Guide to Clinical Endodontics

American Association of Endodontists
211 E. Chicago Ave., Suite 1100
Chicago, IL 60611-2691

Phone: 800/872-3636 (U.S., Canada and Mexico) or 312/266-7255
Fax: 866/451-9020 (U.S., Canada and Mexico) or 312/266-9867
E-mail: *info@aae.org* Web site: *www.aae.org*

Fourth Edition

Introduction

Endodontics is a dental specialty recognized by the American Dental Association for the last 40 years. The American Association of Endodontists represents the specialty of endodontics and sponsors the American Board of Endodontics, the national certifying board for endodontists.

Endodontics is the branch of dentistry which is concerned with the morphology, physiology and pathology of the human dental pulp and periradicular tissues. Its study and practice encompass the basic clinical sciences including biology of the normal pulp, the etiology, diagnosis, prevention and treatment of diseases and injuries of the pulp and associated periradicular conditions.

The American Association of Endodontists is dedicated to excellence in the art and science of endodontics and to the highest standards of patient care. The Association inspires its members to pursue professional advancement and personal fulfillment through education, research, advocacy, leadership, communication and service. As part of this commitment to service, the AAE publishes the *Guide to Clinical Endodontics.*

The *Guide* reflects current practice considerations in endodontics that enhance the patient's quality of care. Endodontists developed this guide for use by endodontists. Though insurance carriers, managed care organizations, attorneys in professional liability cases, legislators and regulators may use the *Guide*, the AAE did not develop the *Guide* specifically for use with reimbursement, litigations, legislation or regulations. These uses may be beyond the scope of these guidelines.

Practitioners cannot guarantee treatment outcomes. Variations in patients' health, teeth, biological, physical and psychological factors will influence outcomes and may preclude success in any given situation. Endodontists using their best professional judgment may deviate from these guidelines for sound clinical reasons based on the circumstances of a particular patient but should include the reason for choosing the procedure performed in the patient's record.

Endodontists should inform patients of all treatment options, including risks, benefits and alternatives to treatment, the option of no treatment and/or extraction. Patients should give their consent before any treatment is initiated. Practitioners should consult with their respective professional liability insurance carriers regarding specific recommendations relative to informed consent.

The scope of endodontics includes but is not limited to diagnosis and management of pulpal and periradicular pathosis through the following avenues:

- Nonsurgical endodontic treatment
- Surgical endodontic treatment
- Vital pulp therapy
- Management of traumatic injuries to the teeth and periradicular structures
- Restorative dental procedures related to enhancing the outcome of endodontic treatment

- Diagnosis and management of orofacial pain
- Repair of coronal or radicular defects caused by trauma, resorption or mechanical insults

Endodontic practice parameters are dynamic, requiring continual development and revision in response to advances in the basic and clinical sciences. The 2004 edition of the *Guide to Clinical Endodontics* represents the fourth major revision of this document since it was originally developed in 1987. The AAE made every effort to assure that the nomenclature and definitions used in the *Guide* correspond to those in the 2003 edition of the *Glossary of Endodontic Terms* and reporting codes in the American Dental Association's *Current Dental Terminology, Fourth Edition*.

The accumulated clinical knowledge and judgment of the practitioner supported by published scientific research is the basis for endodontic treatment. The AAE provides a list of selected references for review, but the document is not a definitive bibliography of all current literature on the subject. The references are a sampling of the best available clinical and scientific evidence applying to each subject. By citing the listed reference material, the AAE does not necessarily imply endorsement of any statement contained in the reference material. Readers should consult other sources available to obtain a complete bibliography on the topic since the literature is constantly changing.

As the demand for endodontic treatment grows, the obligation for treating dentists to make increasingly complex clinical decisions will increase. It is incumbent on the dentist to undertake lifetime learning that results in understanding and accepting limitations in knowledge and clinical skills, and appropriately referring complex cases to specialists for treatment.

The American Association of Endodontists has the expertise and professional responsibility to assist endodontists along the path of continuing professional development. The AAE developed the *Guide to Clinical Endodontics* to serve this purpose.

—Ad Hoc Committee to Revise the *Appropriateness of Care and Quality Assurance Guidelines*

James A. Abbott, D.D.S., M.S., Chair
Paul J. Ashkenaz, D.D.S., M.S.
Gerald N. Glickman, D.D.S., M.S., J.D.
Donna Mattscheck, D.M.D.
W. Craig Noblett, D.D.S., M.S.
Randolph D. Rush, D.D.S.
Jeffrey W. Hutter, D.M.D., M.Ed., Board Liaison

Contents

A. Endodontic Examination and Diagnosis

Many features of evaluation in endodontics are common to all dental practice. These elements are herein abbreviated yet included for purposes of completeness. Diagnostic evaluation of pulpal and periradicular status must be performed for every tooth to be treated.

An adequate medical and dental history, the patient's description of the chief complaint(s) and visual and radiographic examination provide basic information. Some indicated tests, such as thermal, electrical, percussion, palpation and mobility, should be accomplished. Additional periodontal examination, transillumination, observation of occlusal discrepancies and bacteriologic testing may be indicated. Reproducing the patient's symptoms is desirable if not mandatory. In some situations, it may be advisable to make radiographs or digital radiographic images from more than one angle. It may also be necessary to make/take panoramic radiographs, bitewing radiographs, occlusal plane films and radiographs of the contralateral and opposing teeth. The use of enhanced magnification, illumination or intraoral photography may be an adjunct. A pulpal and periradicular diagnosis should be formulated for each tooth for which endodontic treatment is planned. The diagnostic categories used should be those specified in the AAE's *Glossary of Endodontic Terms* for both pulpal and periradicular diagnoses.

It may be necessary to recommend follow-up visits for some patients at periodic intervals to compare specific data from the various examinations to facilitate an accurate pulpal and periradicular diagnosis. At times it may be necessary, when possible, to secure radiographs or digital radiographic images from previous practitioners to assist with the evaluation process.

Objectives:

a. To determine the need for treatment.
b. To determine those cases deemed to be too complex for the level of training, experience and expertise of the practitioner. (See the *AAE Endodontic Case Difficulty Assessment Form and Guidelines* in the Appendix.)
c. To determine if it is advisable to consult with or refer to other health professionals.

SELECTED REFERENCES:
Endodontic Examination and Diagnosis

Bahskar SN. Periapical lesions – types, incidence and clinical features. Oral Surg Oral Med Oral Path 1966;21:657.

Bender IB. Factors influencing radiographic appearance of bony lesions. J Endod 1982;8:161.

Bender IB, Landau MA, Fonseca S, Trowbridge, HO. The optimum placement site of the electrode in electric pulp testing of the twelve anterior teeth. J Am Dent Assoc 1989;118(3):305.

Brannstrom M. The hydrodymanic theory of dentinal pain: Sensation in preparations, caries and dentinal crack syndrome. J Endod 1986;12:453.

Byers MR. Effects of inflammation on dental sensory nerves and vice versa. Proc Finn Dent Soc 1992;88:499.

Cameron CE. Cracked tooth syndrome. J Am Dent Assoc 1964;68:405.

Drinnan AL. Differential diagnosis of orofacial pain. Dent Clin North Am 1987;31:627.

Fuss Z, Trowbridge HO, Bender IB, Rickoff B, Sorin S. Assessment of reliability of electrical and thermal pulp testing agents. J Endod 1986;12:301.

Goldman M, Pearson A, Darzenta N. Endodontic success – who's reading the radiograph? Oral Surg Oral Med Oral Path 1972;33:432.

Himel VT. Diagnostic procedures for evaluating pulpally involved teeth. Curr Opin Dent 1992;2:72.

Hutter JW. Facial space infections of odontogenic origin. J Endod 1991;17:422.

Josell SD. Evaluation, diagnosis, and treatment of the traumatized patient. Dent Clin North Am 1995;39:15.

Lalonde ER, Luebke RG. The frequency and distribution of periapical cysts and granulomas. An evaluation of 800 specimens. Oral Surg Oral Med Oral Path 1968;25:861.

Little, JW. Dental Management of the Medically Compromised Patient. 1997;5 5th Edition, St. Louis, Mosby, 1997.

Narhi M, Jyvasjarvi E, Virtanen A, Huopaniemi T, Ngassapa D, Hirvonen T. Tale of intradental A and C type nerve fibers in dental pain mechanisms. Proc Finn Dent Soc 1992;88:507.

SELECTED REFERENCES:
Endodontic Examination and Diagnosis continued

Pantera E, Anderson R, Pantera C. Reliability of electric pulp testing after pulpal testing with dichlorodifluoromethane. J Endod 1993;19:312.

Pileggi R, Dumsha TC, Myslinski NR. The reliability of electric pulp test after concussion injury. Endod Dent Traumatol 1996;12:16.

Seltzer S, Bender IB. Cognitive dissonance in endodontics. Oral Surg Oral Med Oral Path 1965;20:505.

Seltzer S, Bender IB, Ziontz M. The dynamics of pulp inflammation: Correlations between diagnostic data and actual histologic findings in the pulp. Oral Surg Oral Med Oral Path 1963;16:846,16:969.

Simon JH. Incidence of periapical cysts in relation to the root canal. J Endod 1980;6:845.

Simon JH, Glick DH, Frank AL. The relationship of endodontic-periodontic lesions. J Periodontol 1972;43:202.

Trowbridge HO. Pathogenesis of pulpitis resulting from dental caries. J Endod 1981;7:52.

Trowbridge HO, Franks M, Korostoff E, Emling R. Sensory response to thermal stimulation in human teeth. J Endod 1980;6:167.

Van Hassel HJ. Physiology of the human dental pulp. Oral Surg Oral Med Oral Path 1971;32:126.

B. Endodontic Treatment Planning, Records and Follow-up Visits

Endodontic treatment is based on an analysis of all diagnostic information. Treatment planning should include a determination of the strategic importance of the tooth or teeth considered for treatment, the prognosis and the urgency of treatment. It is incumbent upon providers of endodontic care to address endodontically related emergencies in a timely manner. Other factors, such as excessively curved canals, periodontal disease, occlusion, tooth fractures, calcified or occluded canals, restorability and teeth with complex root canal morphology, should be considered. (See the *AAE Endodontic Case Difficulty Assessment Form and Guidelines* in the Appendix.)

Treatment records should include the chief complaint(s) in the patient's own words; a current medical and dental history; the results of diagnostic tests and clinical examination; clinical impressions based on subjective and objective evaluations; the pulpal and periradicular diagnoses and treatment recommendations; a description of treatment rendered, including pulpal status upon entry; the prognosis as reported to the patient; recommendations for tooth restoration; and the preoperative, appropriate working, postoperative and follow-up radiographs or digital radiographic images. Informed consent is required. It may be helpful to record patient commentaries before, during and after treatment. Prescriptions must be recorded, and consultations should be made part of the patient record.

Endodontic care includes evaluation of the patient's postoperative response to the clinical procedures. Providers of endodontic services should encourage patients to return at appropriate follow-up intervals for evaluation.

SELECTED REFERENCES:
Endodontic Treatment Planning, Records and Follow-up Visits

Allen RK, Newton CW, Brown CE. A statistical analysis of surgical and non-surgical endodontic retreatment cases. J Endod 1989;15:261.

Bender IB, Seltzer S, Soltanoff W. Endodontic success – a reappraisal of criteria: Parts I and II. Oral Surg Oral Med Oral Path 1966;22:780.

Bystrom A, Happonen RP, Sjogren U, Sundqvist G. Healing of periapical lesions of pulpless teeth after endodontic treatment with controlled asepsis. Endod Dent Tramatol 1987;3:58.

Cohen S, Schwartz S. Endodontic complications and the law. J Endod 1987;13:191.

Crump MC. Differential diagnosis in endodontic failure. Dent Clin North Am 1979;23:617.

De Vore DT. Legal considerations for treatment following trauma to teeth. Dent Clin North Am 1995;39:203.

Grahnen H, Hansson L. The prognosis of pulp and root canal therapy – A clinical and radiographic follow-up examination. Odontol Revy 1961;12:146.

Health Insurance Portability and Accountability Act of 1996.

Lin LM, Skribner JE, Gaengler P. Factors associated with endodontic treatment failures. J Endod 1992;18:625.

Ray HA, Trope M. Periapical status of endodontically treated teeth in relation to the technical quality of the root filling and the coronal restoration. Int Endod J 1995;28:12.

Rud J, Andreasen JO. A study of failures after endodontic surgery by radiographic, histologic and stereomicroscopic methods. Int J Oral Surg 1972;1:311.

Seltzer S, Bender IB, Smith J, Freedman I, Nazimov H. Endodontic failures – an analysis based on clinical, roentgenographic, and histologic findings, Part I. Oral Surg Oral Med Oral Path 1967;23:500.

