anesthetics without vasoconstrictors have a less profound effect and shorter duration of action than those that contain epinephrine. Considerable depth of anesthesia is required in endodontics for pulp extirpation and surgery. Any pain felt by the patient might produce much more epinephrine within the individual's own system than would ever be included in the anesthetic solution. For that reason the epinephrine content of 1:100,000 available in many anesthetic solutions is considered safe. These solutions should be injected extremely slowly, at a rate no faster than 30 sec/ml, with frequent aspiration to avoid injection directly into a blood vessel. The caliber of the needle must be 27 gauge or larger to be wide enough for blood to back up into the syringe when aspirated.

It is wise to place the Carpules of anesthetic into a warming chamber for a few minutes before injection. This heats the solution from room temperature, at which it is normally stored, to slightly above body temperature and permits a less painful injection. This is a good practice to follow before any injection.

Because any anxiety induces an increased blood pressure, therapy should be developed to create as tranquil a mood as possible. Case presentation should be streamlined, with minimal mention of any complications or possible failure. The entire therapy must be performed with a firm and confident manner.

The patient's physician should be consulted concerning the need for premedication. Many of these patients may already be receiving some type of hypnotic or tranquilizer

treatment. When the first appointment in a series is handled by the dentist smoothly, competently, and painlessly, the patient will experience more relief from psychogenic attack than could be accomplished by any premedicament. However, when it is anticipated that a particular appointment for endodontic treatment of a hypertensive individual will be long, difficult, and frustrating, suitable premedication should be employed.

In the treatment of known hypertensive patients, a general anesthetic should be avoided and no more than three Carpules of anesthetic solution should be used at any single appointment. In addition, morning appointments are preferred so that the patient does not have all day to mull over the impending procedure. Early appointments may be preceded by a nighttime premedication. If possible, the total length of any single appointment should not exceed 1 hour, and if the dentist sees that the patient is being overstressed, the session should be terminated.

Diabetes

Regardless of the type of maintenance therapy necessary for control of blood glucose level, all diabetic patients present certain problems when undergoing endodontic treatment. Healing is usually retarded, which should be considered when evaluating periodic postoperative recheck radiographs. Radiolucencies are slower to fill with bone than in normal patients (Figure 2-1). Therefore surgical procedures to save a case that appears to be failing should be delayed until it is certain that the radiolucency is really increasing in size rather than merely healing slowly. In a patient who had normal-appearing periapical

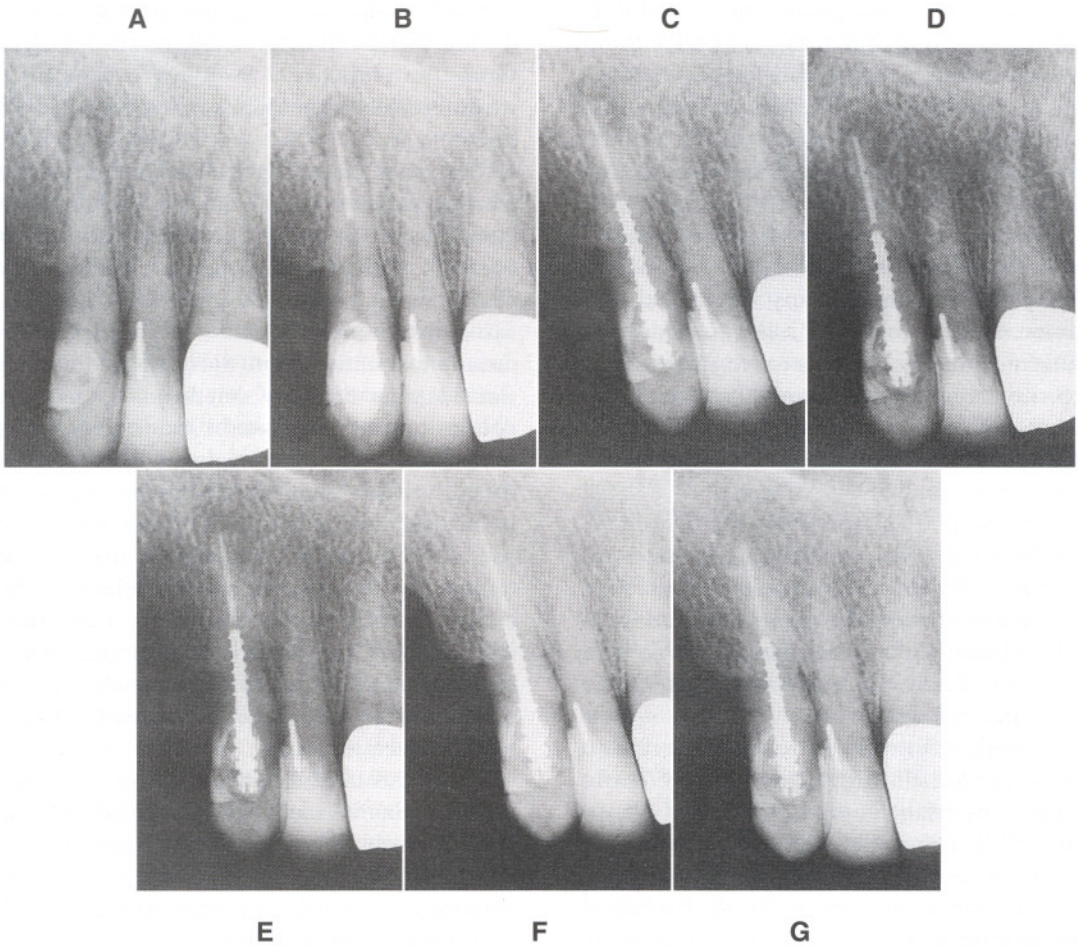


FIGURE 2-1 Delayed healing with diabetic patients. A, Preoperative radiograph of maxillary cuspid with periapical lesion of moderate size, apical tenderness to palpation, nonvital pulp, and obvious pulpal involvement from the distal. **B,** Radiograph immediately after canal filling with laterally condensed gutta-percha and Wach's paste, with post room prepared and a slight excess of sealer apparent. A much larger lesion associated with a maxillary cuspid is shown in Figure 1-9, considerably healed after 1 year and totally healed after 2 years. In Figure 1-13, a lateral lesion, also larger, associated with a maxillary first bicuspid was completely healed after 1 year. Both these patients were healthy. In the diabetic patient, delayed healing is more common. **C,** Six months after treatment, lesion is still the same size, although the excess sealer has migrated slightly to the mesial and apical tenderness is totally absent. **D,** One year after treatment, lesion appears to be slightly smaller. On a healthy patient, you would expect to see considerable healing after 1 year. **E,** Eighteen months after treatment, lesion has decreased slightly and sealer almost gone. **F,** Two years after treatment, lesion has decreased considerably. **G,** Three years after treatment, complete repair. (Restoration by Dr. Steven Fishman, Chicago.)

bone before treatment, 6-month postoperative radiographs may demonstrate a small periapical radiolucency, particularly if the canal was overinstrumented or overfilled. This generally will reverse within a year, again illustrating the slower healing potential of the diabetic patient.

Because diabetic patients are susceptible to infections and to slow healing, antibiotics should be employed in the presence of infection or if a surgical procedure is to be employed. In the case of an infection, penicillin V is the drug of choice, 1000 mg to start and then doses of 500 mg four times a day for 4 days. Diabetic patients, used to taking medication according to a specific schedule, generally cooperate sufficiently to employ the oral route for antibiotics. For surgery the diabetic patient is given penicillin prophylactically on the same schedule as previously discussed for patients with rheumatic heart disease. Erythromycin is used for those patients with a history of penicillin sensitivity.

Alteration in blood glucose level as a result of an acute infection or during and after a surgical procedure is a common finding among diabetic patients. In these circumstances patients should be referred to their physician for any adjustment in medication or diet necessary to combat the change.

The choice of anesthetics for diabetic patients differs from that for other patients. As pointed out by Burket, epinephrine should not be used in the local anesthetic solution because it increases the blood glucose level by stimulating the sympathetic nervous system. Additionally, because diabetic patients often suffer from capillary ischemia due to arteriosclerosis, the increased ischemia produced by the epinephrine may cause tissue sloughs after a surgical procedure. If a vasoconstrictor is desired, levonordefrin (Neo-Cobefrin) may be used because it does not cause sympathetic stimulation (although it does elevate the blood pressure).

Mepivacaine and lidocaine are available without a vasoconstrictor, and both are effective for routine endodontic procedures of short duration. For longer appointments, as when considerable depth of anesthesia is required, and for surgical procedures, either mepivacaine with levonordefrin (2% Carbocaine HCl with Neo-Cobefrin) or a combination of propoxyphene (Ravocaine), procaine (Novocain), and levarterenol bitartrate (norepinephrine bitartrate, Levophed) is an excellent anesthetic solution for use with diabetic patients.

All general anesthetics cause considerable rise in the blood glucose level and should be administered to diabetic patients only with a physician present. When a choice of local or general anesthetic exists for a diabetic patient, local anesthetic should always be preferred.

The scheduling of appointments for diabetic patients requires some discussion. It is important for them to eat at certain specific intervals. Therefore it is best to schedule their appointments early in the morning or early in the afternoon, soon after their meals. In this way, neither running late in appointments nor encountering procedural difficulties that cause a longer appointment than anticipated will delay the mealtime and cause an alarming drop in blood glucose level.

It is well to keep a fresh candy bar in the office among emergency drugs for use in case a diabetic patient feels a coma coming on. Although coma may be due to either too little sugar or too little insulin, it is much safer to administer sugar than insulin in doubtful cases. If the patient does not respond to the sugar administration in a few minutes, a physician should be called. When hypoglycemia is present, the patient's face and clothing becomes wet and clammy whereas the pulse rate, blood pressure, and breathing remain normal. In hypoinsulinism the skin is cold, a severe pallor is present, and both blood pressure and pulse rate are diminished due to imminent circulatory collapse.

Because the healing needed to gain relatively complete bone filling after an extraction is greater than after any endodontic procedure, it is much better for diabetic patients to retain pulpally involved teeth when a satisfactory result seems obtainable. If the prognosis is highly questionable, particularly when a chronically infected tooth is involved, it may be better for the diabetic patient to have the tooth extracted than to chance the products of infection being present constantly.

Hepatitis

The microorganisms responsible for hepatitis, both serum and infectious, are highly resistant to the sterilization procedures normally used in endodontics. Additionally, these microorganisms may remain in the affected patient's blood for a considerable time after the active phase. Therefore, when a patient gives the history of having had hepatitis, all intracanal instruments, which may have picked up causative agents, should be discarded after use. Any files, reamers, broaches, probes, or other such instruments that do pick up potentially dangerous microorganisms, even though subsequently sterilized by dry heat or steam, might cause cross-contamination if used on another patient.