Seltzer S, Bender IB, Smith J, Freedman I, Nazimov H. Endodontic failures – an analysis based on clinical, roentgenographic, and histologic findings, Part II. Oral Surg Oral Med Oral Path 1967;23:517.

SELECTED REFERENCES:
Endodontic Treatment Planning, Records and Follow-up Visits continued

Sjogren U, Hagglund B, Sundqvist G, Wing K. Factors affecting the long-term results of endodontic treatment. J Endod 1990;16:498.

Soltanoff WA. Comparative study of the single visit and multiple visit endodontic procedure. J Endod 1978;4:278.

Strindberg LZ. The dependence of results of pulp therapy on certain factors: An analytic study based on radiographic and clinical follow-up examination. Acta Odontol Scand 1956;14(suppl):1.

Swartz DB, Skidmore AE, Griffin JA. Twenty years of endodontic success and failure. J Endod 1983;9:198.

C. Vital Pulp Therapy

1. Indirect Pulp Capping

Indications for Treatment

Indirect pulp capping is indicated on permanent teeth with immature apices if *all* the following conditions exist:

a. Tooth has a deep carious lesion that is considered likely to result in pulp exposure during excavation.
b. No history of subjective pretreatment symptoms.
c. Pretreatment radiographs should exclude periradicular pathosis.
d. Patient has been fully informed that endodontic treatment may be indicated in the future.

Procedure

Treatment consists of two visits approximately six-to-eight months apart. At the first visit, caries biomass is excavated leaving affected dentin adjacent to the pulp. Calcium hydroxide or other biologically compatible material is placed over the dentin followed by a base, and the tooth is soundly restored. At the second visit, the restorative material and residual caries mass is removed, and the tooth is restored.

Objectives

a. To prevent adverse clinical signs and symptoms.
b. To obtain radiographic evidence of root development.
c. To prevent breakdown of the periradicular supporting tissues.
d. To prevent resorptive defects or accelerated canal calcification as determined by periodic radiographic evaluation.

2. Direct Pulp Capping

Indications for Treatment

Direct pulp capping is indicated when *all* of the following clinical conditions exist:

a. Mechanical exposure of a clinically vital and asymptomatic pulp occurs.
b. Bleeding is controlled at the exposure site.
c. Exposure permits the capping material to make direct contact with the vital pulp tissue.
d. Exposure occurs when the tooth is under dental dam isolation.
e. Adequate seal of the coronal restoration can be maintained.
f. Patient has been fully informed that endodontic treatment may be indicated in the future.

Procedure

A radiopaque capping material is placed directly onto the surface of vital pulp tissue at the site of the pulp exposure followed by a base. The final restoration is placed over the base. The status of the pulp and periradicular tissues should be assessed through periodic recall examinations.

Objectives

a. To prevent adverse clinical signs or symptoms.
b. To develop contact of a radiopaque capping material with the pulpal tissue.
c. To maintain normal responsiveness to electrical and thermal pulp tests.
d. To prevent breakdown of the periradicular supporting tissue.

3. Pulpotomy

Indications for Treatment

A pulpotomy may be indicated if *any* of the following clinical conditions exist:

a. Exposed vital pulps or irreversible pulpitis of primary teeth. Primary teeth with insufficient root structure, internal resorption, furcal perforation or periradicular pathosis that may jeopardize the permanent successor are not indicated for pulpotomy procedures.
b. As an emergency procedure in permanent teeth until root canal treatment can be accomplished.
c. As an interim procedure for permanent teeth with immature root formation to allow continued root development (apexogenesis). (See Section D-3)

Procedure

Pulpotomy is the surgical removal of the coronal portion of vital pulp tissue. A biologically acceptable material is placed in the pulp chamber, and the tooth is restored.

Objectives

a. To prevent adverse clinical signs or symptoms.
b. To obtain radiographic evidence of sufficient root development for endodontic treatment. An increase in root length may be evident.
c. To prevent breakdown of the periradicular supporting tissues.
d. To prevent resorptive defects or accelerated canal calcification as determined by periodic radiographic evaluation.

SELECTED REFERENCES:
Vital Pulp Therapy

Costa CA, Mesas AN, Hebling J. Pulp response to direct pulp capping with an adhesive system. Am J Dent 2000;13:81.

Cox CF, Bergenholtz G, Fitzgerald M et al. Capping of the dental pulp mechanically exposed to the oral microflora—a 5-week observation of wound healing in the monkey. J Oral Pathol 1982;11:327.

Cox CF, Keall HJ, Ostro E, Bergenholtz G. Biocompatibility of surface-sealed dental materials against exposed pulps. J Prosth Dent 1987;57.

Cvek M. A clinical report on partial pulpotomy and capping with calcium hydroxide in permanent incisors with complicated crown fracture. J Endod 1978;4:232.

Cvek M, Cleaton-Jones PE, Austin JC, Andreasen JO. Pulp reactions to exposure after experimental crown fractures or grinding in adult monkeys. J Endod 1982;8:391.

Cvek M, Lundberg M. Histological appearance of pulps after exposure by a crown fracture, partial pulpotomy, and clinical diagnosis of healing. J Endod 1982;9:8.

Falster CA, Araujo FB, Straffon LH, Nor JE. Indirect pulp treatment: *In vivo* outcomes of an adhesive resin system vs. calcium hydroxide for protection of the dentin-pulp complex. Pediatr Dent 2002;24:241.

Fuks AB, Bielak S, Chosak A. Clinical and radiographic assessments of direct pulp capping and pulpotomy in young permanent teeth. Pediatr Dent 1982;24:244.

Haskell EW, Stanley HR, Chellemi J, Stringfellow H. Direct pulp capping treatment: A long-term follow-up. J Am Dent Assoc 1978;97:607.

Hebling J, Giro EM, Costa CA. Biocompatibility of an adhesive system applied to exposed human dental pulp. J Endod 1999;25:676.

Jordan RE, Suzuki M. Conservative treatment of deep carious lesions. J Can Dent Assoc 1971;37:337.

Kakehashi S, Stanley HR, Fitzgerald R. The effect of surgical exposures on dental pulps in germ-free and conventional laboratory rats. Oral Surg Oral Med Oral Path 1965;20:340.

Langeland K. Mangement of the inflamed pulp associated with deep carious lesion. J Endod 1981;7:169.

SELECTED REFERENCES:
Vital Pulp Therapy continued

Matsuo T, Nakanishi T, Shimizu H, Ebisu S. A clinical study of direct pulp capping applied to carious exposed pulps. J Endod 1996;22:551.

Oguntebi BR, Heaven T, Clark AE, Pink FE. Quantitative assessment of dentin bridge formation following pulp capping procedures in miniature swine. J Endod 1995;21:79.

Pitt Ford TR, Torabinejad M, Abedi HR, Bakland LK, Kariyawasam SP. Using mineral trioxide aggregate as a pulp capping material. J Am Dent Assoc 1996;127:1491.

Schroder U, Granath LE. Early reaction of intact human teeth to calcium hydroxide following experimental pulpotomy and its significance to the development of hard tissue barrier. Odontol Revy 1971;22:379.

Stanley HR. Pulp capping: Conserving the dental pulp – Can it be done? Is it worth it? Oral Surg Oral Med Oral Path 1989;68:628.

Stanley HR, Lundy T. Dycal therapy for pulp exposures. Oral Surg Oral Med Oral Path 1972;34:818.

Tronstad L, Mjor IA. Capping of the inflamed pulp. Oral Surg Oral Med Oral Path 1972;34:477.

Ward J. Vital pulp therapy in cariously exposed permanent teeth and its limitations. Aust Endod J 2002;28:29.

Yoshiba K, Yoshiba N, Iwaku M. Effects of antibacterial capping agents on dental pulps of monkeys mechanically exposed to oral microflora. J Endod 1995;21:16.

D. Nonsurgical Endodontics

1. Primary Teeth

Indications for Treatment

Nonsurgical root canal treatment for primary teeth is indicated if *any* of the following clinical conditions exist:

a. Irreversible pulpitis or pulpal necrosis with no evidence of a permanent successor tooth.
b. Pulpal necrosis with or without evidence of periradicular disease.
c. Treatment will not jeopardize the permanent successor.

Procedure

Root canal treatment involves the use of biologically acceptable chemical and mechanical treatment of the root canal system to promote healing and repair of the periradicular tissues.

Debridement, enlargement, disinfection and obturation of all canals are accomplished using an aseptic technique with dental dam isolation. The appropriate biologically acceptable material is used to obturate the root canal(s).

- When a permanent successor tooth is evident, the debridement and shaping of the canal system are followed by obturation with an absorbable obturating material.
- When no permanent successor tooth is present, the canals of the primary tooth are obturated with a biologically acceptable nonabsorbable endodontic material. Root canal sealers are used in conjunction with the obturating material to establish an adequate seal.

Objectives

a. To alleviate present and prevent future adverse clinical signs or symptoms.
b. To create the radiographic appearance of a well-obturated root canal system where the root canal filling extends as close as possible to the apical constriction of each canal. Gross overextension, underfilling in the presence of patent canals, ledges and perforations should be avoided.
c. To prevent further breakdown of periradicular tissues.
d. To allow resorption of root structures and absorption of obturating material to occur when a permanent successor tooth emerges.

2. Permanent Teeth

Indications for Treatment

Nonsurgical root canal treatment for permanent teeth is indicated if *any* of the following clinical conditions exist:

a. Irreversible pulpitis.
b. Necrotic pulp with or without evidence of periradicular disease.
c. Teeth with a pulp that would be compromised during dental procedures, including but not limited to overdenture abutments, malposed teeth, post insertion and root resection.
d. Cracked or fractured teeth with pulpal involvement (with or without clinical symptoms) that can reasonably be expected to maintain satisfactory periodontal health.
e. Teeth with thermal hypersensitivity that significantly interferes with normal function, when alternative methods have failed to reduce the hypersensitivity.

Procedure

Root canal treatment for permanent teeth involves the use of biologically acceptable chemical and mechanical treatment of the root canal system to promote healing and repair of the periradicular tissues.

Proper access is dictated by the size and shape of the pulp chamber and its canal orifices, as well as by the tooth's position in the arch. The entire roof of the pulp chamber is removed.

Cleaning, shaping, disinfection and obturation of all canals are accomplished using an aseptic technique with dental dam isolation. Root canal sealers are used in conjunction with a biologically acceptable semi-solid or solid obturating material to establish an adequate seal of the root canal system.

It is recognized that intracanal instruments will occasionally separate due to situations that are beyond the practitioner's control. Recognizing this possibility, the practitioner must use sterilized intracanal instruments made of biocompatible materials, such as stainless steel and/or nickel-titanium. In the event that the fragment cannot be removed or bypassed without compromising tooth structure, the remainder of the accessible root canal space should be obturated with a biologically acceptable semi-solid or solid material. The patient should be informed of any incidence of instrument separation. This discussion should be noted in the patient record.

Paraformaldehyde-containing pastes or obturating materials have been shown to be unsafe. Root canal obturation with paraformaldehyde-containing materials is below the standard of care for endodontic treatment. The American Association of Endodontists and the American Dental Association do not recommend their use.

Following nonsurgical root canal treatment, the tooth must be restored as soon as possible in order to prevent coronal leakage into the root canal system and prevent fracture of the remaining tooth structure.

Objectives

a. To alleviate present and prevent future adverse clinical signs or symptoms.
b. To debride and shape the root canal system.
c. To create the radiographic appearance of a well-obturated root canal system where the root canal filling extends as close as possible to the apical constriction of each canal. Gross overextension, underfilling in the presence of patent canals, ledges and perforations should be avoided.
d. To maintain health and/or promote healing and repair of periradicular tissues:
    i. If a tooth had a normal periodontal ligament space and an intact lamina dura surrounding the root(s) at the time of obturation, the subsequent postoperative radiographic appearance should remain unchanged after a suitable period of time for resolution of any transitory radiographic changes.
    ii. If the radiolucent area is decreasing in size or not enlarging and the tooth is asymptomatic, healing is considered to be incomplete, and additional follow-up visits with radiographic or digital radiographic images are indicated.
    iii. If a tooth had a preoperative periradicular radiolucency, the follow-up radiographs or digital radiographic images should optimally demonstrate an intact lamina dura and a normal periodontal ligament space around the root(s) under observation.
    iv. There may be periradicular bone healing without reformation of a normal periodontal ligament space.

3. Apexification, Apexogenesis and Recalcification

Indications for Treatment

Apexification, apexogenesis and recalcification procedures performed in conjunction with nonsurgical endodontics are indicated if *any* of the following clinical conditions exist:

a. Incomplete apical closure.
b. External root resorption or when the possibility of external root resorption exists.