A history of hepatitis, jaundice, or other liver disease may indicate less-than-normal liver function. Any drugs that are detoxified by the liver should be avoided. Drugs typically used in dentistry and falling into this category include erythromycin and halothane (Fluothane), a nonexplosive general anesthetic agent.

Blood Diseases

Although it is relatively rare, a patient with hemophilia may require endodontic therapy. The extraction of a hemophiliac's tooth, at one time a potentially lethal situation, may now be safely accomplished by using packs and prefabricated splints. Even so, using endodontic therapy to avoid an extraction is still more desirable.

Among the greatest hazards involved in treating a hemophiliac patient is the chance of internal bleeding caused by the injection of a local anesthetic, particularly for a mandibular block. If the tooth to be treated has a necrotic pulp, no injection is needed. However, if a vital pulp is involved, extirpation becomes too painful without an anesthetic. To accomplish pulp removal without chancing the possibility of severe internal bleeding caused by an injection, the dentist can gain access to the cavity by using a high-speed instrument with a very sharp bur, water spray, and a brush stroke. When pulp exposure has been gained, a cotton pellet dampened with formocresol is placed as a dressing and sealed with zinc oxide–eugenol (ZOE), and the patient is scheduled to return approximately a week later. The formocresol acts as a fixative on the pulpal tissue and aids in gaining a satisfactory clot by its caustic action.

At the second appointment the dressing is opened and any fixed pulpal tissue removed by sharp spoon excavators and broaches until pain becomes severe. Another formocresol dressing is placed; because much tissue has been removed, the medicament must be placed on a paper point to reach the vital tissue. This process is repeated until all the vital tissue has been removed, and the canals can be enlarged and filled with relatively little pain.

As in all endodontic procedures, the use of the rubber dam is mandatory. Care must be exercised to avoid placing the rubber dam clamp on the gingival tissues and causing severe bleeding. To avoid this possibility, notches may be placed on the labial and lingual surfaces of the treated tooth with a fissure bur, into which the clamp's prongs will fit tightly (Figure 2-2).

Some patients give a history of periodic oral bleeding. This is usually due to a periodontal condition, will clear up after proper therapy, and has no real significance during endodontic therapy.

There are many disease states in which oral bleeding is a much more serious sign, however. Thinking that it falls into the dentist's province, patients may bring this symptom to the attention of their dentist rather than their physician. Among the diseases characterized by gingival hemorrhage are aplastic anemia, cyclic neutropenia, thrombocytopenia, leukemia, purpura, and macroglobulinemia. Two other blood diseases, pernicious anemia and sprue, are accompanied by burning tongue, which might be revealed to the dentist.

If gingival bleeding is not halted by periodontal therapy, referral to a physician is mandatory to investigate for the possible presence of a systemic condition. Except for emergency treatment, endodontic therapy should not be instituted until the systemic condition is diagnosed and under control.

Small petechial hemorrhages near the junction of the hard and soft palate, coupled with weakness, fever, sore throat, chills, and severe lymphadenopathy, indicate the presence of infectious mononucleosis. Endodontic treatment of patients with this disease is exasperating because it is characterized by severe intratreatment pain, exacerbations, and exaggerated responses to drugs. Because some of the symptoms of the disease are similar to those encountered during a severe dental infection, the dentist may be fooled into thinking that an involved tooth is responsible for the condition. "Mono" usually attacks young persons, who normally pose no problems during therapy. Therefore the presence of these typical symptoms in a young patient should alert the dentist to the presence of mononucleosis.

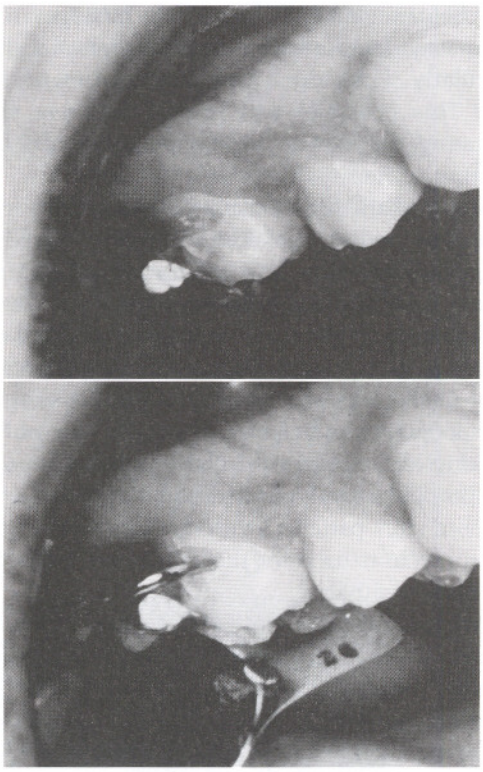


FIGURE 2-2 **A,** In endodontic therapy for a hemophiliac patient, a groove is cut on both buccal and lingual surfaces of the tooth to be treated. **B,** Rubber dam clamp is placed into depressions so there will be no chance for impingement and resultant bleeding of gingival tissues.

After a regimen of bed rest, special diet, and antibiotics, in some patients the disease will run its course of 2 to 6 weeks. If the patient can be kept dentally comfortable while the disease is in its acute state, it is better to postpone the final canal enlargement and filling procedures until all the symptoms subside. At that time the patient's normal level of resistance is regained and a more favorable prognosis results.

Prostheses for Total Replacement of Joints

According to Mulligan, patients who have had total replacement of joints with prostheses are also very susceptible to infections. The most common joint to be

replaced is the hip, but knees, elbows, and shoulders may also become involved. If a bacteremia occurs, which may be initiated by dental treatment, the infection may lead to failure of the prosthesis.

Therefore Mulligan suggests that when such patients are being treated, antibiotic coverage is indicated in any dental procedure that might cause bleeding (e.g., vital extirpation or surgery). The patient's orthopedic surgeon should be contacted before the appointment to determine the desired antibiotic coverage, which may or may not coincide with that suggested for patients with a history of rheumatic fever. If a patient with a replaced joint develops a dental infection, culture and sensitivity testing should be instituted immediately to determine the most effective antimicrobial agent. If a joint becomes painful after dental treatment, the patient should consult the orthopedic surgeon immediately.

Other Serious Diseases

The foregoing diseases have the greatest implication in endodontics, and when the medical history is taken, patients should be asked specifically about them. They should be asked further if they have had other serious diseases, and any mentioned should be recorded.

Some infrequently present but often debilitating diseases (e.g., malignancy, nephritis, pemphigus) will indicate that treatment may take longer than usual to gain a desirable result; the delay is due to the alteration of local responses by the systemic condition.

Asthma, hay fever, hives, or skin rashes indicate hypersensitivity states. Only when necessary should drugs and medications be used for a patient with this type of problem. Unless a history of nonsensitivity is established, no new or unusual drugs should be prescribed.

HIV, Syphilis, and Other Sexually Transmitted Diseases

With changes in sexual attitudes in the 1960s, STDs have increased dramatically recently, and some symptoms of these illnesses may be manifested by lesions in the oral cavity that prompt patients to seek treatment from a dentist. With the advent of antibiotics, syphilis cases very significantly decreased, but now again are on the increase. Oral syphilitic lesions may resemble a chronic draining sinus tract (fistulous tract), poorly healed apicoectomy or periodontal surgery scar, fibroma, or draining periodontal pocket. As a result of decreased resistance, HIV patients may succumb to Kaposi's sarcoma, which demonstrates oral lesions in approximately half its occurrences.

HIV has become the scourge of those involved in public health. Much has been written and discussed about the subject, some factual and some speculative. As with the bubonic plague 400 years ago and poliomyelitis 45 years ago, some of the information concerning HIV may be blown out of proportion or be incorrect.

HIV does have two seriously insidious aspects that cannot be minimized. First, patients with HIV have little to look forward to except probable death, perhaps not from the virus that causes the disease, but from associated illnesses that attack people whose immune systems have been seriously weakened. Second, for every person with active symptoms of HIV, it is estimated that 10 times as many have precursors of the disease, and as many as 50 times that number will test positive for the antibody to the virus responsible for the disease.

Originally called *AIDS,* or *acquired immunodeficiency syndrome,* this disease is now referred to in terms of the etiologic agent, the *human immunodeficiency virus (HIV).* Patients suffering from HIV will test positive for HIV and thus are considered to be HIV positive. HIV is considered to be a lentivirus, or slow virus, indicating a long incubation period and slow progression of the disease. The mean incubation period, from first contact and infection to initial signs and clinical symptomatology, is approximately 10 years, but this time is extremely variable.

Because HIV progressively incapacitates the immune system, any diseases that thrive in this immunologically depressed atmosphere will fulminate in these patients. Because of the long period of latency, initially no deviation from normal may be noted by the patient or during cursory examination by a health professional. Eventually, however, opportunistic infections (persistent candidiasis, herpes simplex or zoster, Mycobacterium infections, pneumonia, Salmonella infections) or neoplasms (Kaposi's sarcoma, several types of lymphoma) eventually cause death. The symptoms of several types of these diseases may be revealed after examination or consultation with a dentist.

One of the major factors in the insidious attack of HIV is that it is a retrovirus and therefore carries genetic material such as ribonucleic acid (RNA) and reverse transcriptase, which may convert into the proviral deoxyribonucleic acid (DNA). The latter attaches and then enters into the infected host cell and is able to produce more viruses. The usually infected cell is the T4-helper lymphocyte, important in immune regulation and cellular response to infections. When infected by HIV, the T4-helper lymphocytes no longer perform their normal function and reduce significantly in number, from 700 to 1000 cells/mm^3 to less than 500 cells/mm^3 in adults. Thus the infections and other conditions previously listed have an enhanced environment in which to develop.

In the United States, 96% of HIV-positive patients are male homosexuals and bisexuals, IV drug users, or recipients of infected blood. Inner-city poor are overrepresented in these statistics, with blacks (12% of U.S. population) accounting for 25% of the cases and Hispanics (7% of population) 14% of cases.

It would appear that performing endodontic treatment, even for those at high risk for HIV, can be made acceptably safe. The virus seems to be killed easily by 5% sodium

hypochlorite, the dominant irrigant used during therapy. Contact with the patient's blood is very minimal because most therapy is performed without surgery with a rubber dam in place, and the major condition in which blood may flow in significant amounts is during the extirpation of a vital, inflamed pulp. Even at that time the dentist does not contact any of the blood, and the instruments used to extirpate the pulp and enlarge the bloody canal are disposed of according to those involved with possibly blood-borne pathogens. Chapter 13 will present the suggestions for barrier controls for HIV and other possibly infected patients.