Procedure

One method of apexification is to induce a calcified apical barrier in a root with an open apex or to encourage the continued apical development of an incompletely formed root in which the pulp is necrotic. Another method of apexification involves the placement of an artificial apical barrier prior to nonsurgical endodontic obturation. This method may be appropriate when patient compliance or long-term follow-up care is questionable.

Apexogenesis is vital pulp therapy performed to allow continued physiological development and formation of the root.

Recalcification procedures are methods for the treatment or prevention of external resorptive defects and internal resorptive defects perforating to the external tooth surface. The purpose of the procedure is to encourage biologic root repair.

These three procedures may involve several treatments (medication changes) over an extended period of time. Biologically acceptable materials should be used. When closure or repair is complete, nonsurgical root canal treatment should be completed.

Objectives

a. To alleviate present and prevent future adverse clinical signs or symptoms.
b. To induce radiographic evidence of apical closure or repair without breakdown of supporting tissues.
c. To provide biologic repair of the resorptive defect.

4. Perforation Repair

Indications for Treatment

Nonsurgical repair is indicated if *any* of the following clinical conditions exist:

a. A perforation of tooth structure has occurred during nonsurgical root canal treatment or post space preparation, and the perforation is within alveolar bone.
b. A communication between the pulp space and external root surface as a result of internal root resorption.

Procedure

The perforation defect is repaired using a biologically acceptable material to seal the communication between the pulp canal space and external root surface.

Objectives

a. To seal the root canal space from the external surface of the root.
b. Minimize extrusion of the repair material.
c. Promote healing of the periodontal structures at the site of the perforation.

5. Nonsurgical Root Canal Retreatment

Indications for Treatment

Nonsurgical root canal retreatment is indicated if *any* of the following clinical conditions exist:

a. Continued periradicular pathosis.
b. Radiographic evidence of a deficiency in the quality of the root canal obturation when periradicular pathosis or symptoms continue after endodontic treatment.
c. Persistent symptoms.

d. Anticipated restorative or prosthetic procedures that could compromise any pre-existing root canal obturations.
e. Anticipated restorative or prosthetic procedures on a tooth where the previous treatment quality is questionable.
f. Salivary contamination when bacterial leakage into the root canal system is suspected.

Procedure

Nonsurgical root canal retreatment is a procedure to remove the previously placed root canal obturating material and re-obturate the tooth. Cleaning, shaping, disinfection and obturation of all canals are accomplished using an aseptic technique with dental dam isolation. Root canal sealers are used in conjunction with a biologically acceptable semi-solid or solid obturating material to establish an adequate seal of the root canal system.

Additional procedures may be required to remove posts and manage canal obstructions, radicular defects, aberrant canal morphology, ledges or perforations. (See the AAE *Guidelines for Assessing the Difficulty of Endodontic Cases* in the Appendix.)

Retreatment cases may vary greatly in complexity, requiring greater effort, time and skill, and should be undertaken with due regard to the ability and experience of the practitioner. Retreatment may require augmentation by other treatment modalities, such as apexification, recalcification or surgical intervention to provide optimal treatment.

Objectives

a. To alleviate present and prevent future adverse clinical signs or symptoms.
b. To create the radiographic appearance of a well-obturated root canal system where the root canal filling extends as close as possible to the apical constriction of each canal. Gross overextension, underfilling in the presence of patent canals, ledges and perforations should be avoided. To maintain health and/or promote healing and repair of periradicular tissues:
    i. If a tooth had a normal periodontal ligament space and an intact lamina dura surrounding the root(s) at the time of obturation, the subsequent postoperative radiographic appearance should remain unchanged after a suitable period of time for resolution of any transitory radiographic changes.
    ii. If the radiolucent area is decreasing in size or not enlarging and the tooth is asymptomatic, healing is considered to be incomplete, and additional follow-up visits with radiographic or digital radiographic images are indicated.
    iii. If a tooth had a preoperative periradicular radiolucency, the follow-up radiographs or digital radiographic images should optimally demonstrate an intact lamina dura and a normal periodontal ligament space around the root(s) under observation.
    iv. There may be periradicular bone healing without reformation of a normal periodontal ligament space.

SELECTED REFERENCES:
Nonsurgical Endodontics

Allison DA, Weber CR, Walton RE. The influence of the method of canal preparation on the quality of apical and coronal obturation. J Endod 1979 Oct;5(10):298-304.

Barthel CR, Rosenkranz B, Leuenberg A, Roulet JF. Pulp capping of carious exposures: treatment outcome after 5 and 10 years: a retrospective study. J Endod 2000 Sep;26(9):525-8.

Baumgartner JC. Microbiologic and pathologic aspects of endodontics. Curr Opin Dent 1991;1:737.

Bergenholtz G, Lekholm U, Milthon R, Heden G, Odesjo B, Engstrom B. Retreatment of endodontic fillings. Scand J Dent Res 1979;87:217.

Bystrom A, Sundqvist G. Bacteriologic evaluation of the efficacy of mechanical root canal instrumentation in endodontic therapy. Scand J Dent Res 1981;89:321.

Coll JA, Sadrian R. Predicting pulpectomy success and its relationship to exfoliation and succedaneous dentition. Pediatr Dent 1996;18:57.

Cunningham WT, Martin H. A scanning electron microscope evaluation of root canal debridement with the endosonic ultrasonic synergistic system. Oral Surg Oral Med Oral Pathol 1982;53:527.

Cvek M. Treatment of non-vital permanent incisors with calcium hydroxide. Odontol Revy 1972;23:27.

Dummer PMH, McGinn JH, ree DG. The position and topography of the apical constriction and apical foramen. Int Endod J 1984;17:192.

El Deeb ME, El Deeb M, Tabibi A, Jensen JR. An evaluation of the use of amalgam, Cavit, and calcium hydroxide in the repair of furcation perforations. J Endod 1982;8:459.

England MC, Best E. Noninduced apical closure in immature roots of dogs' teeth. J Endod 1977;3:411.

Esposito PT, Cunningham CJ. A comparison of canal preparation with nickel-titanium and stainless steel instruments. J Endod 1995 Apr;21(4):173-6.

Fish EW. Bone infection. J Am Dent Assoc 1939;26:691.

Frank AL, Weine FS. Nonsurgical therapy for the perforative defect of internal resorption. J Am Dent Assoc 1973 Oct;87(4):863-8.

SELECTED REFERENCES:
Nonsurgical Endodontics continued

Frank A. Therapy for the divergent pulpless tooth by continued apical formation. J Am Dent Assoc 1966;72:87.

Friedman S, Stabholz A. Endodontic retreatment—case selection and technique. Part 1: Criteria for case selection. J Endod 1986;12:28.

Friedman S, Stabholz A, Tamse A. Endodontic retreatment—case selection and technique. 3. Retreatment techniques. J Endod 1990;16:543.

Fuss Z, Trope M. Root perforations: classification and treatment choices based on prognostic factors. Endod Dent Traumatol 1996;12:255.

Goodman A, Schilder H, Aldrich W. The thermomechanical properties of gutta-percha. Part IV. A thermal profile of the warm gutta-percha packing procedure. Oral Surg Oral Med Oral Pathol 1981 May;51(5):544-51.

Grossman LI. Physical properties of root canal cements. J Endod 1976;2:166.

Haapasalo M. *Bacteroides spp.* in dental root canal infections. Endod Dent Traumatol 1989;5:1.

Hammarstrom LE, Blomlof LB, Feiglin B, Lindskog SF. Effect of calcium hydroxide treatment on periodontal repair and root resorption. Endod Dent Traumatol 1986;2:184.

Heithersay GS. Calcium hydroxide in the treatment of pulpless teeth with associated pathology. J Br Endod Soc 1975;8:74.

Holan G, Topf J, Fuks AB. A comparison of pulpectomies using ZOE and KRI paste in primary molars: a retrospective study. Pediatr Dent 1993;15:403.

Katebzadeh N, Sigurdsson A, Trope M. Radiographic evaluation of periapical healing after obturation of infected root canals: an *in vivo* study. Int Endod J 2000 Jan;33(1):60-6.

Khemaleelakul S, Baumgartner JC, Pruksakorn S. Identification of bacteria in acute endodontic infections and their antimicrobial susceptibility. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2002 Dec;94(6):746-55.

Kleier DJ, Barr ES. A study of endodontically apexified teeth. Endod Dent Traumatol. 1991 Jun;7(3):112-7.

Kuttler Y. Microscopic investigation of root apexes. J Am Dent Assoc 1955;50:544.

SELECTED REFERENCES:
Nonsurgical Endodontics continued

Lazarski MP, Walker WA III, Flores CM, Schindler WG, Hargreaves KM. Epidemiological evaluation of the outcomes of nonsurgical root canal treatment in a large cohort of insured dental patients. J Endod 2001 Dec;27(12):791-6.

Leonardo MR, da Silva LA, Tanomaru Filho M, Bonifacio KC, Ito IY. *In vitro* evaluation of antimicrobial activity of sealers and pastes used in endodontics. J Endod 2000 Jul;26(7):391-4.

Lovdahl PE, Gutmann JL. Problems in Nonsurgical Root Canal Retreatment in Problem Solving in Endodontics: Prevention, Identification, and Management. Year Book Medical Publishers Inc. 1988;73.

Maddox D, Walton RE, Davis C. Incidence of post-treatment endodontic pain related to medicaments and other factors. J Endod 1977:3;447.

Magara ME, Kafrawy AH, Brown CE, Newton CW. Human saliva coronal microleakage in obturated root canals: An *in vitro* study. J Endod 1991;17:324.

Newton CW, Patterson SS, Kafrawy AH. Studies of Sargenti's technique of endodontic treatment: six-month and one-year responses. J Endod 1980;6:509.

O'Keefe EM. Pain in endodontic therapy: preliminary study. J Endod 1976;2:315.

Pratten DH, McDonald NJ. Comparison of radiographic and electronic working lengths. J Endod 1996;22:173.

Rimondini L, Baroni C. Morphologic criteria for root canal treatment of primary molars undergoing resorption. Endod Dent Traumatol 1995;11:136.

Schilder H. Cleaning and shaping the root canal. Dent Clin N Am 1974;18:269.

Seltzer S et al. A scanning electron examination of silver cones removed from endodontically treated teeth. Oral Surg Oral Med Oral Pathol 1972;33:589.

Seltzer S, Soltanoff W, Smith J. Biologic aspects of endodontics. V. Periapical tissue reactions to root canal instrumentation beyond the apex and root canal fillings short of and beyond the apex. Oral Surg Oral Med Oral Pathol 1973;36:725.

Shabahang S, Goon WW, Gluskin AH. An *in vivo* evaluation of Root ZX electronic apex locator. J Endod 1996 Nov;22(11):616-8.

Simon JH, Glick DH, Frank AL. Predictable endodontic and periodontic failures as a result of radicular anomalies. Oral Surg Oral Med Oral Pathol 1971 Jun;31(6):823-6.

SELECTED REFERENCES:
Nonsurgical Endodontics continued

Siqueira JF Jr, Rjcas IN, Lopes HP, Elias CN, de Uzeda M. Fungal infection of the radicular dentin. J Endod 2002 Nov;28(11):770-3.

Sjogren U, Figdor D, Spångberg L, Sundqvist G. The antimicrobial effect of calcium hydroxide as a short term intracanal dressing. Int Endod J 1991;24:119.

Sjogren U, Figdor D, Persson S, Sundqvist G. Influence of infection at the time of root filling on the outcome of endodontic treatment of teeth with apical periodontitis. Int Endod J 1997 Sep;30(5):297-306.

Sjogren U, Hagglund B, Sundqvist G, Wing K. Factors affecting the long-term results of endodontic treatment. J Endod 1990 Oct;16(10):498-504.

Slowey RR. Radiographic aids in the detection of extra root canals. Oral Surg Oral Med Oral Pathol 1974;37:762.

Spångberg L. Biologic effects of root canal filling materials. The effect on bone tissue of two formaldehyde-containing root canal filling pastes: N2 and Riebler's paste. Oral Surg Oral Med Oral Pathol 1974;38:934.

Spångberg L, Langeland K. Biologic effects of dental materials. 1. Toxicity of root canal filling materials on HeLa cells *in vitro*. Oral Surg Oral Med Oral Pathol 1973;35:402.

Stabholz A, Friedman S. Endodontic retreatment—case selection and technique. Part 2: Treatment planning for retreatment. J Endod 1988;14:607.

Sundqvist G. Taxonomy, ecology, and pathogenicity of the root canal flora. Oral Surg Oral Med Oral Pathol 1994;78:522.

Sundqvist G, Figdor D, Persson S, Sjogren U. Microbiologic analysis of teeth with failed endodontic treatment and the outcome of conservative retreatment. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1998;85:86.

Sundqvist G, Johansson E, Sjogren U. Prevalence of black-pigmented bacteroides species in root canal infections. J Endod 1989;15:13.

Swanson K, Madison S. An evaluation of coronal microleakage in endodontically treated teeth. Part I. Time periods. J Endod 1987;13:56.

Torabinejad M, Chivian N. Clinical applications of mineral trioxide aggregate. J Endod 1999 Mar;25(3):197-205.

SELECTED REFERENCES:
Nonsurgical Endodontics continued

Torabinejad M, Handysides R, Khademi AA, Bakland LK. Clinical implications of the smear layer in endodontics: A review. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2002 Dec;94(6):658-66.

Torneck CD, Smith JS, Grindall P. Biologic effects of endodontic procedures on developing incisor teeth. IV. Effect of debridement procedures and calcium hydroxide-camphorated prachlorophenol paste in the treatment of experimentally induced pulp and periapical disease. Oral Surg Oral Med Oral Pathol 1973;35:541.

Tronstad L, Asbjornsen K, Doving L, Pedersen I, Eriksen HM. Influence of coronal restorations on the periapical health of endodontically treated teeth. Endod Dent Traumatol 2000 Oct;16(5):218-21.

Trope M. Cervical root resorption. J Am Dent Assoc 1997;128 Suppl:56S.

Trope M, Tronstad L. Long-term calcium hydroxide treatment of a tooth with iatrogenic root perforation and lateral periodontitis. Endod Dent Traumatol 1985;1:35.

Walton RE. Current concepts of canal preparation. Dent Clin N Amer 1992;36:309.

Walton RE, Chiappinelli J. Prophylactic penicillin: Effect on post-treatment symptoms following root canal treatment of asymptomatic periapical pathosis. J Endod 1993;19:466.

Weiger R, Rosendahl R, Lost C. Influence of calcium hydroxide intracanal dressings on the prognosis of teeth with endodontically induced periapical lesions. Int Endod J 2000 May;33(3):219-26.

Weine FS, Healy HJ, Theiss EP. Endodontic emergency dilemma: Leave tooth open or keep it closed? Oral Surg Oral Med Oral Pathol 1975;40:531.

Weine FS, Kelly RF, Lio PJ. The effect of preparation procedures on original shape and on apical foramen shape. J Endod 1975;1:225.

Wu MK, Wesselink PR, Walton RE. Apical terminus location of root canal treatment procedures. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2000;89(1):99-103.

Vertucci FJ. Root canal anatomy of the human permanent teeth. Oral Surg Oral Med Oral Pathol 1984 58(5):589-99.

Zerr MA, Walton R, Peterson L. Antibiotics: indications, contraindications, and non-indications. Northwest Dent 1998 Jul-Aug;77(4):19-24.

E. Surgical Endodontics

1. Incision and Drainage/Trephination

Indications for Treatment

Incision and drainage of soft tissues is indicated if *any* of the following clinical conditions exist:

a. If a pathway is needed in soft tissue with localized fluctuant swelling that can reasonably be expected to provide necessary drainage.
b. When pain is caused by accumulation of exudate within soft tissues.
c. When necessary to collect samples for bacteriologic analysis.

Trephination of hard tissues is indicated in *any* of the following clinical situations:

a. If a pathway is needed from hard tissue that can reasonably be expected to provide necessary drainage.
b. When pain is caused by accumulation of exudate within the alveolar bone.
c. When necessary to collect samples for bacteriologic analysis.

Procedure

Incision and drainage is a surgical opening created in soft tissue for the purpose of releasing exudate or decompressing the area of swelling.

Trephination is the surgical perforation of the alveolar cortical bone to release accumulated tissue exudate.

These procedures may include the placement and subsequent timely removal of a drain.

Antibiotics may be indicated if there is diffuse swelling (cellulitis), systemic symptoms or in patients who are immunocompromised.

Objectives

a. To alleviate present and prevent future adverse clinical signs or symptoms.
b. To reduce localized soft tissue swellings.
c. To promote acceptable repair of hard and soft tissues.
d. To prevent damage to teeth or anatomical structures.

2. Periradicular Curettage

Indications for Treatment

Periradicular curettage is indicated if *any* of the following clinical conditions exist:

a. Persistent periradicular pathosis following endodontic treatment.
b. A periradicular lesion that enlarges after endodontic treatment, as noted on follow-up radiographs or digital radiographic images.
c. A marked overextension of obturating materials interfering with healing.
d. A biopsy is deemed necessary.

Procedure

Periradicular curettage is a surgical procedure to remove diseased or reactive tissue and/or foreign material from the alveolar bone in the apical or lateral region surrounding an endodontically treated tooth. By definition, the root is not resected.

A mucoperiosteal flap is surgically elevated and, when necessary, bone is removed to allow direct visualization of and access to the affected area. Thorough removal of all targeted tissue and/or foreign material is performed. Guided tissue regeneration techniques and/or bone replacement may be used if, at the time of surgery, the clinical condition warrants their use. Primary closure of the surgical site is desired.

Objectives

a. To alleviate present and prevent future adverse clinical signs or symptoms.
b. To promote repair of hard and soft tissues.
c. To minimize damage to adjacent teeth or anatomical structures.

3. Root-end Resection (Apicoectomy)

Indications for Treatment

A root-end resection (apicoectomy) in conjunction with periradicular curettage is indicated if *any* of the following clinical conditions exist:

a. Persistent periradicular pathosis following endodontic treatment.
b. A periradicular lesion that enlarges after endodontic treatment, as noted on follow-up radiographs or digital radiographic images.
c. A marked overextension of obturating materials interfering with healing.
d. Access for periradicular curettage, biopsy or to an additional root is necessary.
e. Access for root-end preparation and root-end filling is necessary.
f. When the apical portion of the root canal system of a tooth with periradicular pathosis cannot be cleaned, shaped and obturated.

Procedure

Root-end resection (apicoectomy) is the preparation of a flat surface by the excision of the apical portion of the root and any subsequent removal of attached soft tissues.

A mucoperiosteal flap is surgically elevated and, when necessary, bone is removed to allow direct visualization of and access to the affected area. Thorough removal of all targeted tissue and/or foreign material is performed. Guided tissue regeneration techniques and/or bone replacement may be used if, at the time of surgery, the clinical condition warrants their use. Primary closure of the surgical site is desired.

Objectives

a. To alleviate present and prevent future adverse clinical signs or symptoms.
b. To promote repair of hard and soft tissues.
c. To minimize damage to adjacent teeth or anatomical structures.
d. To preserve as much root length as possible.

4. Root-end Filling (Retrofilling)/Root Repair

Indications for Treatment

Root-end filling (retrofilling) and root repair, when anatomically feasible, are indicated if *any* of the following clinical conditions exist:

a. Persistent periradicular pathosis resulting from an inadequate apical seal that cannot be corrected nonsurgically.
b. Periradicular pathosis and a blockage of the root canal system that could not be obturated by nonsurgical root canal treatment.
c. Root perforations.
d. Resorptive defects.

Procedure

Root-end filling (retrofilling) is an additional procedure following root-end resection (apicoectomy). A biologically acceptable restorative material is placed into a root-end preparation. Root resorptive defects and perforations are repaired with a biologically acceptable filling material.

Following root-end resection, a preparation is made and a biologically acceptable repair material is placed. Guided tissue regeneration techniques and/or bone replacement may be used if, at the time of surgery, the clinical condition warrants their use. Primary closure of the surgical site is desired.

Objectives

a. To alleviate present and prevent future adverse clinical signs or symptoms.
b. To promote acceptable repair of hard and soft tissues.
c. To minimize damage to adjacent teeth or anatomical structures.
d. To preserve maximum root length possible.
e. To limit root-end filling and root repair materials to the confines of the preparation.
f. To seal the root canal system or defect.

5. Biopsy

Indications for Treatment

A biopsy is indicated if *any* of the following clinical conditions exist:

a. When an adequate amount of tissue or foreign material can be removed from the periradicular surgical site for histopathologic examination.
b. Persistent pathosis or pathosis inconsistent with endodontic disease is noted on clinical or radiographic examination.
c. Medical history indicates the merits of biopsy.

Procedure

A biopsy is the surgical removal of a soft and/or hard tissue specimen for histopathologic examination.

Objective

To establish a diagnosis by histopathologic examination.

6. Hemisection

Indications for Treatment

Hemisection is indicated if any of the following clinical conditions exist:

a. Class III or Class IV periodontal furcation defect.
b. Infrabony defect of one root of a multi-rooted tooth that cannot be successfully treated periodontally.
c. Coronal fracture extending into the furcation.
d. Vertical root fracture confined to the root to be separated and removed.
e. Carious, resorptive root or perforation defects that are inoperable or cannot be corrected without root removal.
f. Persistent periradicular pathosis where nonsurgical treatment or periradicular surgery is not possible and the problem is confined to one root.

Procedure

Hemisection is the surgical separation of a multi-rooted tooth through the furcation in such a way that a root and the associated portion of the crown may be removed. Occasionally, this procedure is performed on maxillary molars or premolars. Hemisection requires root canal treatment on all retained root segments. When possible, it is preferable to complete the root canal procedure and place a permanent restoration that extends into the canal orifices prior to the hemisection procedure.

Objectives

a. To alleviate present and prevent future adverse clinical signs or symptoms.
b. To eliminate or reduce significant periodontal defects.
c. To perform acceptable root canal obturation(s) in the remaining root segment(s).
d. To perform proper contouring of remaining tooth structure.
e. To seal all external openings into the pulp chamber.
f. To provide a portion(s) of the tooth that is/are restorable and that can be maintained by the patient.

7. Root Resection (Root Amputation)

Indications for Treatment

A root resection procedure is indicated if *any* of the following clinical conditions exist:

a. Class III or Class IV periodontal furcation defect.
b. Infrabony defect of one root of a multi-rooted tooth that cannot be successfully treated periodontally.

c. An existing fixed prosthesis that will be seriously compromised by a hemisection.
d. Vertical root fracture confined to the root to be separated and removed.
e. Carious, resorptive root or perforation defects that are inoperable or cannot be corrected without root removal.
f. Persistent periradicular pathosis where nonsurgical root canal treatment or periradicular surgery is not possible.
g. At least one root is structurally sound.

Procedure

Root resection (root amputation) is the surgical removal of an entire root(s) leaving the crown of the tooth intact. Root resection requires root canal treatment on all retained root segments. When possible, it is preferable to complete the root canal procedure and place a permanent restoration that extends into the canal orifices prior to the root resection procedure.

Objectives

a. To alleviate present or prevent future adverse clinical signs or symptoms.
b. To eliminate or reduce significant periodontal defect(s).
c. To perform acceptable root canal obturation(s) in the remaining root segment(s).
d. To perform proper contouring of remaining tooth structure.
e. To seal all external openings into the pulp chamber.
f. To provide a portion(s) of the tooth that is/are restorable and that can be maintained by the patient.
g. To preserve an existing prosthesis where one root of an abutment requires removal.

8. Intentional Replantation (Extraction/Replantation)

Indications for Treatment

Intentional replantation is indicated when *all* of the following clinical conditions exist:

a. Persistent periradicular pathosis following endodontic treatment.
b. Nonsurgical retreatment is not possible or has an unfavorable prognosis.
c. Periradicular surgery is not possible or involves a high degree of risk to adjacent anatomical structures.
d. The tooth presents a reasonable opportunity for removal without fracture.
e. The tooth has an acceptable periodontal status prior to the replantation procedure.

Procedure

Intentional replantation is the insertion of a tooth into its alveolus after the tooth has been extracted for the purpose of accomplishing a root-end filling or root repair. Stabilization of the replanted tooth may or may not be necessary. When possible, root canal treatment is performed prior to intentional replantation.

Objectives

a. To alleviate present and prevent future adverse clinical signs or symptoms.
b. To properly orient the tooth in the socket.
c. To eliminate periradicular pathosis.
d. To minimize periodontal pathosis.
e. To preserve the maximum root length possible.
f. To place root-end filling(s) or root repair material(s).
g. To maintain the tooth as a functional member of the dentition.

9. Surgical Removal of the Apical Segment of a Fractured Root

Indications for Treatment

When a root fracture occurs in the apical portion and pulpal necrosis results, the fractured segment may be removed surgically following or in conjunction with nonsurgical root canal treatment. Surgical removal of the apical segment of a fractured root is indicated when *all* of the following clinical conditions exist:

a. Root fracture in the apical portion of the root.
b. Pulpal necrosis in the apical segment as indicated by a periradicular lesion or clinical signs or symptoms.
c. Coronal tooth segment is restorable and functional.

Procedure

A mucoperiosteal flap is surgically elevated and, when necessary, bone is removed to allow direct visualization of and access to the affected site. The apical portion of the affected root and all of the targeted tissue are removed. A root-end resection and/or root-end filling may be necessary. Guided tissue regeneration techniques and/or bone replacement may be used if, at the time of surgery, the clinical condition warrants their use. Primary closure of the surgical site is desired.