Those working in dental offices, including doctors, assistants, and auxiliaries, seem to be doing a very good job preventing transmission of HIV from infected patients. At this writing, no documented case of HIV to dental workers has been reported. It is estimated that the risk of HIV to workers in the health care industry is very low, much less than the risk of hepatitis B. Most of the documented HIV transmissions have involved nurses or laboratory technicians infected by blood due to needle sticks or sharps accidents.

Similarly, studies concerning transmissions of HIV from HIV-infected health care workers to their patients indicate that the case involving the dentist from Florida is the only one on record. Recently an investigation by the Centers for Disease Control and Prevention indicated that 19,036 patients treated by 57 HIV-infected health care workers resulted in absolutely no HIV transmissions. This information should make all of us feel much better as to the scourge of HIV attacking us in our offices. Undoubtedly, this has resulted from the care and intensity applied to the aseptic techniques, barrier control practices, and sterilization procedures carried out in dental offices. However, this should not lead anyone to believe that these high standards need not be maintained. On the contrary, the success undoubtedly is due to the diligence thus far practiced.

Other STDs may be found in the general dental population with oral manifestations or the ability to be transmitted during dental treatment. Sexually transmitted herpes has struck 20 million heterosexual Americans. The disease is incurable, may be painful, may have oral lesions, but is never fatal. Gay males may be struck by hepatitis, which might be fatal but usually is not, and certain lower GI diseases, which fall under the umbrella term *gay bowel syndrome,* usually related to having sexual encounters with inhabitants from or visitors to tropical islands. Gonorrhea, as with syphilis, is easily treated with antibiotics.

Recent Change in Weight

Although not a disease in itself, a recent significant gain or loss of weight may indicate factors to be considered during endodontic therapy. If this symptom or any other symptom uncovered in the taking of the medical history is suggestive of systemic disease, the dentist should immediately contact the patient's physician, who would conduct further diagnostic examinations.

A common cause for significant loss of weight is intentional dieting. Many drugs—hypnotics, antibiotics, analgesics, and occasionally local anesthetics—may have increased action or possibly cause ordinarily rarely seen side effects, particularly in the GI system, when administered to a patient who is dieting. Also, if a surgical procedure is to be performed, optimal healing requires that correct amounts of vitamins, minerals, and proteins be present in the diet. If a diet is being followed under the advice and guidance of a physician, usually no problems arise. However, if the diet is self-imposed, an analysis of the foodstuffs ingested often reveals considerable lack of balance and supplementation is required.

Loss of weight may be due to appetite decrease from drug ingestion, anxiety, pain, excessive smoking, or alcoholism. Neoplasms, diabetes, and Addison's disease also are accompanied by weight loss.

Weight gain generally is due to excessive eating, which may be stimulated by psychogenic reasons, hormonal disturbances, or pregnancy. This increased food ingestion usually is heaviest in carbohydrates and may be accompanied by increased caries incidence. If this is the case, restorations, particularly after endodontic therapy, must be fabricated to give the greatest possible protection to exposed tooth surfaces. Temporary crowns, splints, orthodontic bands, or other prostheses and appliances should be removed frequently and the teeth examined for recurrent decay.

Weight gain may also result from water and salt retention due to renal or heart disturbances, which have already been discussed. The endodontic patient with water retention problems frequently suffers from intratreatment exacerbations when not receiving medications. Typically, this patient has swollen, edematous ankles or wrists. During the taking of the medical history, direct questioning about the condition will either confirm its presence or rule it out. Many patients with water retention problems take their medications only at certain times (e.g., women who take diuretics shortly before their menstrual period). If it is established that a patient falls into this category, a consultation with the patient's physician is indicated to prescribe necessary medication to avert the possibility of exacerbations.

Patients who give a history of recurrent acute exacerbations in relation to previous endodontic therapy and who appear to have the typical water retention problem should be referred to their physician for consultation before a new tooth is treated. Emergency treatment should be given, of course, but the patient should be evaluated before routine treatment is provided.

Psychologic Problems

There is not sufficient space here for listing all the psychologic problems that may enter into the treatment of a

patient in endodontics. The fact that a patient is under the care of a psychiatrist for an emotional difficulty does not indicate that a serious management problem will arise during dental treatment. In fact, a patient receiving treatment for an emotional condition may have come to grips with the disorders and be able to react normally to the phases of endodontic therapy. On the other hand, a patient with unsolved psychologic disorders who is not receiving professional help may prove to be difficult to manage.

Although it is helpful to know, it is difficult to ask the patient directly about emotional problems. Certain hints concerning a patient's emotional condition may be disclosed during the taking of the medical history. Some physical problems indicate a tendency toward anxiety, fears, and other emotional disorders. These include colitis, stomach and duodenal ulcers, asthma, hypertension, frequent severe headaches, and temporomandibular joint (TMJ) dysfunction syndrome. Persons taking tranquilizers or antidepressives probably have some type of emotional problem.

If the patient is referred by another dentist, the referring individual is usually aware of the problems and alerts a colleague by a phone call or note before the patient is seen to facilitate proper handling to avoid an initial disturbing conflict. Relatives may be a source of information by similarly advising the dentist of the prevailing situation. Some patients freely volunteer such information, including their psychiatrist, when asked for the names of their physicians or stating that they are receiving psychotherapy when disclosing what diseases they have had.

Some of the more frequent psychologic problems that might affect endodontic therapy will be briefly discussed. If more information is desired by the reader, the bibliography at the end of this chapter may act as a guide.

In general, two types of patients with emotional conditions must be considered in relation to endodontic therapy. One type is the patient who has converted a psychologic condition into a physical problem in or around the oral cavity. The other is the patient with such severe fears and anxieties that treatment becomes extremely difficult.

Conversion reactions are those in which a physical dysfunction is manifested from an emotional conflict without any organic pathosis. The physical symptom reduces the emotional pain and anxiety, attracts attention and concern from others (e.g., family and members of the medical professions), and provides a concrete condition to avoid treatment for the true problem. Because the oral cavity is the earliest site of pleasure for the infant and remains an area of pleasurable responses throughout life, it is only natural that diseases of emotional origin may be encountered in the vicinity.

Fortunately for those involved in endodontics, few disorders of this type stimulate a typical pulpal or periapical condition. However, occlusal problems, particularly bruxism, and such periodontal conditions as acute necrotizing gingivitis, desquamative gingivitis, lichen planus, glossodynia, and dental caries may have psychosomatic origins. Of these, only advanced dental caries causing pulpal involvements is likely to bring this type of emotionally disturbed patient directly in contact with an endodontic problem. However, here the symptoms of pulpal exposure are quite real and will respond favorably.

Problems arise for the endodontist when a patient is treated for a dental condition with a psychosomatic etiology. No relief is provided, and thus a pulpal problem is suspected. The patient may have several deep restorations or other suspicious elements, and endodontic treatment may be undertaken. When no change in symptoms is noted after seemingly correct treatment in a patient who is suspected of having emotional problems, the existence of a conversion reaction must be strongly considered.

Certain patients become extremely upset before and during dental treatment and are so physically and emotionally drained during even the briefest appointment that they are unable to function properly for at least the remainder of that day. These patients have a deep fear of dental pain and manipulation or treatment, to the extent that they are completely worked up before even entering the office.

Many state that they have had unfortunate dental experiences, such as severely painful injections; syncope after injections; poor reaction to an anesthetic or inability to be anesthetized; rough, inhumane, or sadistic treatment; dry sockets; or other severe postoperative pain. Any of these symptoms may occur to any patient who has had considerable dental treatment, but the patient with deep anxiety tells of the recurrences of these problems and greatly dramatizes the events. He or she is obviously fearful that the approaching appointment will lead to another traumatic experience. Because of this deep fear, regular dental visits are neglected; when finally forced to seek treatment for relief of pain or because of family pressures, the person may have an extremely advanced periodontal or carious condition requiring complex endodontic, periodontal, and restorative procedures.

In treating patients of this type, the practitioner must maintain a friendly but firm manner. The case presentation should be brief but confident. Instruments should be kept out of sight of the patient during the explanatory period. Booklets prepared by the ADA and the American Association of Endodontists (AAE) to give patients information concerning endodontics are excellent and supportive. They may be given to the anxious patient at the end of the appointment, to be read at home. Often a fearful patient is so tense that the case presentation is neither heard nor understood, and after appointment completion, he or she may conjure up incorrect assumptions. These would be dispelled by these brochures.

Many researchers have documented that as the degree of anxiety is increased, the tolerance for pain decreases and the response to pain increases. Anxiety, which is reflected as a psychologic stress in certain individuals,

causes the same kind of physiologic changes that occur when there is direct physical assault to the tissues. Beacher and Sweet reported on the effects of anxiety in two groups of 150 young men. One group required surgery after injuries at the Anzio beachhead during World War II. The other group was composed of surgery patients in a civilian hospital. Of the soldiers, only 32% required a narcotic for pain relief, whereas 83% of the civilians needed a narcotic. For the soldiers, leaving the field of battle reduced their anxieties because the war was a greater threat than was surgery. The civilians were removed from their normal comforting environment and subjected to surgery. Their anxieties were increased, as was their pain.

Applications of this information in treating the patient with anxiety about approaching endodontic therapy are apparent. One must emphasize that endodontics is preferable to extraction. The patient should be told that the treatment saves the tooth and prevents drilling of adjacent teeth, that no bleeding results, and that any pain after the appointment is minimal. When treating a tooth with necrotic pulp, the dentist should point out that no injection is needed.

If a choice of teeth to treat at the initial visit exists, the easiest should be chosen (preferably not a mandibular molar, where the greatest anesthetic problems occur). All the anesthetic administration precautions discussed in the segment on hypertension should be observed. By all means, some treatment, even if only perfunctory, should be performed at the first visit. A smooth, relatively painless initial visit is the best medicine to indicate that further treatment will be uneventful.

For long or potentially painful appointments, hypnotics should be prescribed if someone is available to accompany the patient when he or she leaves the office. Under no circumstances should these premedicaments be used if the patient cannot be so chaperoned.

A highly emotional state that may be encountered in endodontics is seen in patients suffering from cancerophobia. Great care must be exercised in the case presentation to avoid even the mere suggestion that a growth is present because a problem in the periapical area might be carelessly described. A chronic draining sinus, chronic alveolar abscess, or endodontic–periodontal pocket might be thought of as malignant by such a patient. If a cancerophobic patient has a periapical area disorder and is concerned about its implication, surgery with biopsy of the lesion may be the best method by which to set the patient's mind to rest. The time required for a radiolucency to demonstrate healing after nonsurgical treatment may cause too much anxiety.

Drug and Medication Therapy

In addition to illnesses, the medical history must include information concerning the patient's past and present drug and medication therapy. This information is important in clarifying any questions about a patient's physical condition and the possible effects expected from any medications that might be needed for the present dental problem. This segment of the history must also include any adverse reactions that the patient has had to any drugs, particularly to those used in connection with dental therapy.