Objectives

a. To alleviate present and prevent future adverse clinical signs or symptoms.
b. To remove the fractured root segment.
c. To promote acceptable repair of hard and soft tissues.
d. To maintain a favorable crown-to-root ratio.
e. To prevent damage to adjacent teeth or anatomical structures.
f. To maintain the tooth as a functional member of the dentition.

SELECTED REFERENCES:
Surgical Endodontics

Abdul AK, Retief DH. Apical seal via retrosurgical approach. Oral Surg Oral Med Oral Pathol 1982;53:614.

Andreason JO. Cementum repair after apicoectomy in humans. Acta Odontol Scand 1973;31:211.

Andreasen JO, Rud J. Modes of healing histologically after endodontic surgery in 70 cases. Int J Oral Surg 1972;1:148.

Antrim DD, Bakland LK, Parker LK, Parker MW. Treatment of endodontic urgent care cases. Dent Clin North Am 1986;30:549.

Becker SA, von Fraunhofer JA. The comparative leakage behavior of reverse filling materials. J Endod 1989;15:246.

Beisterfeld RC, Taintor JF. Endodontic considerations related to hemisection and root amputation. Northwest Dent 1978;57(3):142.

Beltes P, Zervas P, Lambrianidis T, Molyvdas I. *In vitro* study of the sealing ability of four retrograde filling materials. Endod Dent Traumatol 1988;4:82.

Bender IB, Rossman LE. Intentional replantation of endodontically treated teeth. Oral Surg, Oral Med, Oral Path, Oral Rad, Endod 1993;76:623.

Bondra DL, Hartwell GR, MacPherson MG, Portell FR. Leakage *in vitro* with IRM, high copper amalgam, and EBA cement as retrofilling materials. J Endod 1989;15:157.

Denio D, Torabinejad M, Bakland LK. Anatomical relationship of the mandibular canal to its surrounding structures in mature mandibles. J Endod 1992;18:161.

Dorn SO, Gartner AH. Retrograde filling materials: a retrospective success-failure study of amalgam, EBA, and IRM. J Endod 1990;16:391.

Eastman JR, Backmeyer J. A review of the periodontal, endodontic, and prosthetic considerations in odontogenous resection procedures. Int J Periodontics Restorative Dent 1986;6:34.

Ericson SD, Finne K, Persson G. Results of apicoectomy of maxillary canines, premolars, and molars with special reference to oroantral communication as a progenerate factor. Int J Oral Surg 1974;3:386.

Figdor D, Tyas MJ. Apical dentin permeability and microleakage associated with root end resection and retrograde filling. J Endod 1994;20:22.

SELECTED REFERENCES:
Surgical Endodontics continued

Fine BC, Sheckman PR, Bartlett JC. Incision and drainage of soft tissue abscesses and bacteremia. Ann Intern Med 1985;103:645.

Fouad A, Rivera EM, Walton RE. Penicillin as a supplement in resolving the localized acute apical abscess. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1996;81:590.

Freedland JB. Conservative reduction of large periapical lesions. Oral Surg Oral Med Oral Pathol 1970;29:455.

Gilheaney PA, Figdor D, Tyas MJ. Apical dentin permeability and microleakage associated with root end resection and retrograde filling. J Endod 1994;20:22.

Grossman, L. Intentional replantation of teeth: a clinical evaluation. J Am Dent Assoc 1981;104:633.

Gunraj MN. Decompression of a large periapical lesion utilizing an improved drainage device. J Endod 1990;16:140.

Gutmann JL. Principles of endodontic surgery for the general practitioner. Dent Clin N Amer 1984;28:895.

Harrington GW, Natkin E. Midtreatment flare-ups. Dent Clin N Amer 1992;36:409.

Harrison JW. The effect of root resection on the sealing properties of root canal obturation. Oral Surg Oral Med Oral Pathol 1980;50:264.

Koenig KH, Nguyen NT, Barkhordar RA. Intentional replantation: a report of 192 cases. Gen Dent 1988;36:327.

Kryshtalskyj E. Root amputation and hemisection. Indications, techniques and restoration. J Can Dent Assoc 1986;52:307.

Langer B, Stein SD, Wagneberg B. An evaluation of root resections: a ten-year study. J Periodontol 1981;52:719.

Lantz B, Persson PA. Periodontal tissue reactions after surgical treatment of root perforations in dogs' teeth. A histologic study. Odontol Revy 1970;21:51.

Lin LM, Gaengler P, Langeland K. Periradicular curretage. Int Endod J 1996;29:220.

Lindeberg RW, Girardi AF, Traxell JB. Intentional replantation: management in contraindicated situations. Compend Contin Educ Dent 1986;7:248.

SELECTED REFERENCES:
Surgical Endodontics continued

Loe H, Waerhaug J. Experimental replantation of teeth in dogs and monkeys. Arch Oral Biol 1961;3:176.

MacPherson MG, Hartwell GR, Bondra DL, Weller RN. Leakage *in vitro* with high-temperature thermoplasticized gutta-percha, high copper amalgam, and warm gutta-percha when used as retrofilling materials. J Endod 1989;15:212.

Molven O, Halse A, Grung B. Incomplete healing (scar tissue) after periapical surgery – radiographic findings 8 to 12 years after treatment. J Endod 1996;22:264.

Oliet S, Grossman LI. Root resection. Compend Contin Educ Dent 1983;4:9.

Persson G. Prognosis of re-operation after apicoectomy. A clinical-radiological investigation. Sven Tandlak Tidskr 1973;66:49.

Rud J, Andreasen JO, Jenses JEM. Radiographic criteria for the assessment of healing after endodontic surgery. Int J Oral Surg 1972;1:195.

Schmitt SM, Brown FH. The hemisected mandibular molar: a strategic abutment. J Prosthet Dent 1987;58:140.

Stabholz A, Friedman S, Abed J. Marginal adaptation of retrograde fillings and its correlation with sealability. J Endod 1985;11:218.

Thirawat J, Edmunds DH. The sealing ability of materials used as retrograde root fillings in endodontic surgery. Int Endod J 1989;22:295.

Torabinejad M, Smith PW, Kettering JD, Pitt-Ford TR. Comparative investigation of marginal adaptation of mineral trioxide aggregate and other commonly used root-end filling materials. J Endod 1995;21:295.

Torabinejad M, Walton RE. Managing endodontic emergencies. J Am Dent Assoc 1991;122:99, 101.

Trope M, Lost C, Schmitz HJ, Friedman S. Healing of apical periodontitis in dogs after apicoectomy and retrofilling with various filling materials. Oral Surg Oral Med Oral Pathol Oral Rad, Endod 1996;82:221.

Zetterqvist L, Anneroth G, Danin J, Roding K. Microleakage of retrograde fillings—a comparative investigation between amalgam and glass ionomer cement *in vitro*. Int Endod J 1988;2:1.

F. Management of Traumatic Dental Injuries

1. Enamel Fracture (Uncomplicated Crown Fracture)

Indications for Treatment

Treatment of enamel fracture is indicated if *any* of the following clinical conditions exist:

a. Enamel fracture.
b. Chipped enamel not involving underlying dentin.

Procedure

Enamel fractures usually require minimal treatment; chipped enamel can either be smoothed or repaired with bonded resin.

Objectives

a. To alleviate present and prevent future adverse clinical signs or symptoms.
b. To establish an acceptable esthetic and functional tooth.

2. Crown Fracture Without Pulp Exposure (Uncomplicated Crown Fracture)

Indications for Treatment

Treatment of crown fracture involving enamel and dentin, but without direct exposure of the pulp, is indicated when *both* of the following clinical conditions exist:

a. The crown fracture involves enamel and dentin with no pulp exposure.
b. The pulp tests reveal no indication for endodontic treatment.

Procedure

In addition to restoring the esthetic aspect of the tooth, procedures for treating crown fractures without pulpal exposure are intended to protect the dentin and the underlying vital pulp. In immature teeth, continued root development may take place.

Objectives

a. To alleviate present and prevent future adverse clinical signs or symptoms.
b. To establish an esthetic and functional tooth.
c. To determine radiographic evidence of continued/complete root development in immature teeth.

3. Crown Fracture With Pulp Exposure (Complicated Crown Fracture)

Indications for Treatment

Treatment of crown fracture is indicated when *both* of the following clinical conditions exist:

a. Crown fracture involves enamel, dentin and exposure of the pulp.
b. The pulp is vital.

Procedure

For immature teeth:
The purpose of treatment is to protect the pulp so that root development may continue to mature. Pulp capping or shallow pulpotomy procedures are indicated. A biologically acceptable material is placed directly in contact with the pulp to maintain the vitality and function of the remaining radicular portion of the pulp. A final restoration is placed. When the root reaches full maturation, nonsurgical root canal treatment and crown placement may be indicated.

For permanent (fully formed) teeth:
If a crown is not necessary for restoring the fractured tooth, it is acceptable to use pulp capping or shallow pulpotomy procedures followed by bonded composite resin or bonded fractured crown segment restorations, if carried out on teeth without clinical signs or symptoms of irreversible pulpitis and in a manner consistent with minimizing bacterial contamination. In any other case, nonsurgical root canal treatment is indicated. If the tooth requires a crown to restore function or esthetics, nonsurgical root canal treatment is an appropriate procedure prior to the crown placement.

Objectives

a. To alleviate present and prevent future adverse clinical signs or symptoms.
b. To place a radiopaque capping material in contact with the pulpal tissue.
c. To establish an acceptable esthetic and functional tooth.
d. To test pulps for vitality.
e. To maintain health and/or promote healing and repair of the periradicular supporting tissue.
f. To observe no resorptive defects or accelerated canal calcification as determined by periodic radiographic evaluation.
g. To promote sufficient root development for endodontic treatment. An increase in root length may be evident.

4. Crown-Root Fracture

Indications for Treatment

Crown fracture involves enamel, dentin and cementum that may or may not involve the pulp.

Procedure

For immature teeth, the need for protecting the pulp is most important. Treatment, both immediate and definitive, is more complex and often requires innovative and unusual procedures.

Immature Teeth:
Immediate care. The purpose of treatment is to protect the pulp so that root development may continue. Pulp capping or shallow pulpotomy procedures are indicated. A biologically acceptable material is placed directly in contact with the pulp to maintain the vitality and function of the remaining radicular portion of the pulp. A final restoration is placed. When the root reaches full maturation, nonsurgical root canal treatment and crown placement may be indicated. In addition, soft tissue surgery to allow access to the fracture site may be necessary.

Definitive care. The same procedures as for crown fractures with pulp exposure are indicated.

Fully Formed Teeth:
Immediate and definitive care. Nonsurgical root canal treatment is indicated in most cases. Procedures to facilitate restorations may include, but are not limited to, surgical crown lengthening and root extrusion.

Objectives

a. To alleviate present and prevent future adverse clinical signs or symptoms.
b. To place a radiopaque capping material in contact with the pulpal tissue.
c. To establish an acceptable esthetic and functional tooth.
d. To maintain normal responsiveness to electrical and thermal pulp tests.
e. To maintain health and/or promote healing and repair of the periradicular supporting tissue.
f. To minimize resorptive defects or accelerated canal calcification as determined by periodic radiographic evaluation.
g. To promote sufficient root development for endodontic treatment. An increase in root length may be evident.

5. Root Fracture

Indications for Treatment

Root fracture involves cementum, dentin and pulp, and may be horizontal or oblique.

Procedure

In most cases, immediate care is directed toward reduction and stabilization of the fracture site.

Immediate care. Immediate care includes reduction and stabilization of the fracture site.

Definitive care. Definitive care is limited to periodic radiographic and clinical evaluations. If pulpal necrosis develops, root canal treatment is indicated.

If a root fracture occurs in the apical portion and pulpal necrosis results, the fractured segment may be removed surgically following/or in conjunction with nonsurgical root canal treatment. (See Section E-9)

If coronal tooth structure is lost apical to crestal bone, root extrusion or surgical crown lengthening may be indicated.

Objectives

a. To alleviate present and prevent future adverse clinical signs or symptoms.
b. To establish an acceptable esthetic and functional tooth.
c. To observe radiographic evidence of continued/complete root formation in immature teeth.
d. To observe radiographic evidence of root fracture repair (calcific, fibrous/fibrotic or bony).
e. To establish minimal tooth mobility.

6. Luxation

Indications for Treatment

Luxation includes slight to severe injuries to teeth and their supporting structures.

a. Concussion —Trauma resulting in sensitivity to percussion but no excessive mobility and no displacement.
b. Subluxation — Injury to supporting tissues resulting in abnormal loosening of a tooth or teeth without displacement.
c. Extrusive luxation — Partial axial displacement of the tooth out of its socket.
d. Lateral luxation — Displacement of the tooth in a direction other than axially that can be accompanied by fracture of the alveolar socket.
e. Intrusive luxation—Axial displacement of the tooth into the alveolus and can be accompanied by fracture of the alveolar socket.

Procedure

Immediate care. Includes repositioning the tooth and nonrigid stabilization, when needed, to allow re-establishment of periodontal ligament support for the tooth.

Definitive care. Includes nonsurgical root canal treatment in teeth with pulpal necrosis or irreversible pulpitis as determined by appropriate diagnostic procedures.

The treatment for immature teeth varies from fully formed teeth in that efforts must be attempted to allow revascularization of the immature pulps, while fully formed teeth can receive nonsurgical root canal treatment as soon as pulpal necrosis or irreversible pulpitis has been established. In the case of intruded immature permanent teeth with open apices, immediate care can appropriately consist of monitoring on a regular basis for re-eruption.

Objectives

a. To alleviate present and prevent future adverse clinical signs or symptoms.
b. To create the radiographic appearance of a well-obturated root canal system where the root canal filling extends as close as possible to the apical constriction of each canal. Gross overextension, underfilling in the presence of patent canals, ledges and perforations should be avoided.

c. To maintain health and/or promote healing and repair of periradicular tissues:
   i. If a tooth had a normal periodontal ligament space and an intact lamina dura surrounding the root(s) at the time of obturation, the subsequent postoperative radiographic appearance should remain unchanged after a suitable period of time for resolution of any transitory radiographic changes.
   ii. If the radiolucent area is decreasing in size or not enlarging and the tooth is asymptomatic, healing is considered to be incomplete, and additional follow-up visits with radiographic or digital radiographic images are indicated.
   iii. If a tooth had a preoperative periradicular radiolucency, the follow-up radiographs or digital radiographic images should optimally demonstrate an intact lamina dura and a normal periodontal ligament space around the root(s) under observation.
   iv. There may be periradicular bone healing without reformation of a normal periodontal ligament space.

7. Avulsion (Exarticulation)

Indications for Treatment

Treatment is indicated when a tooth is completely separated from its alveolus.

Procedure

Immediate care is directed toward timely replantation of the avulsed tooth. The patient should be referred to his or her physician to evaluate the need for a tetanus booster if the avulsed tooth has come into contact with soil or if tetanus coverage is uncertain.

- ***The following pertains to teeth with less than one hour of extra-oral dry time or teeth transported in an acceptable transport medium.***

  Immediate care. Without compromising the root surface, rinse the tooth with sterile saline. Irrigate the tooth socket and gently replace the tooth into its normal position. Stabilize, if necessary, by splinting to adjacent teeth using a nonrigid splint; stabilize for the appropriate time to allow reattachment of periodontal ligament fibers. Systemic antibiotics are advisable.

  Definitive care. For immature teeth with wide open apices, pulpal revascularization may occur and definitive care consists of monitoring on a regular basis for evidence of pulpal revascularization and continued root formation. For immature teeth in which revascularization does not take place, apexification procedures are followed by nonsurgical root canal treatment.

For mature teeth, timely nonsurgical root canal treatment that includes intracanal procedures to minimize resorption is indicated following replantation. Primary teeth are not suitable for replantation.

- ***The following pertains to teeth with greater than one hour of extra-oral dry time.***

  Immediate care. Remove debris and necrotic periodontal ligament from the root surface, immerse the tooth in a sodium fluoride solution, flush the socket with saline to remove coagulum and gently replace the tooth into its normal position. Stabilize, if necessary, by splinting to adjacent teeth using a nonrigid splint; stabilize for the appropriate time to allow reattachment of periodontal ligament fibers. Systemic antibiotics are advisable. The patient should be referred to his or her physician to evaluate the need for a tetanus booster if the avulsed tooth has come into contact with soil or if tetanus coverage is uncertain.

  Definitive care. For mature teeth, timely nonsurgical root canal treatment that includes intracanal procedures to minimize resorption is indicated following replantation.

  Permanent teeth with immature apices and an extra-oral dry time of greater than one hour are not suitable for replantation.

Objectives

a. To establish revascularization in teeth with immature root development.
b. To achieve re-attachment of periodontal ligament fibers and establish a normal periodontal ligament space.
c. To re-establish a fully functioning tooth.
d. To alleviate present and prevent future adverse clinical signs or symptoms.
e. To create the radiographic appearance of a well-obturated root canal system where the root canal filling extends as close as possible to the apical constriction of each canal. Gross overextension, underfilling in the presence of patent canals, ledges and perforations should be avoided.
f. To maintain health and/or promote healing and repair of periradicular tissues:
   i. If a tooth had a normal periodontal ligament space and an intact lamina dura surrounding the root(s) at the time of obturation, the subsequent postoperative radiographic appearance should remain unchanged after a suitable period of time for resolution of any transitory radiographic changes.
   ii. If the radiolucent area is decreasing in size or not enlarging and the tooth is asymptomatic, healing is considered to be incomplete, and additional follow-up visits with radiographic or digital radiographic images are indicated.
   iii. If a tooth had a preoperative periradicular radiolucency, the follow-up radiographs or digital radiographic images should optimally demonstrate an intact lamina dura and a normal periodontal ligament space around the root(s) under observation.
   iv. There may be periradicular bone healing without reformation of a normal periodontal ligament space.

If nonsurgical endodontic treatment is required:

a. To create the radiographic appearance of a well-obturated root canal system, as close as possible to the apical constriction of each canal. Gross overextension or underfilling in the presence of patent canals, ledges and perforations should be avoided.
b. To remove root canal contents.
c. To promote healing and repair of periradicular tissues.
d. To prevent further breakdown of periradicular tissues:
   i. If a tooth had a normal periodontal ligament space and an intact lamina dura surrounding the root(s) at the time of obturation, the subsequent postoperative radiographic appearance should remain unchanged after a suitable period of time for resolution of any transitory radiographic changes.
   ii. If the radiolucent area is decreasing in size or not enlarging and the tooth is asymptomatic, healing is considered to be incomplete, and additional follow-up visits with radiographic or digital radiographic images are indicated.
   iii. If a tooth had a preoperative periradicular radiolucency, the follow-up radiographs or digital radiographic images should optimally demonstrate an intact lamina dura and a normal periodontal ligament space around the root(s) under observation. There may be periradicular bone healing without reformation of a normal periodontal ligament space.
   iv. Periradicular surgery may become indicated.

8. Alveolar Fracture Involving Teeth

Indications for Treatment

Treatment is indicated when there is an alveolar fracture that involves the socket of the tooth.

Procedure

Immediate care. Requires reduction of the fractured alveolar segment and rigid splinting for an appropriate period of time.

Definitive care. Involves the evaluation of the pulpal status of the associated teeth and completing nonsurgical root canal treatment when indicated.

Objectives

a. To achieve satisfactory healing of the alveolar fracture.
b. To provide nonsurgical root canal treatment when indicated.

(See the Recommended Guidelines of the American Association of Endodontists for the Treatment of Traumatic Dental Injuries *for specific information.)*

SELECTED REFERENCES:
Management of Traumatic Dental Injuries

Andersson L, Bodin I, Sorensen S. Progression of root resorption following replantation of human teeth after extended extraoral storage. Endod Dent Traumatol 1989;5:38.

Andreasen FM. Histological and bacteriological study of pulps extirpated after luxation injuries. Endod Dent Traumatol 1988;4:170.

Andreasen FM. Pulpal healing after luxation injuries and root fracture in the permanent dentition. Endod Dent Traumatol 1989;5:111.

Andreasen FM. Transient apical breakdown and its relation to color and sensibility changes after luxation injuries to teeth. Endod Dent Traumatol 1986;2:9.

Andreasen FM, Andreasen JO. Resorption and mineralization processes following root fracture of permanent incisors. Endod Dent Traumatol 1988;4:202.

Andreasen FM, Andreasen JO. Treatment of traumatic dental injuries: a shift in strategy. Tandlaegebladet 1989;93(12):450-7.

Andreasen FM, Andreasen JO. Treatment of traumatic dental injuries. Shift in strategy. Int J Technol Assess Health Care 1990;6(4):588-602.

Andreasen FM, Andreasen JO, Bayer T. Prognosis of root-fractured permanent incisors—prediction of healing modalities. Endod Dent Traumatol 1989;5:11.

Andreasen FM, Daugaard-Jensen J. Treatment of traumatic dental injuries in children. Curr Opin Dent 1991;1(5):535-50.

Andreasen FM, Daugaard-Jensen J. Treatment of traumatic dental injuries in children. Tandlaegernes Tidsskr 1992;(3):76-89.

Andreasen FM, Pedersen BV. Prognosis of luxated permanent teeth—the development of pulp necrosis. Endod Dent Traumatol 1985;1:207.

Andreasen FM, Steinhardt U, Bille M, Munksgaard EC. Bonding of enamel-dentin crown fragments after crown fracture. An experimental study using bonding agents. Endod Dent Traumatol 1993;9:111.

Andreasen FM, Zhijie Y, Thomsen BL. Relationship between pulp dimensions and development of pulp necrosis after luxation injuries in the permanent dentition. Endod Dent Traumatol 1986;2:90.

Andreasen JO, Andreasen FM. [Biology of traumatic dental injuries]. Tandlaegebladet 1989;93(11):385-92.

Andreasen JO, Andreasen FM, Skeie A et al. Effect of treatment delay upon pulp and periodontal healing of traumatic dental injuries — a review article. Dent Traumatol 2002;18(3):116-28.

G. Intracoronal Bleaching

Indications for Treatment

An intracoronal bleaching procedure is indicated for a tooth that has *both* of the following clinical conditions:

a. The tooth is discolored from an internal source.
b. Acceptable root canal treatment has been performed if possible.

Procedure

The intracoronal bleaching procedure uses oxidizing agents within the coronal portion of an endodontically treated tooth to remove tooth discoloration. Dental dam isolation is essential. The degree of restoration to a normal color and return of the coronal translucency is dependent upon the cause, severity and duration of the discoloration.

To reduce the potential for resorption, a cement barrier must be placed to minimize penetration of the oxidizing agent into dentinal tubules in the cervical area. The use of heat in combination with 30% hydrogen peroxide should be avoided.

Objectives

a. To alleviate present and prevent future adverse clinical signs or symptoms.
b. To reduce or eliminate discoloration.
c. To improve the degree of translucency.
d. To minimize potential resorption.

SELECTED REFERENCES:
Intracoronal Bleaching

Abbott PV. Aesthetic considerations in endodontics: internal bleaching. Pract Periodontics Aesthet Dent 1997;9(7):833-40; quiz 42.

Baumgartner JC, Reid DE, Pickett AB. Human pulpal reaction to the modified McInnes bleaching technique. J Endod 1983;9:527.

Casey LJ, Schindler WG, Murata SM et al. The use of dentinal etching with endodontic bleaching procedures. J Endod 1989;15(11):535-8.

Castellucci A. Bleaching on endodontically treated teeth. Attual Dent 1987;3(35):14-6.

Cohen S, Parkins FM. Bleaching tetracycline stained vital teeth. Oral Surg Oral Med Oral Pathol 1970;29:465.

Crane DL. The walking bleach technique for endodontically treated teeth. CDS Rev 1984;77(1):49-51.

Demarco FF, Freitas JM, Silva MP et al. Microleakage in endodontically treated teeth: influence of calcium hydroxide dressing following bleaching. Int Endod J 2001; 34(7):495-500.

Frazier KB. Nightguard bleaching to lighten a restored, nonvital discolored tooth. Compend Contin Educ Dent 1998;19(8):810-3.

Freccia WF, Peters DD, Lorton L, Bernier WE. An *in vitro* comparison of nonvital bleaching techniques in the discolored tooth. J Endod 1982;8:70.

Friedman S, Potstein I, Libfeld H, Stabholz A, Heling I. Incidence of external root resorption and esthetic results in 58 bleached pulpless teeth. Endod Dent Traumatol 1988;4:23.

Fuss Z, Szajkis S, Tagger M. Tubular permeability to calcium hydroxide and to bleaching agents. J Endod 1989;15(8):362-4.

Goon WW, Cohen S, Borer RF. External cervical root resorption following bleaching. J Endod 1986;12(9):414-8.

Harrington G, Natkin E. External resorption associated with bleaching of pulpless teeth. J Endod 1979;5:344.

Hansen-Bayless J, Davis R. Sealing ability of two intermediate restorative materials in bleached teeth. Am J Dent 1992;5(3):151-4.

Heller D, Skriber J, Lin LM. Effect of intracoronal bleaching on external cervical root resorption. J Endod 1992;18(4):145-8.

Ho S, Goerig AC. An *in vitro* comparison of different bleaching agents in the discolored tooth. J Endod 1989;15:106.