Some dentists prefer to take a medical history directly, rather than by having the patient fill out a form. However, because of the long list of drugs presently in common use, the patient's history of medications must be obtained by using a prepared list or by having the patient fill out a questionnaire. If a form is used, it should include the following information.

Have you taken or are you now taking any of the following drugs or medications? Indicate any unusual reactions you have had to any of them.

Penicillin
Sulfonamides
Other antibiotics
Aspirin or aspirin substitutes
Other pain relievers, such as Darvon, Tylenol, or Vicodin
Antihistamines
Sedatives or sleeping pills
Tranquilizers
Cortisone or other steroids
Anticoagulants or blood thinners
Digitalis, nitroglycerin, or other drugs for heart trouble
Medicines to reduce blood pressure
Medicines to reduce excessive fluids (diuretics)
Insulin or other medications for diabetes
Others (please list)

A patient may be taking a medication but be unaware of its action or its major ingredients. Through *Mosby's Drug Consult 2003*, the drug may be determined by matching with the drug identification guide, which has full-color reproductions of most products. The type and action of most drugs may be explained by other sections of *Mosby's Drug Consult*. Consultation with the patient's physician is advisable if further clarification is needed.

Before prescribing any drugs for a patient, the dentist must be certain that previous administration has not resulted in an allergic reaction or idiosyncrasy. This is particularly true for antibiotics or analgesics, which are frequently prescribed during endodontic treatment but have considerable allergic potential. Allergic reactions to penicillin or tetracyclines have been reported with some frequency. Some patients experience gastric distress after taking aspirin, and others have unusual reactions to codeine, Darvon, or other pain relievers. Sulfonamide may be used as an intracanal medication, but only when there is no history of allergy.

Patients with general allergies, as opposed to those solely caused by specific medications, may offer some problems during the course of endodontic therapy. Although no hard facts are available, many clinicians have

observed that allergenic patients suffer from flare-ups more frequently than nonallergic patients. This should be considered when treating conditions that are more prone to intratreatment problems in patients with a history of allergies. When treating patients with periapical lesions, the time set between appointments should be kept to the minimum when using the tables in Chapter 16. Such patients should be well monitored during treatment and seen quickly if an incipient sign of exacerbation is noted. Merely putting these patients under antibiotic coverage may not solve the problem. The antibiotic may be ineffective or, worse still, cause an allergic response. The flare-up might be immunologic rather than bacterial.

Just as no contraindications exist to endodontic therapy for any specific illnesses, no regimens of medication suggest avoidance of such treatment. However, patients taking heavy dosage of steroids often experience intratreatment pain and exacerbations due to the suppression of the inflammatory response. Steroids are prescribed for patients with pemphigus, rheumatoid arthritis, scleroderma, lupus erythematosus, and other collagen diseases. The mildest type of infection may become serious in patients receiving steroid therapy. Also, many signs and symptoms of inflammation that aid a physician or dentist in making a diagnosis are suppressed.

When performing endodontic treatment on patients receiving steroid therapy, the dentist should ensure that the appointments are scheduled a maximum of 48 to 72 hours apart. The usual separation of appointments by a week or more stretches out the period of therapy too greatly and increases the possibility for microorganisms to be attracted to the site of irritation and gain a foothold for an exacerbation. Therapy for teeth with vital pulps should be completed in two sittings, even if each appointment requires considerable time. Necrotic cases are completed in three appointments whenever possible, preferably in a 1-week period. Rapid sealing of the apical areas prevents microbes from finding an excellent breeding area. If indications of an infection appear or if surgery is required, antibiotic therapy plus increased dosage of steroids must be instituted by the patient's physician. Stressful conditions for these patients, as in surgery, infections, or trauma, might produce adrenal insufficiency unless the steroid dose is raised.

Patients who consume large and frequent doses of aspirin may experience bleeding problems after periapical surgery or extraoral incision and drainage. Patients receiving major tranquilizer therapy may experience unusual reactions when hypnotics or narcotics are prescribed by the dentist. The physician should be consulted before any additional drugs are suggested.

DENTAL HISTORY

Frequently the greatest problem causing failure to gain patient acceptance of a treatment plan is that the patient's wishes are not solicited. A new patient comes to the dental office and is examined by radiographs, study models, explorer, and periodontal probe. A careful diagnosis is made, and a treatment plan is formulated and presented. All this will have taken considerable time, and excellent judgment but may be rejected because of lack of pertinence to the patient's goals.

Many problems are averted by merely asking the patient simple questions, such as "What may I do for you?" or "What problems are you having with your teeth?" or "What would you like to accomplish with your dental treatment?" The last question indicates both your desire to hear about and respond to the patient's problem and your understanding that there should be an overall objective reached, rather than a series of patchwork, piecemeal treatments given.

During the initial consultation, a number of other questions should be asked either verbally by the dentist or, as suggested by many experts in the field of practice management, by a patient questionnaire. Typical among these questions are "Do your gums bleed?" "Does food pack between your teeth?" "Does dental floss catch on your fillings?" These queries set the wheels in motion for stressing to the patient the importance of periodontal therapy, restorations of proper contour, and other sophisticated facets of dentistry, of which endodontics is an important branch.

After hearing the replies to these questions, the dentist should record in the patient's own words the answers given. When the case presentation is made, referral to these answers will show that the treatment plan is aimed at accomplishing the patient's objectives. If the current objectives are not appropriate to best dentistry, the patient must be given a thorough explanation that indicates the need for reappraisal and adjustment to reach a suitable goal of dental health. A patient's failure to respond positively to a realistic and progressive treatment plan usually indicates a lack of receptivity to modern dentistry, and that the patient is a poor candidate for inclusion in an effective dental practice.

A patient seeks dental treatment for one of five purposes, as follows

1. Relief of pain or discomfort—as with pulp exposure, fractured or mobile tooth, bleeding gingiva, acute abscess (either periapical or periodontal), TMJ pain, broken prosthesis, or dislodged restoration, etc.
2. Correction of masticatory inefficiency or insufficiency—result of multiple missing teeth, severe malocclusion, or prematurities, etc.
3. Improvement of cosmetics—unesthetic appearance due to large unsightly synthetic restorations, missing teeth, obvious metal restorations, large carious lesions, edematous gingiva, poorly matching or shaped jackets, diastemas, or malocclusion, etc.
4. Examination for oral-systemic relationship—patient usually referred by a physician, when a disease state is

suggestive of having originated in or spread to the oral cavity or when a disease is determined to be present but the rest of the body appears to be normal

5. Checkup—periodic with many people but also needed for women during pregnancy and for patients who are to have a surgical procedure (when the surgeon wants to be sure that the patient has no chronic dental problem that might interfere with healing)

It is important to ascertain which of these reasons has brought the patient to the dental office. Occasionally a patient indicates to the dentist a reason that is a cover-up for the true one. A typical example of this is the patient who fears that an oral ulcer is malignant yet states a completely different reason for seeking dental treatment.

Much of the dental history is recorded in the patient's dentition and must be related to the verbal information that is supplied. Multiple edentulous areas without replacement, heavy stain accumulation, obvious carious lesions, and minimal restorations indicate that the patient has a poor appreciation for dental treatment. Unless a strong motivation is supplied by the dentist or the patient's family and fully accepted by the patient, it is fruitless to attempt to formulate a treatment plan, particularly one which includes sophisticated procedures.

Multiple missing teeth replaced with poorly designed or fabricated bridges and partial dentures indicate that the patient has desired good dentistry but has been treated by practitioners incapable of supplying the best treatment. Usually this patient realizes that dental health is important but may be reluctant to undergo further extensive therapy for fear that the same result will occur. In this type of case, it must be indicated to the patient that a more progressive form of treatment will be followed. The use of periodontal and endodontic therapy must be emphasized so that the philosophy of extracting teeth is averted.

Patients with excellent restorative work rarely require introduction to sophisticated dentistry. They may have left their previous dentist because of a personality conflict but not from dissatisfaction with treatment. Taking time to explain some of the facets of therapy is frequently all that is required to gain control of the problem and restore a desirable dentist–patient relationship.

RADIOGRAPHS—THE MOST IMPORTANT DIAGNOSTIC AID

Use of the radiograph is mandatory in the diagnosis of any dental situation. In endodontics the radiograph is the most important single diagnostic aid because it is the only reliable method for gaining needed information concerning the pulp canal space and periapical tissues, which are not observable to the naked eye. Any of the routine radiographic techniques described in textbooks or taught in dental schools can give the desired results necessary for adequate endodontic diagnosis. Although the bisected-angle method may be used, long-cone techniques are now preferred, particularly for endodontic and periodontal evaluations.

Film Holder

Use of a film holder is an excellent aid in obtaining reliable radiographs, particularly for posterior teeth. Film holders are commercially available or may be made from

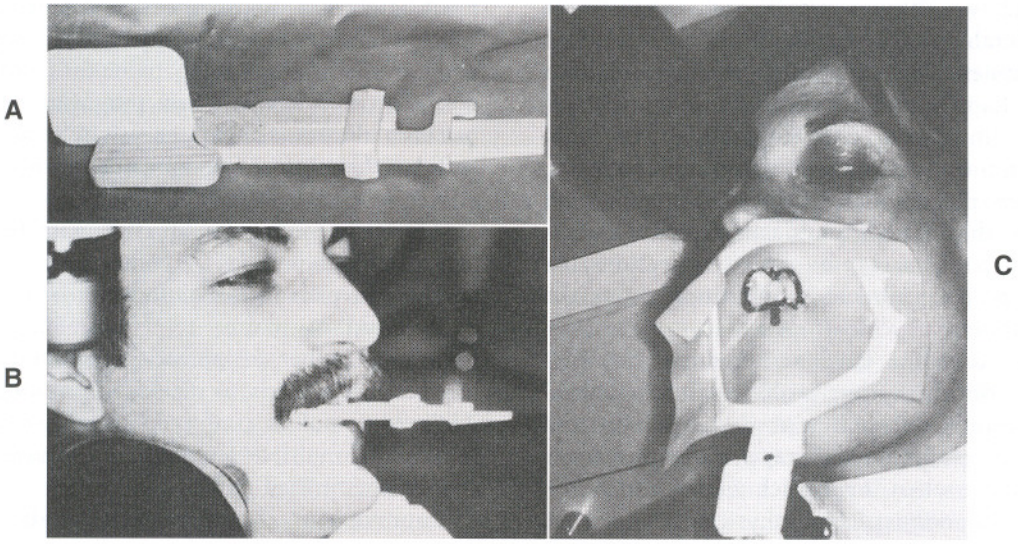


FIGURE 2-3 **A,** Film holder, which is very useful in taking any intraoral radiograph. **B,** Patient is able to close on the holder while the film is being exposed, a much more comfortable position than having to keep the mouth open while film is finger held. With this technique, the film has no opportunity to move between the time of placement and exposure. **C,** During treatment the film holder may be used for anterior teeth so that working length and master cone films can be acquired without the patient having to touch the film or holder and with the rubber dam still in place. Merely slip mounted film under rubber dam, and it will be held in place perfectly during exposure.

wooden blocks or impression compound (Figure 2-3, A). They are mandatory for the long-cone technique.