Lado EA. Bleaching of endodontically treated teeth: an update on cervical resorption. Gen Dent 1988;36(6):500-1.

SELECTED REFERENCES:
Intracoronal Bleaching continued

Lado E, Stanley HR, Weisman M. Cervical resorption in bleached teeth. Oral Surg Oral Med Oral Pathol 1983;55:78.

Madison S, Walton R. Cervical root resorption following bleaching of endodontically treated teeth. J Endod 1990;16:570.

Montgomery S. External cervical resorption after bleaching a pulpless tooth. Oral Surg Oral Med Oral Pathol 1984;57:203.

Nutting EB, Poe GS. A combination for bleaching teeth. J South Calif Dent Assoc 1963;32:289.

Rivera EM, Vargas M, Ricks-Williamson L. Considerations for the aesthetic restoration of endodontically treated anterior teeth following intracoronal bleaching. Pract Periodontics Aesthet Dent 1997;9:117.

Rotstein I. Role of catalase in the elimination of residual hydrogen peroxide following tooth bleaching. J Endod 1993;19(11):567-9.

Rotstein I, Friedman S, Mor C, Katznelson J, Sommer M, Bab I. Histological characterization of bleaching-induced external root resorption in dogs. J Endod 1991;17:436.

Rotstein I, Lewinstein I, Zuwabi O et al. Effect of cervical coating of ethyl cellulose polymer and metacrylic acid copolymer on the radicular penetration of hydrogen peroxide during bleaching. Endod Dent Traumatol 1992;8(5):202-5.

Rotstein I, Torek Y, Lewinstein I. Effect of bleaching time and temperature on the radicular penetration of hydrogen peroxide. Endod Dent Traumatol 1991;7(5):196-8.

Rotstein I, Torek Y, Misgav R. Effect of cementum defects on radicular penetration of 30% H_2O_2 during intracoronal bleaching. J Endod 1991;17(5):230-3.

Spasser HF. A simple bleaching technique using sodium perborate. NY State Dent J 1961;27:332.

Suarez JA, Segade LA, Varela G et al. Bleaching of endodontically treated teeth. Stoma (Lisb) 1988;1(10):43-4, 7-8, 51.

Swift EJ, Jr. Treatment of a discolored, endodontically treated tooth with home bleaching and composite resin. Pract Periodontics Aesthet Dent 1992;4(3):19-21.

Walton RE, O'Dell NL, Myers DL, Lake FT, Shimp RG. External bleaching of tetracycline stained teeth in dogs. J Endod 1982;8:536.

Warren K. Bleaching discoloured endodontically treated teeth. Restorative Dent 1985;1(5):132, 4, 6.

Weiger R, Hahn R. The conservative management of a discolored pulpless premolar: a case report. Quintessence Int 1994;25(3):191-3.

H. Restoration of Endodontically Treated Teeth

1. Post (Dowel)

Indications for Treatment

Post placement is indicated if *both* of the following clinical conditions exist:

a. The remaining coronal tooth structure is inadequate for the retention of a restoration.
b. When there is sufficient root length to accommodate the post while maintaining an adequate apical seal.

Procedure

Following nonsurgical root canal treatment, a post space is created in the root canal by careful removal of the coronal canal obturating material. A sufficient amount of material must be retained in the apical portion of the canal to maintain an adequate apical seal. A custom or proprietary post is fitted and cemented into the root canal for core retention. The post should be passively retained and is cemented and/or bonded into place so that no voids exist between the post and the surrounding tooth structure and root canal filling material. Preparation of the post space and placement of the post should be accomplished using an aseptic technique with dental dam isolation.

Objectives

a. To retain the core restoration.
b. To place the post along the long axis of the root.
c. To avoid perforations or root fractures.
d. To preserve the apical seal.
e. To eliminate any space between the post and the surrounding tooth structure or root canal filling material.
f. To place the post in root structure that is supported by bone.
g. To minimize contamination of the root canal system during the procedure.

2. Core

Indications for Treatment

Core restorations are indicated if *any* of the following clinical conditions exist:

a. The replacement of missing coronal tooth structure is necessary.
b. When the enhanced retention and resistance to displacement of the final restoration is necessary.

Procedure

The core material fills the pulp chamber and the coronal portions of the obturated root canal spaces, enhances the coronal seal and replaces missing coronal tooth structure in an endodontically treated tooth prior to the placement of the final restoration. The core may be constructed with a variety of acceptable materials and may or may not be used in conjunction with posts.

Objectives

a. To provide retention for the final restoration.
b. To occupy the entire pulp chamber with the core when possible.
c. The core does not perforate the pulp chamber floor.
d. To eliminate space between the core and the root canal filling material.

3. Posterior Teeth

It is recommended that endodontically treated posterior teeth be restored with a full cuspal protective restoration. The restoration should protect the remaining tooth structure and provide a coronal seal.

4. Anterior Teeth

Restoration of an endodontically treated anterior tooth is based on its clinical condition. Choice of the final restoration should be based on esthetic and functional requirements. The restoration should protect the remaining tooth structure and provide a coronal seal.

SELECTED REFERENCES:
Restoration of Endodontically Treated Teeth

Aquilino SA, Caplan DJ. Relationship between crown placement and the survival of endodontically treated teeth. J Prosthet Dent 2002;87(3):256-63.

Assif D, Gorfil C. Biomechanical considerations in restoring endodontically treated teeth. J Prosthet Dent 1994;71:565.

Barkhordar RA, Kempler D. Microleakage of endodontic access cavities restored with composites. J Calif Dent Assoc 1997;25(3):215-8.

Berutti E. Microleakage of human saliva through dentinal tubules exposed at the cervical level in teeth treated endodontically. J Endod 1996;22(11):579-82.

Bolhuis HPB, De Gee AJ, Feilzer AJ et al. Fracture strength of different core build-up designs. Am J Dent 2001;14(5):286-90.

Boschian Pest L, Cavalli G, Bertani P et al. Adhesive post-endodontic restorations with fiber posts: push-out tests and SEM observations. Dent Mater 2002;18(8):596-602.

Boucher Y, Matossian L, Rilliard F et al. Radiographic evaluation of the prevalence and technical quality of root canal treatment in a French subpopulation. Int Endod J 2002;35(3):229-38.

Brandal JL, Nicholls JI, Harrington GW. A comparison of three restorative techniques for endodontically treated anterior teeth. J Prosthet Dent 1987;58:161.

Cooley RL, Robbins JW, Barnwell S. Dimensional stability of glass ionomer used a core material. J Prosthet Dent 1990;64:651.

Cooney JP, Caputo AA, Trabert KC. Retention and stress distribution of tapered-end endodontic dowels. J Prosthet Dent 1986;55:540.

Cormier CJ, Burns DR, Moon P. *In vitro* comparison of the fracture resistance and failure mode of fiber, ceramic, and conventional post systems at various stages of restoration. J Prosthodont 2001;10(1):26-36.

Eskitascioglu G, Belli S, Kalkan M. Evaluation of two post core systems using two different methods (fracture strength test and a finite elemental stress analysis). J Endod 2002;28(9):629-33.

Ferrari M, Vichi A, Garcia-Godoy F. Clinical evaluation of fiber-reinforced epoxy resin posts and cast post and cores. Am J Dent 2000;13(Spec No):15B-8B.

Fradeani M, Aquilano A, Barducci G. Aesthetic restoration of endodontically treated teeth. Pract Periodontics Aesthet Dent 1999;11(7):761-8; quiz 70.

SELECTED REFERENCES:
Restoration of Endodontically Treated Teeth continued

Fredriksson M, Astback J, Pamenius M et al. A retrospective study of 236 patients with teeth restored by carbon fiber-reinforced epoxy resin posts. J Prosthet Dent 1998;80(2):151-7.

Freeman MA, Nicholls JI, Kydd WL et al. Leakage associated with load fatigue-induced preliminary failure of full crowns placed over three different post and core systems. J Endod 1998;24(1):26-32.

Fuss Z, Lustig J, Katz A et al. An evaluation of endodontically treated vertical root fractured teeth: impact of operative procedures. J Endod 2001;27(1):46-8.

Gish SP, Drake DR, Walton RE, Wilcox L. Coronal leakage: bacterial penetration through obturated canals following post preparation. J Am Dent Assoc 1994;125:1369.

Gutmann JL, Tidwell E. Restoring endodontically treated teeth. Tex Dent J 1997;114(10):14-23.

Guzy GE, Nicolls JI. *In vitro* comparison of intact endodontically treated teeth with and without endo-post reinforcement. J Prosthet Dent 1979;42:39.

Hansen EK. *In vivo* cusp fracture of endodontically treated premolars restored with MOD amalgam or MOD resin fillings. Dent Mater 1988;4:169.

Heydecke G, Butz F, Strub JR. Fracture strength and survival rate of endodontically treated maxillary incisors with approximal cavities after restoration with different post and core systems: an *in-vitro* study. J Dent 2001;29(6):427-33.

Ho HH, Chu FC, Stokes AN. Fracture behavior of human mandibular incisors following endodontic treatment and porcelain veneer restoration. Int J Prosthodont 2001;14(3):260-4.

Hoag EP, Dwyer TG. A comparative evaluation of three post and core techniques. J Prosthet Dent 1982;47:177.

Jensen ME, Redford DA, Williams BT, Gardner F. Posterior etched-porcelain restorations: an *in vitro* study. Compend Contin Educ Dent 1987;8:615.

Kimmel SS. Restoration of endodontically treated tooth containing wide or flared canal. N Y State Dent J 2000;66(10):36-40.

Kwan EH, Harrington GW. The effect of immediate post preparation on apical seal. J Endod 1981;7:325.

Leary JM, Aquilino SA, Svare CW. An evaluation of post length within the elastic limits of dentin. J Prosthet Dent 1987;57:277.

SELECTED REFERENCES:
Restoration of Endodontically Treated Teeth continued

Mannocci F, Bertelli E, Sherriff M et al. Three-year clinical comparison of survival of endodontically treated teeth restored with either full cast coverage or with direct composite restoration. J Prosthet Dent 2002;88(3):297-301.

Martelli R. Fourth-generation intraradicular posts for the aesthetic restoration of anterior teeth. Pract Periodontics Aesthet Dent 2000;12(6):579-84; quiz 86-8.

Mattison GD, Delivanis PD, Thacker RW, Jr., Hassell KJ. Effect of post preparation on the apical seal. J Prosthet Dent 1984;51:785.

Nayyar A, Walton RE, Leonard LA. An amalgam coronal-radicular dowel and core technique for endodontically treated posterior teeth. J Prosthet Dent 1980;44:511.

Neagley RL. The effect of dowel preparation on the apical seal of endodontically treated teeth. Oral Surg Oral Med Oral Pathol 1969;28:739.

Patierno JM, Rueggeberg FA, Anderson RW et al. Push-out strength and SEM evaluation of resin composite bonded to internal cervical dentin. Endod Dent Traumatol 1996;12(5):227-36.

Pilo R, Cardash HS, Levin E et al. Effect of core stiffness on the *in vitro* fracture of crowned, endodontically treated teeth. J Prosthet Dent 2002;88(3):302-6.

Portell FR, Bernier WE, Lorton L, Peters DD. The effect of immediate versus delayed dowel space preparation on the integrity of the apical seal. J Endod 1982;8:154.

Ray HA, Trope M. Periapical status of endodontically treated teeth in relation to the technical quality of the root filling and the coronal restoration. Int Endod J 1995;28(1):12-8.

Reeh ES, Douglas WH, Messer HH. Stiffness of endodontically-treated teeth related to restoration technique. J Dent Res 1989;68:1540.

Reeh ES, Messer HH, Douglas WH. Reduction in tooth stiffness as a result of endodontic and restorative procedures. J Endod 1989;15:512.

Robbins JW. Restoration of the endodontically treated tooth. Dent Clin North Am 2002;46(2):367-84.

Robbins JW, Cooley RL, Barnwell S. Fracture resistance of reinforced glass ionomer as a buildup material. Oper Dent 1990;15:23.

Sorensen JA, Engelman MJ. Effect of post adaptation on fracture resistance of endodontically treated teeth. J Prosthet Dent 1990;64:419.

Sorensen JA, Engelman MJ. Ferrule design and fracture resistance of endodontically treated teeth. J Prosthet Dent 1990;63:529.

SELECTED REFERENCES:
Restoration of Endodontically Treated Teeth continued

Sorensen JA, Martinoff JT. Clinically significant factors in dowel design. J Prosthet Dent 1984;52:28.

Sorensen JA, Martinoff JT. Intracoronal reinforcement and coronal coverage: a study of endodontically treated teeth. J Prosthet Dent 1984;51:780.

Stampalia LL, Nicholls JI, Brudvik JS. Fracture resistance of teeth with resin-bonded restorations. J Prosthet Dent 1986;55:694.