Because of the angle of the hard palate, radiographs that are held by thumb or finger usually show the maxillary molars as having short buccal roots and a long palatal root. In actuality, the palatal root is rarely more than 2 mm longer than the buccal roots—a relationship that is correctly shown on films held by a film holder (Figure 2-4).

For mandibular molars, film in a holder is exposed with the teeth closed rather than open, as in finger-held views. Therefore the film has less chance to gouge the tissues on the floor of the mouth when a film holder is used because the mylohyoid muscle is relaxed when the jaws are closed (see Figure 2-3, B).

The film holder ensures that the film will be parallel to the occlusal surfaces of the teeth and aids in the positioning of the x-ray tube. It is easier to reproduce film angles for a series of the same area, and the film holder provides a method by which a particular tooth may be centered in the film. Because many articles have been written in nonprofessional magazines concerning the dangers of radiation, patients are more comfortable when a device other than their own finger is used in holding the film.

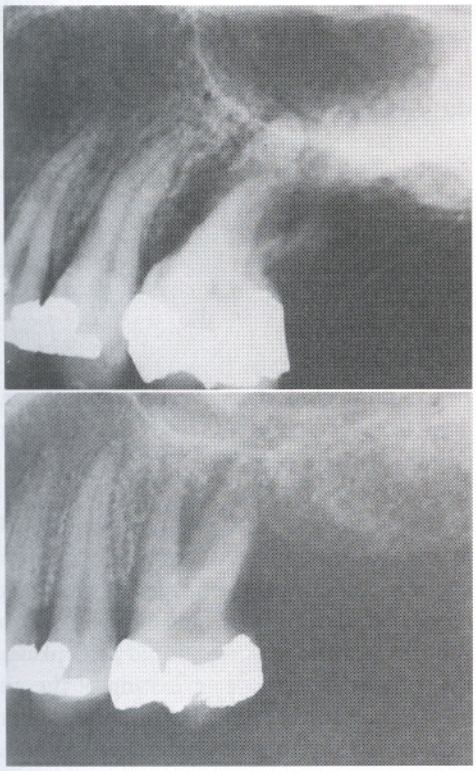


FIGURE 2-4 **A,** Radiograph of maxillary molar taken by having patient hold film with his thumb. Film was bent toward palate, distorting image, and was rotated. **B,** Same view taken with film holder. Note more normal relationship of root lengths and much better diagnostic quality of film.

For working films on anterior teeth, the opposite end of the film holder may be used so that the patient need not touch either the film holder or the film (see Figure 2-3, C). The mounted film is placed under the dam and positioned behind the tooth to be radiographed. The plastic rubber dam frame keeps the holder in position, and an excellent film is obtainable.

Types of Intraoral Views to Take for Endodontic Therapy

In addition to the normal 18 to 22 views of a routine full-mouth radiographic survey, endodontic therapy requires supplementary films. Any tooth for which therapy is considered must have a minimum of two views, and posterior teeth may require three. One view should be the normal, straight-on or direct exposure that shows the tooth to be treated well centered and allows for visualization of its mesiodistal dimensions. By altering the horizontal angulation of the cone, the dentist takes the additional films from a mesial and/or distal angle that retains the centering of the tooth in question but also gives some clues as to its buccolingual dimensions. Because many teeth are wider buccolingually than mesiodistally, much diagnostic information is available from these radiographs. Examination with a magnifying glass or projector for enlargement is encouraged.

The direct view should give the following information concerning the tooth.

1. *Approximate overall length.* Depending on the vertical angulation required for the particular area, the measured length of the tooth image on the film may or may not correspond to the true tooth length. Views of mandibular molars and bicuspids taken at close to zero-degree angulation, with the film parallel to the teeth, result in a close correlation of tooth length to measured length of image. Maxillary anterior teeth, particularly cuspids, which require increased angulation, have a poorer correlation. However, if the film holder is used routinely and careful radiographic technique is followed, examination of the image gives significant clues as to relative tooth length so that sufficient warning is available before treatment when teeth are either much shorter or much longer than normal (Figure 2-5).
2. *Mesiodistal width of the pulp canal space.* Radiographs instantly reveal something about the width of the pulp canal space in general terms: that it is of normal width, is sclerotic, is very wide (Figure 2-6, *A*), or shows resorption. Such information is of obvious value during the course of therapy or in determining the method of treatment. Normal width may vary with the patient's age but is indicated by a definite radiolucent line from some position in the crown to the apical area. The sclerotic canal is vague

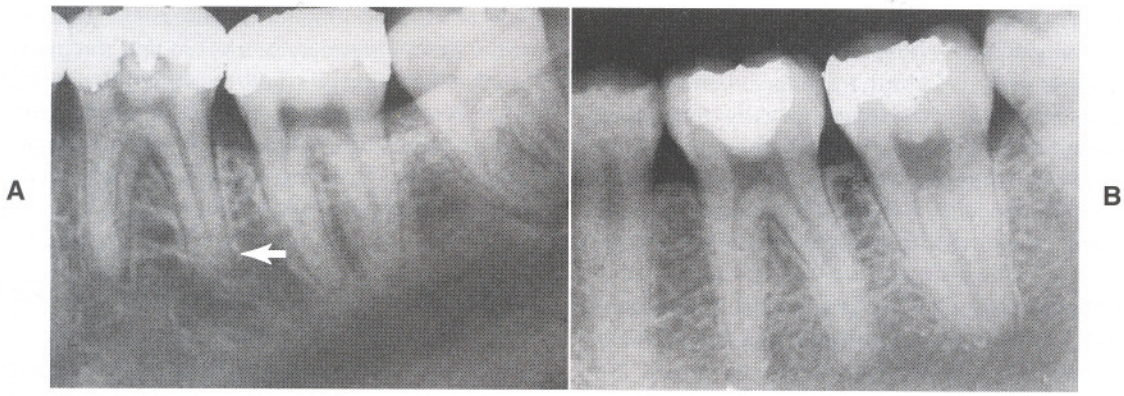


FIGURE 2-5 **A,** Mandibular first molar measured 17 mm on preoperative straight-on radiograph, shorter than average for that tooth. When the tooth was under treatment, the working lengths of the mesial canals were 17.5 mm. Also, note that this view shows distal canal curving off and exiting short of the apex *(arrow)*. **B,** Another mandibular first molar measured 23.5 mm on the preoperative direct view, longer than average. The working lengths calculated during treatment were 23.5 mm for the mesial canals and 24 mm for the distal canal.

on the film, is uneven in width or perhaps disappearing from view, and may only begin beneath the cervical line (Figure 2-6, *B*). The very wide canal is one much wider than the patient's age would suggest and may or may not be associated with other entities, such as an open apex (see Figure 2-6, *A*).

Resorptive defects are also discernible on the radiograph and may cause an alteration in canal shape. An internal resorption defect alters the canal shape by causing a radiolucent bulge somewhere between the coronal and the apical portion of the canal (Figure 2-6, *C*). Instituting endodontic therapy on these teeth almost always halts the resorption. Chapters 7 and 14 will discuss treatment methodology for these cases. An external resorption defect does not start within the pulp canal but rather begins adjacent to the periodontal ligament. Therefore external resorption does not cause any alteration in pulp canal shape (Figure 2-6, *D*). Endodontic therapy may or may not halt the resorption. Unless there is a definite indication that a change from normalcy has occurred in the pulp or immediate periapical tissues, I do not recommend instituting endodontics for external resorption problems.

3. *Position of the orifice to other elements of the crown.* Because it is most important to find the canal, the radiograph shows some of the relationships to the other elements of the crown to aid in location of the orifice. These other features radiographically discernible in the crown are the enamel, caries, restorations, bases, pulpotomy dressings, cementoenamel junction, and dentinoenamel junction. The etiology for pulpal or periapical injury must be noted (Figure 2-7).
4. *Mesial or distal curvature of the root.* It is rare to find a tooth whose root is perpendicular to the occlusal plane. The straight-on radiograph indicates the relative angulation of the root and discloses if a mesial or distal curvature is present. The film also indicates in general terms the type of dilaceration present, either gradual or sharp (Figure 2-8).
5. *Some guides to the position of the apical foramen.* Factors such as root curvature, areas of occlusal stress, amount of cementum deposition, and tooth morphology determine the position of the apical foramen to the root. The direct radiograph indicates when the exit is definitely short of the radiographic apex if such emergence occurs on either the mesial or the distal surface of the root (see Figure 2-5, *A*). The film does not indicate if the exit occurs on the buccal or the lingual surface. However, if it appears that the pulp canal space abruptly halts at a point near the apex, this is usually indicative that the canal does exit short of the radiographic apex on either the buccal or the lingual aspect.
6. *Existence of apical radiolucencies resulting from pulpal damage and/or treatment* (Figure 2-9). The condition of the periapical tissues may be quite difficult to discern from radiographs. However, it is of prime importance in diagnosis, treatment planning, and therapy for endodontics to make such a determination. The difference between a normal periodontal ligament space and a widening of the space or between a widening of the space and a radiolucency must be determined. Magnification or, even better, projection with a slide projector is particularly helpful in this area. The site of exiting of the canal is often disclosed by the position of the change in the periodontal ligament space. Evaluation of previously treated cases depends tremendously on the position and shape of radiolucencies present (see Figure 2-9, *B-F*). When evaluating radiolucencies, one must always remember that the true size of the lesion is much larger than the image seen on the radiograph.

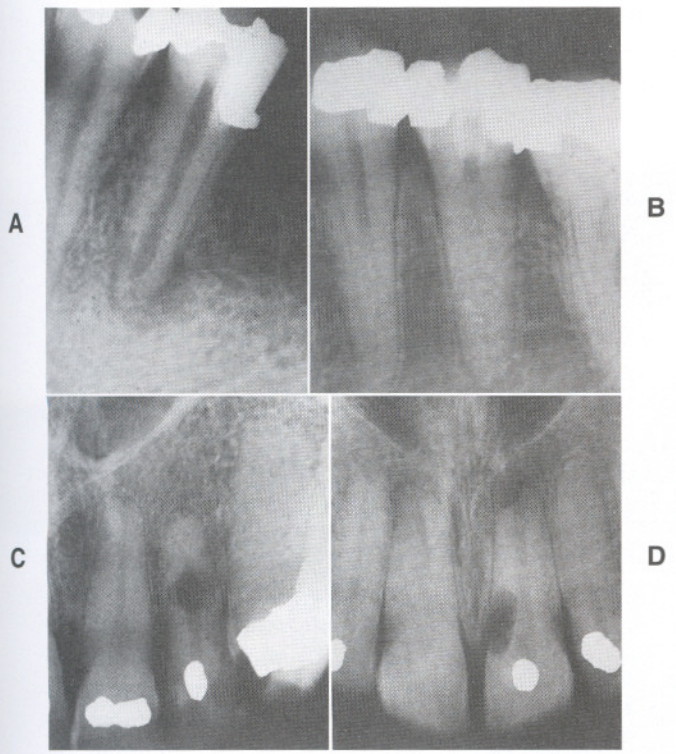


FIGURE 2-6 **A and B,** Preoperative radiographs taken before treatment of mandibular second bicuspids of two patients, both 24 years of age. **A,** Very wide, irregular canal, at least size 70 or larger, before treatment. Heavy irrigation and rasping of walls with Hedstrom files (Chapter 5) are needed for proper debridement of this canal. **B,** Very narrow sclerotic canal, probably because of long-standing chronic pulpitis. Referring dentist's attempt to locate canal was unsuccessful. Careful exploration and enlargement with use of chelating agents and incremental instrumentation (Chapter 5) are needed to prepare this canal. **C and D,** Maxillary incisors, affected by resorptive defects. **C,** An internal resorption defect alters shape of canal. As the canal is followed apically from coronal portion of tooth, there is obvious ballooning in middle third. (For completion of this case, see Figure 12-3.) **D,** An external resorption defect, on the other hand, does not alter canal shape. This central incisor has a pulpoperiapical problem, but resorption from mesial is external only.

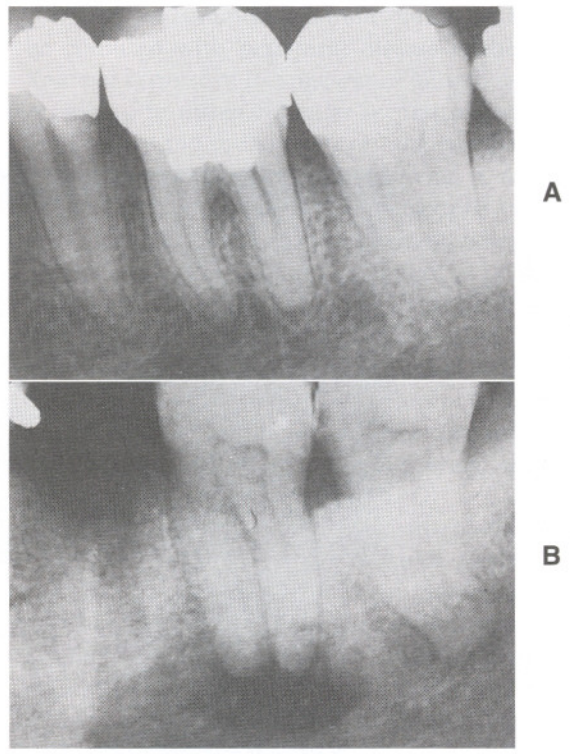


FIGURE 2-7 **A,** Preoperative view of mandibular posterior area. Note following features, all indicative of probable need for endodontic treatment. Second bicuspid—deep restoration with base or pulp capping; some secondary dentin deposition on distal side of pulp canal, which is side toward restoration. First molar—pulpotomy dressing past cervical line; distal canal may divide in middle third; mesial canals not sclerosed. Second molar—possible pulpotomy or pulp cap; distal canal indistinct. **B,** Mandibular first molar has large periapical radiolucency, typical of the kind associated with necrotic pulp. However, etiology of pulpal death is not apparent because no restoration or decay is present, and there is no fracture. Pulp proved to be vital, and biopsy of lesion demonstrated eosinophilic granuloma. Had endodontic therapy been performed without consideration for cause of pulpal death, serious error would have delayed diagnosis and prevented correct treatment. (Courtesy Dr. William Shafer, formerly of Indianapolis.)

7. *Radiolucencies not caused by pulpal damage and/or treatment.* The mere finding of a radiolucency in proximity to a tooth in itself does not indicate the need for endodontic treatment. In addition to those caused by pulpal damage and/or treatment, radiolucencies of the jaws may occur for many other reasons, totally unrelated to the pulpal condition or any local treatment. Because much of the total area of the maxilla and mandible is taken up with the roots of the teeth, any radiolucencies present for other reasons may appear in contact with, adjacent to, or superimposed on a root(s). A careless examination and evaluation may cause such teeth to be

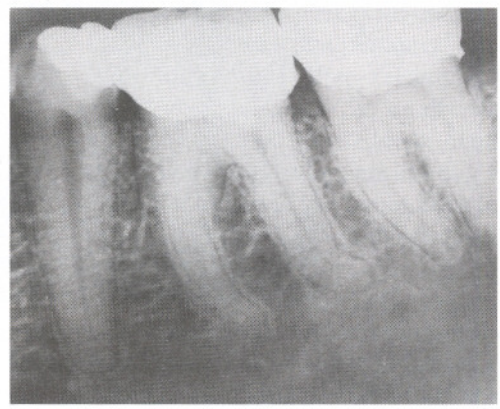


FIGURE 2-8 Mandibular first molar with sharp distal dilaceration of canal in distal root.

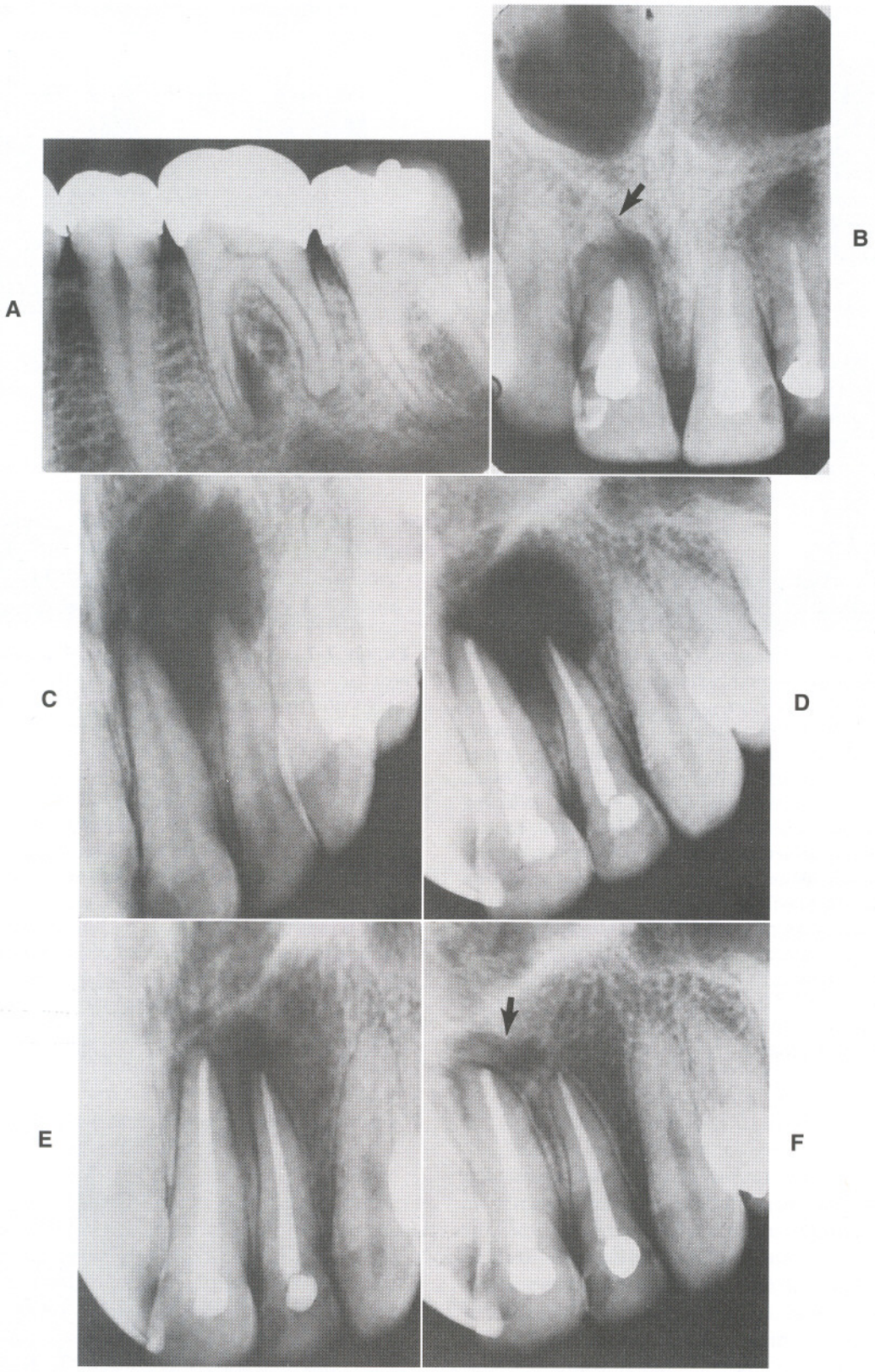


FIGURE 2-9 Interesting radiolucencies. A, on distal border of mesial root of mandibular first molar. Note canal leaving root short of apex toward defect. **B,** Associated with endodontically treated right central incisor. Patient gave history of apical surgery to all three treated anterior teeth. The retained root *(arrow)* and an incomplete seal are probably responsible for lesion. **C–F,** Maxillary central and lateral incisors treated surgically. **C** is preoperative; **D** was taken 3 months after surgery; **E** and **F** were made at yearly intervals. Without earlier radiographs for comparison, all postoperative films might be interpreted to indicate endodontic failure. Radiolucency shown in *F (arrow)* is fibrous tissue scar, does not indicate diseased tissue, and may never fill in with bone. The maxillary lateral incisor is the most common tooth to exhibit fibrous scar tissue after healing, particularly if periapical surgery was performed.

treated endodontically. There is no worse feeling than entering a pulp canal in a tooth with an apical radiolucency and then finding a normal, vital pulp present. Therefore incorrect treatment has been performed when the etiologic agent is misunderstood and does not result from pulpal damage or treatment. Care must always be exercised before starting treatment to verify that the pulp is involved and/or that the periapical tissues have been affected by the pulpal damage.

The most common periapical radiolucency that causes unneeded endodontic treatment is the so-called cementoma, also referred to as periapical fibroma, now called periapical fibrous dysplasia (Figure 2-10). Several other benign neoplasms may mimic periapical disease but are more serious and usually require some type of surgically related treatment, such as the ameloblastomas or the various developmental cysts. Avoiding errors in treatment for these entities requires the use of pulp testing (see later discussion) to rule out the cementoma. For the benign neoplasms, pulp testing coupled with knowledge of the radiographic appearance for these lesions (ameloblastomas often are multilobulated) and the anatomic position of developmental cysts (globulomaxillary cysts are found between the maxillary cuspid and lateral incisor; many cysts are in the third molar vicinity) is very helpful.



FIGURE 2-10 Radiograph of mandibular incisors of a 35-year-old white female, indicating multiple periapical radiolucencies. Although the patient was referred for therapy for the four teeth, I would not treat them without confirming information. The patient was certain that the teeth had never been traumatized, and there was no visible damage to the crowns. All the teeth responded to electric pulp testing, indicating a diagnosis of multiple periapical fibrous dysplasia, formerly referred to as cementomas.

The most common anatomic condition that may be confused with periapical disease is the mental foramen because of its appearance on radiographs in proximity to the mandibular second bicuspid. The nasal cavity and sometimes even the maxillary sinus may appear to be a lesion involving a maxillary tooth. Pulp tests and angled radiographs (root tips move away from the anatomic radiolucencies) help to make a correct diagnosis. Figure 2-11 demonstrates a lingual mandibular salivary gland depression, first reported by Stafne in 1942. It is a congenital defect and may be bilateral. One of the interesting aspects of the radiolucency shown in Figure 2-11 is that 20 years later, the depression had smoothed out and was barely apparent radiographically (see Figure 2-11, *D*).

Figure 2-7, *B*, illustrates an eosinophilic granuloma mimicking periapical disease of a mandibular molar. This condition is often associated with sore or loose teeth. Therefore periodontists or endodontists may be called on to evaluate these symptoms. Together with Hand-Schüller-Christian disease and Letterer-Siwe disease, eosinophilic granuloma forms the histiocytosis X group, each of which may mimic periapical disease. Histologic evaluation of biopsy specimens leads to the correct diagnosis.

Hormonal dysfunctions may also lead to radiolucent areas of the jaws. In hyperparathyroidism the first clinical sign or symptom may be a cyst of the jaws or a "ground-glass" appearance of bone. Sarcomas of the jaws may exhibit a "sunburst" appearance on radiographs. Multiple myeloma also may cause radiolucent features in bones, including the maxilla or mandible. If the dentist cannot locate an etiologic agent for pulpal damage and pulp tests are negative with these conditions, consultation with a physician is mandatory.

The traumatic bone cyst (not a true cyst) is an interesting condition that may be found in conjunction with a tooth requiring endodontic treatment. As suggested by its name, the lesion results from trauma, which may also have caused pulpal damage or death and resultant periapical extension. The surgical appearance after raising a flap is pathognomic. The cavity may be totally empty or contain a small amount of reddish exudate or clotted blood. Merely opening and lightly curetting this lesion leads to healing. If the root of an involved tooth is within the lesion, it should be treated before surgery.

In summary, many situations give rise to radiolucencies of the jaws that may be confused with periapical disease. Some are perfectly normal, some are mild, but some are quite serious. Before initiating endodontic treatment, the etiology should be clearly established. If an unanticipated condition is



FIGURE 2-11 Lingual mandibular salivary gland depression mimicking periapical disease. A, Preoperative radiograph of mandibular molar area indicating large radiolucency seemingly associated with the second molar and two smaller radiolucencies, each associated with a root of the first molar. Potential etiology for pulpal damage to the first molar is a large, distal carious lesion surrounding a large inlay. The second molar also has a large casting. Electric and temperature testing of the first molar gave no responses, but the second molar did respond. The first molar was slightly tender to percussion; the second molar reacted normally to percussion. **B,** It was decided to treat the first molar only and reevaluate the second molar later, considering the lesion to be a lingual mandibular salivary gland depression. Accordingly, the first molar was filled with laterally condensed gutta-percha and Wach's paste, with some sealer extruded past both apices. **C,** One year after treatment, periapical lesion on the distal root of the first molar is gone and that on the mesial root is decreased considerably. The radiolucency is still associated with the second molar, although slightly different in shape, and the tooth still responds to electric pulp testing. **D,** Twenty years after original treatment, perfect healing is apparent on the first molar, with all excess sealer gone and tooth comfortable. The second molar still responds to electric and temperature testing, same casting is still present, and tooth is comfortable. Whereas the radiolucency is still present, it is much less radiolucent than in the first film. A study by Karmiol and Walsh indicated that salivary gland depression was present in the mandible in 18 of 4963 full-mouth radiographs investigated (0.4%), several times bilaterally. This patient did not exhibit the same radiographic finding on the opposite side.

found on entry, further consideration should be rendered, including the possibility of consultation with other medical professionals.

8. *Existence of lateral radiolucencies and observations concerning lateral canals.* The lateral surfaces of roots should be carefully examined for areas of pathosis and exiting of canals. A definite lateral radiolucency often indicates the presence of a significant lateral canal that is housing necrotic material. Some endodontists believe that the frequent display of filling materials demonstrating lateral canals in postoperative films indicates that the filling technique used is superior. I do not share this view because I have seen lateral canals demonstrated by sealer using every canal filling method. Figure 2-12 indicates a maxillary bicuspid with a large periapical lesion, both apical and lateral, and a disruption of the floor of the maxillary sinus. The canal filling film indicates the presence of multiple lateral canals, perhaps eight or more. A postoperative film taken 20 years later indicates perfect healing and reestablishment of the floor of the sinus. The canal filling method was with modified chloropercha, not usually my first choice, and a method repudiated by some as ineffective. Several other modified chloropercha cases appear near the end of Chapter 5, with lateral canals demonstrated.

I believe that the condition of the pulp of the tooth is a much better indicator for whether or not lateral canals will be demonstrated. Teeth with necrotic pulps have a much higher percentage of sealer in such canals than teeth with vital pulps. In

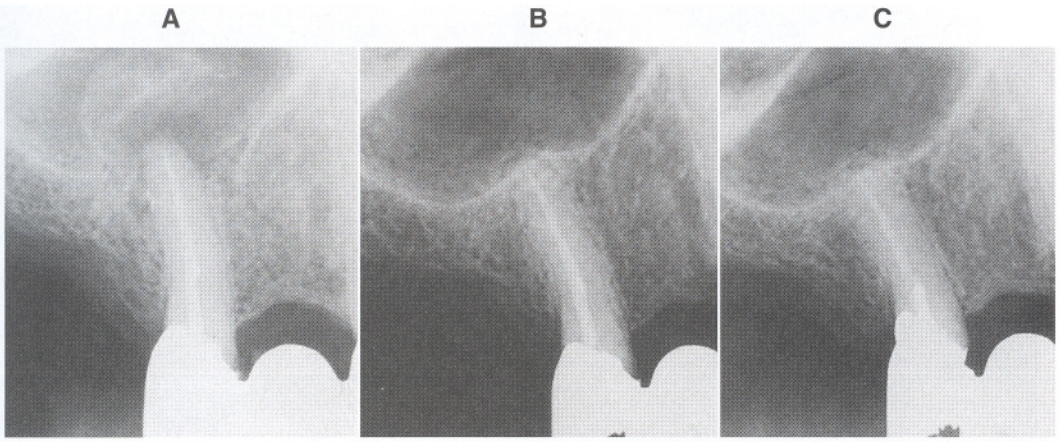


FIGURE 2-12 Multiple lateral canals demonstrated after canal filling with laterally condensed modified chloropercha. **A,** Immediate postfilling film of maxillary second bicuspid indicating periapical and lateral lesions and chloropercha in many lateral canals. The radiolucent lesion seems to have disrupted the continuity of the floor of the maxillary sinus. **B,** Film taken 2 years after treatment, indicating complete healing of the apical and lateral lesions and reconstitution of the floor of the sinus. **C,** Film taken 20 years after treatment, perfect healing of periapical, lateral, and sinus floor lesions still apparent. Though the material in the lateral canals is no longer apparent, no lateral radiolucencies are seen. (Restorations by Dr. Sherwin Strauss, Chicago.)

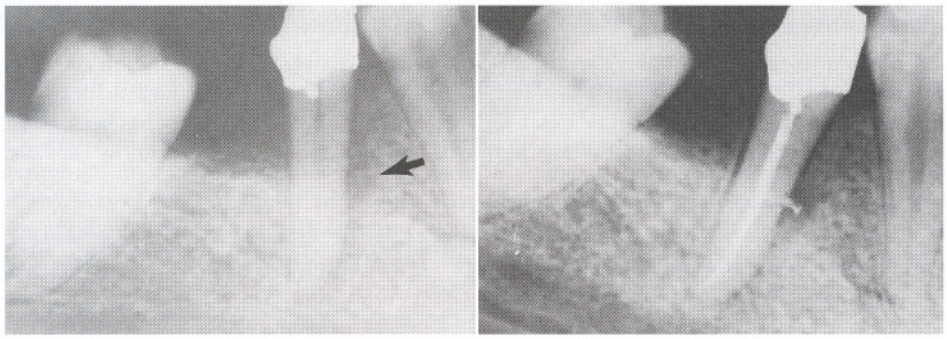


FIGURE 2-13 **A,** Radiolucency on mesial surface of mandibular bicuspid *(arrow)* probably indicating a significant lateral canal with necrotic material, and only a minimal periapical lesion. **B,** Immediately after canal filling with laterally condensed gutta-percha and Wach's paste as sealer. The sealer has extruded toward the radiolucency. This is one of the first cases (circa 1965) I treated in which I expressed sealer toward a radiolucent area. Seeing this on film was entirely unexpected!

a survey of patients treated by graduate students from Loyola University and myself, we found that when the pulp was necrotic, lateral canals were demonstrated 38% of the time, whereas if the pulp had been vital, the percentage of lateral canals decreased to only 3%.

Many different types of lateral lesions are observable by radiographs. From a developmental standpoint, the first to discuss is the situation in which the lateral lesion is quite obvious, but there is no periapical lesion or only a minimal lesion at the apex (Figure 2-13, A). Usually this is indicative of an apically progressing necrotic pulp that has allowed the exit of irritating materials through a significant lateral canal before the noxious elements reach the apex. It is possible that there is true breakdown at the apex as well, but it is barely observable because of thicker overlying bone or insufficient apical breakdown of bone. Generally, at the time of filling, the sealer is extruded through the lateral canal to the site of the lateral radiolucency (Figure 2-13, *B*).

If allowed to progress without endodontic intervention, this condition may next be seen as the second type, in which one or more lateral lesions exist plus a periapical lesion, but the lesions are separate and distinct (Figure 2-14, *A*). Now, sufficient numbers of irritating materials have emerged through both the lateral and the apical orifices in the root to allow for visualization of both sets of lesions.

If still allowed to progress without treatment, the periapical and lateral lesions coalesce into a single lesion. This type of lesion has been called a "wraparound" lesion because it involves both the tip

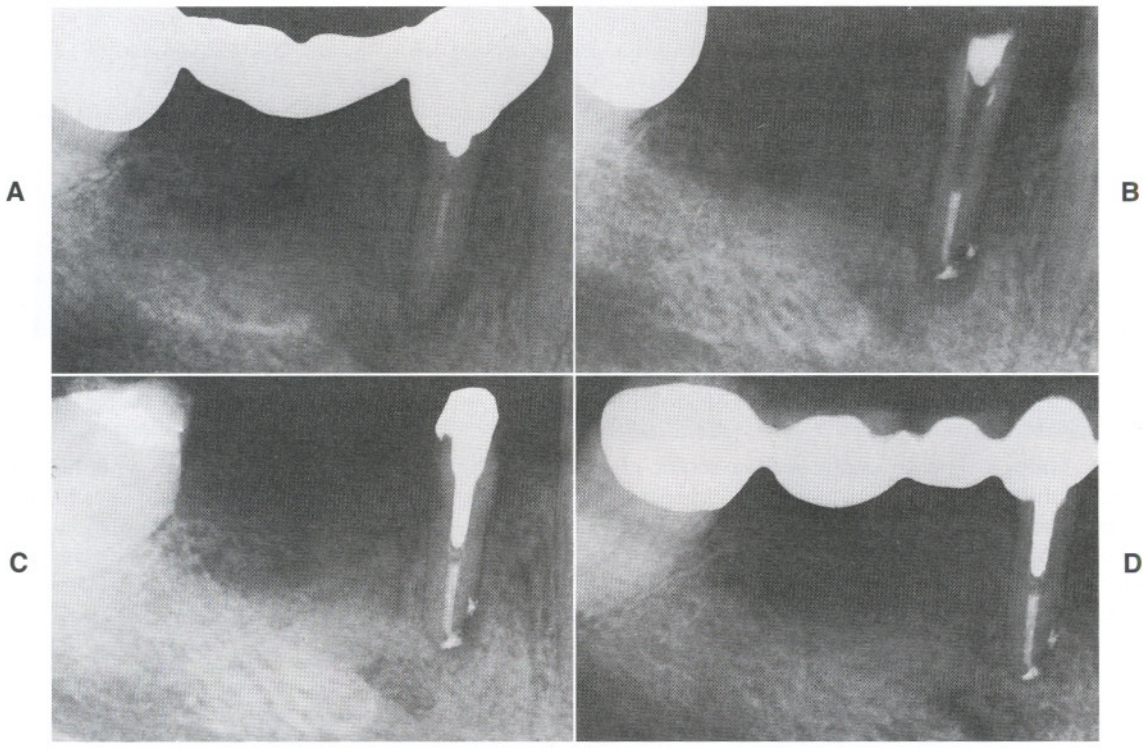


FIGURE 2-14 **A,** Mandibular bicuspid with failing endodontics due to insufficient canal preparation and filling. Two radiolucencies are present, one apical and one lateral. **B,** Canal filling with laterally condensed gutta-percha and Wach's paste as sealer. Excess sealer has been expressed beyond apex and through the lateral canal. **C,** Three months after filling, a post has been placed and the radiolucency is beginning to heal. **D,** Eighteen months after canal filling, healing is quite advanced. (Restorations by Dr. Robert Salk, Chicago.)

of the root and one or both of the mesial and/or distal lateral walls (Figure 2-15). However, the etiology of the lesion remains as separate exit sites off the root.

Another type of periapical lesion closely resembles this "wraparound" type, but it may not involve etiology from the lateral canal. Figure 2-16, *A*, demonstrates such a case in which the lesion expands down a side of the root rather than ballooning out apically, as is usually the situation. When the immediate postfilling film is viewed (Figure 2-16, *B*), the clinician may be disappointed to observe no sealer exiting to the lateral lesion. However, subsequent films (Figure 2-16, *C-E*) indicate that healing has taken place. Healing in this type of situation means either that no lateral canal was present to cause the lesion and that the source was solely from the apex, or that the lateral canal need not be demonstrated with sealer for healing to transpire. In the latter case, perhaps dentin chips covered over the lateral canal, preventing necrotic tissue within it from feeding the lateral lesion but also stopping sealer from exiting to the periodontal ligament area. Another possibility is that some sealer has gone through the lateral canal but the canal is so small and/or the sealer lacks sufficient radiopacity (true of Wach's paste) that the exit site cannot be seen on the radiograph.

Figure 2-17 demonstrates another "wraparound" condition. A chronic draining sinus tract was present, extending to the distal area of the mandibular second bicuspid, but the file-in-place film (see Figure 2-17, *A*) indicated that the canal exited to the mesial. When the canal was filled (see Figure 2-17, *B*), the sealer exited from several sites and seemed to wrap around the buccal or lingual portion of the tooth from the mesial to the distal. Excellent healing was observed later (see Figure 2-17, *C*).

In the cases shown in Figures 2-14, 2-15, and 2-16, demonstration of lateral canals was fully expected. In Figure 2-16, it was anticipated but did not appear. Many times, however, lateral canals of considerable size are demonstrated without being expected. Figure 2-18 is an instance in which I did not expect to see a lateral canal demonstrated. The patient had several teeth treated in prior years and was always most cooperative. At the start of treatment (see Figure 2-18, *A*), the pulp was vital, with all the symptoms of a pulpitis present, and no lesions, lateral or apical, were noted. Treatment was started successfully and the pulpitis eliminated, but due to a variety of reasons, completion was delayed

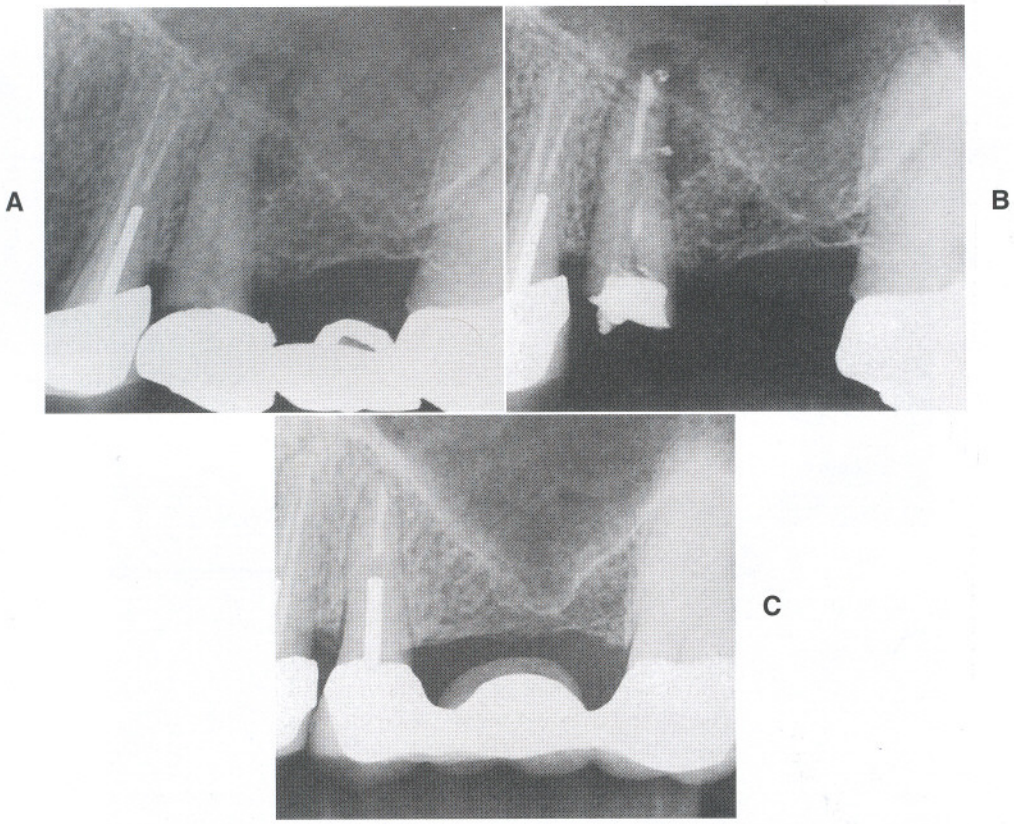


FIGURE 2-15 **A,** Preoperative mesial-angled view of maxillary second bicuspid with a "wraparound" periapical lesion, encompassing the apical area and a portion of the lateral distal surface of the root. **B,** Immediate postoperative view, after canal filling with laterally condensed gutta-percha and Kerr's Antiseptic Root Canal Sealer. That a lateral canal was involved in the pathogenesis of the lesion was verified by the sealer expressed through the root to the distal. **C,** Four years after treatment, straight view. The entire lesion has healed, with minimal amounts of sealer observable in the surrounding bone. The maxillary sinus, although adjacent to the lesion, was not involved, as it was in Figure 2-12. (Restoration by Dr. Ascher Jacobs, formerly of Chicago.)

for 6 months. When I finally filled the canals (see Figure 2-18, *B*), I was shocked to see several lateral canals, both exiting to lateral lesions that were not present before treatment. The cause for the pulpitis was also seen as the recurrent decay under the mesial portion of the bridge abutment. Some pulp, vital at the start of treatment, was present in these lateral canals. Because of the long time required for therapy, the tissue became necrotic but was removed, probably by the sodium hypochlorite irrigant, and allowed for passage of the sealer into the tissues surrounding the lateral canals. Healing of the lateral lesions was demonstrated subsequently (see Figure 2-18, *C*).

Figure 2-19 illustrates a tooth with a large periapical lesion with some lateral extension associated with a maxillary first bicuspid (see Figure 2-19, *A*), symptomatic before treatment. Again, although not anticipated, a lateral canal was filled with sealer, several millimeters from the apex of the palatal root (see Figure 2-19, *B*), pointing toward the major portion of the radiolucency. Excellent healing resulted from the treatment (see Figure 2-19, *C* and *D*).

Lateral lesions may cause pressures that deflect teeth. A large lesion, perhaps a "wraparound," associated with a maxillary lateral incisor (Figure 2-20, *A*) was treated, and the canal filling indicated a lateral canal extending to the lesion (Figure 2-20, *B*). Subsequent films indicated excellent healing but also decreased distance between the lateral and the adjacent cuspid (Figure 2-20, *C-F*).

Damage from a lateral canal lesion may be revealed subsequent to completion of routine treatment. The maxillary cuspid shown in Figure 2-21, *A*, required endodontic treatment. At treatment the pulp was vital, and no apical or lateral lesions were noticed. After filling and post room preparation (Figure 2-21, *B*), the tooth was temporized (Figure 2-21, *C*), but because the patient coincidentally required cardiac surgery, final restoration was delayed. When the patient returned for evaluation, a lateral lesion was noted in the area of the post room (Figure 2-21, *D*). Re-treatment of this segment of