Standlee JP, Caputo AA, Collard EW, Pollack MH. Analysis of stress distribution by endodontic posts. Oral Surg Oral Med Oral Pathol 1972;33:952.

Standlee JP, Caputo AA, Hanson EC. Retention of endodontic dowels: effects of cement, dowel length, diameter, and design. J Prosthet Dent 1978;39:400.

Stockton L, Lavelle CL, Suzuki M. Are posts mandatory for the restoration of endodontically treated teeth? Endod Dent Traumatol 1998;14(2):59-63.

Taleghani M, Leinfelder KF. Evaluation of a New Glass Ionomer Cement with Silver as a Core Buildup under a Cast Restoration. Chicago: Quintessence Int, 1988;19:19.

Trabert KC, Caputo AA, Abou-Rass M. Tooth fracture—A comparison of endodontic and restorative treatments. J Endod 1978;4:341.

Tronstad L, Asbjornsen K, Doving L et al. Influence of coronal restorations on the periapical health of endodontically treated teeth. Endod Dent Traumatol 2000;16(5):218-21.

Trope M, Maltz DO, Tronstad L. Resistance to fracture of restored endodontically treated teeth. Endod Dent Traumatol 1985;1:108.

Trope M, Tronstad L. Resistance to fracture of endodontically treated premolars restored with glass ionomer cement or acid etch composite resin. J Endod 1991;17:257.

Vermilyea SG, Gardner FM, Moergeli JR Jr. Composite dowels and cores: effect of moisture on the fit of cast restorations. J Prosthet Dent 1987;58:429.

Wendt SL Jr, Harris BM, Hunt TE. Resistance to cusp fracture in endodontically treated teeth. Dent Mater 1987;3:232.

Yang HS, Lang LA, Molina A et al. The effects of dowel design and load direction on dowel-and-core restorations. J Prosthet Dent 2001; 85(6):558-67.

Zmener O. Effect of dowel preparation on the apical seal of endodontically treated teeth. J Endod 1980;6:687.

I. Post/Post and Core Removal

Indications for Treatment

The removal of a post, post and core, or core restoration is indicated if *any* of the following clinical conditions exist:

a. Loss of adequate retention.
b. Recurrent caries associated with the existing post, core or both.
c. Fracture of the post, core or both.
d. When access to the root canal system for nonsurgical retreatment is necessary.

Procedure

Posts and cores are removed in a variety of ways. These methods must be applied in a judicious manner to minimize the potential for damage to the root and the adjacent teeth and tissues.

Objectives

a. To alleviate present and prevent future adverse clinical signs or symptoms.
b. To remove the entire post.
c. To avoid root fractures or perforations.
d. To minimize damage to the tooth, adjacent teeth or tissues.

SELECTED REFERENCES:
Post/Post and Core Removal

Abbott PV. Incidence of root fractures and methods used for post removal. Int Endod J 2002;35(1):63-7.

Abramovitz L, Lev R, Fuss Z et al. The unpredictability of seal after post space preparation: a fluid transport study. J Endod 2001;27(4):292-5.

Altshul JH, Marshall G, Morgan LA et al. Comparison of dentinal crack incidence and of post removal time resulting from post removal by ultrasonic or mechanical force. J Endod 1997;23(11):683-6.

Berbert A, Filho MT, Ueno AH et al. The influence of ultrasound in removing intraradicular posts. Int Endod J 1995;28(1):54-6.

Castrisos T, Abbott PV. A survey of methods used for post removal in specialist endodontic practice. Int Endod J 2002;35(2):172-80.

de Rijk WG. Removal of fiber posts from endodontically treated teeth. Am J Dent 2000;13(Spec No):19B-21B.

Dixon EB, Kaczkowski PJ, Nicholls JI et al. Comparison of two ultrasonic instruments for post removal. J Endod 2002;28(2):111-5.

Gaffney JL, Lehman JW, Miles MJ. Expanded use of the ultrasonic scaler. J Endod 1981;7:228.

Gerstein H, Weine FS. Specially prepared burs to remove silver cones and fractured dowels. J Endod 1977;3:408.

Gettleman BH, Spriggs KA, El Deeb ME et al. Removal of canal obstructions with the Endo Extractor. J Endod 1991;17(12):608-11.

Gomes AP, Kubo CH, Santos RA et al. The influence of ultrasound on the retention of cast posts cemented with different agents. Int Endod J 2001;34(2):93-9.

Goon WW. Efficient amalgam core elimination and root preservation with ultrasonic instrumentation. J Prosthet Dent 1992;68(2):261-4.

Johnson WT, Leary JM, Boyer DB. Effect of ultrasonic vibration on post removal in extracted human premolar teeth. J Endod 1996;22(9):487-8.

Machtou P, Sarfati P, Cohen AG. Post removal prior to retreatment. J Endod 1989;15(11):552-4.

Rovatti L, Dallari A. Removal of root canal prefabricated posts for orthograde endodontic retreatment. Attual Dent 1990;6(24):26-30, 2-4.

SELECTED REFERENCES:
Post/Post and Core Removal continued

Sakkal S. Carbon-fiber post removal technique. Compend Contin Educ Dent Suppl 1996;20):S86.

Saunders EM, Saunders WP. The heat generated on the external root surface during post space preparation. Int Endod J 1989;22(4):169-73.

Smith BJ. Removal of fractured posts using ultrasonic vibration: an *in vivo* study. J Endod 2001;27(10):632-4.

Stamos DE, Gutmann JL. Revisiting the post puller. J Endod 1991;17:466.

Takashina M, Ebihara A, Sunakawa M et al. The possibility of dowel removal by pulsed Nd:YAG laser irradiation. Lasers Surg Med 2002;31(4):268-74.

Williams VD, Bjorndal AM. The Masserann technique for the removal of fractured posts in endodontically treated teeth. J Prosthet Dent 1983;49(1):46-8.

Wu MK, Pehlivan Y, Kontakiotis EG et al. Microleakage along apical root fillings and cemented posts. J Prosthet Dent 1998;79(3):264-9.

Yoshida T, Gomyo S, Itoh T et al. An experimental study of the removal of cemented dowel-retained cast cores by ultrasonic vibration. J Endod 1997;23(4):239-41.

AAE Endodontic Case Difficulty Assessment Form and Guidelines

PATIENT INFORMATION

Name_____

Address_____

City/State/Zip_____

Phone_____

DISPOSITION

Treat in Office: Yes ☐ No ☐

Refer Patient to:

_____

Date:_____

Guidelines for Using the AAE Endodontic Case Difficulty Assessment Form

The AAE designed the Endodontic Case Difficulty Assessment Form for use in endodontic curricula. The Assessment Form makes case selection more efficient, more consistent and easier to document. Dentists may also choose to use the Assessment Form to help with referral decision making and record keeping.

Conditions listed in this form should be considered potential risk factors that may complicate treatment and adversely affect the outcome. Levels of difficulty are sets of conditions that may not be controllable by the dentist. Risk factors can influence the ability to provide care at a consistently predictable level and impact the appropriate provision of care and quality assurance.

The Assessment Form enables a practitioner to assign a level of difficulty to a particular case.

LEVELS OF DIFFICULTY

MINIMAL DIFFICULTY	Preoperative condition indicates routine complexity (uncomplicated). These types of cases would exhibit only those factors listed in the MINIMAL DIFFICULTY category. Achieving a predictable treatment outcome should be attainable by a competent practitioner with limited experience.
MODERATE DIFFICULTY	Preoperative condition is complicated, exhibiting one or more patient or treatment factors listed in the MODERATE DIFFICULTY category. Achieving a predictable treatment outcome will be challenging for a competent, experienced practitioner.
HIGH DIFFICULTY	Preoperative condition is exceptionally complicated, exhibiting several factors listed in the MODERATE DIFFICULTY category or at least one in the HIGH DIFFICULTY category. Achieving a predictable treatment outcome will be challenging for even the most experienced practitioner with an extensive history of favorable outcomes.

Review your assessment of each case to determine the level of difficulty. If the level of difficulty exceeds your experience and comfort, you might consider referral to an endodontist.

AAE Endodontic Case Difficulty Assessment Form

Criteria and Subcriteria	Minimal Difficulty	Moderate Difficulty	High Difficulty
A. PATIENT CONSIDERATIONS			
Medical history	☐ No medical problem (ASA Class 1*)	☐ One or more medical problems (ASA Class 2*)	☐ Complex medical history/serious illness/disability (ASA Classes 3-5*)
Anesthesia	☐ No history of anesthesia problems	☐ Vasoconstrictor intolerance	☐ Difficulty achieving anesthesia
Patient disposition	☐ Cooperative and compliant	☐ Anxious but cooperative	☐ Uncooperative
Ability to open mouth	☐ No limitation	☐ Slight limitation in opening	☐ Significant limitation in opening
Gag reflex	☐ None	☐ Gags occasionally with radiographs/treatment	☐ Extreme gag reflex which has compromised past dental care
Emergency condition	☐ Minimum pain or swelling	☐ Moderate pain or swelling	☐ Severe pain or swelling
B. DIAGNOSTIC AND TREATMENT CONSIDERATIONS			
Diagnosis	☐ Signs and symptoms consistent with recognized pulpal and periapical conditions	☐ Extensive differential diagnosis of usual signs and symptoms required	☐ Confusing and complex signs and symptoms: difficult diagnosis ☐ History of chronic oral/facial pain
Radiographic difficulties	☐ Minimal difficulty obtaining/interpreting radiographs	☐ Moderate difficulty obtaining/interpreting radiographs (*e.g.*, high floor of mouth, narrow or low palatal vault, presence of tori)	☐ Extreme difficulty obtaining/interpreting radiographs (*e.g.*, superimposed anatomical structures)
Position in the arch	☐ Anterior/premolar ☐ Slight inclination (<10°) ☐ Slight rotation (<10°)	☐ 1st molar ☐ Moderate inclination (10-30°) ☐ Moderate rotation (10-30°)	☐ 2nd or 3rd molar ☐ Extreme inclination (>30°) ☐ Extreme rotation (>30°)
Tooth isolation	☐ Routine rubber dam placement	☐ Simple pretreatment modification required for rubber dam isolation	☐ Extensive pretreatment modification required for rubber dam isolation
Morphologic aberrations of crown	☐ Normal original crown morphology	☐ Full coverage restoration ☐ Porcelain restoration ☐ Bridge abutment ☐ Moderate deviation from normal tooth/root form (*e.g.*, taurodontism, microdens) ☐ Teeth with extensive coronal destruction	☐ Restoration does not reflect original anatomy/alignment ☐ Significant deviation from normal tooth/root form (*e.g.*, fusion, dens in dente)
Canal and root morphology	☐ Slight or no curvature (<10°) ☐ Closed apex (<1 mm in diameter)	☐ Moderate curvature (10-30°) ☐ Crown axis differs moderately from root axis. Apical opening 1-1.5 mm in diameter	☐ Extreme curvature (>30°) or S-shaped curve ☐ Mandibular premolar or anterior with 2 roots ☐ Maxillary premolar with 3 roots ☐ Canal divides in the middle or apical third ☐ Very long tooth (>25 mm) ☐ Open apex (>1.5 mm in diameter)
Radiographic appearance of canal(s)	☐ Canal(s) visible and not reduced in size	☐ Canal(s) and chamber visible but reduced in size ☐ Pulp stones	☐ Indistinct canal path ☐ Canal(s) not visible
Resorption	☐ No resorption evident	☐ Minimal apical resorption	☐ Extensive apical resorption ☐ Internal resorption ☐ External resorption
C. ADDITIONAL CONSIDERATIONS			
Trauma history	☐ Uncomplicated crown fracture of mature or immature teeth	☐ Complicated crown fracture of mature teeth ☐ Subluxation	☐ Complicated crown fracture of immature teeth ☐ Horizontal root fracture ☐ Alveolar fracture ☐ Intrusive, extrusive or lateral luxation ☐ Avulsion
Endodontic treatment history	☐ No previous treatment	☐ Previous access without complications	☐ Previous access with complications (*e.g.*, perforation, non-negotiated canal, ledge, separated instrument) ☐ Previous surgical or nonsurgical endodontic treatment completed
Periodontal-endodontic condition	☐ None or mild periodontal disease	☐ Concurrent moderate periodontal disease	☐ Concurrent severe periodontal disease ☐ Cracked teeth with periodontal complications ☐ Combined endodontic/periodontic lesion ☐ Root amputation prior to endodontic treatment

*American Society of Anesthesiologists (ASA) Classification System

Class 1: No systemic illness. Patient healthy.
Class 2: Patient with mild degree of systemic illness, but without functional restrictions, *e.g.*, well-controlled hypertension.
Class 3: Patient with severe degree of systemic illness which limits activities, but does not immobilize the patient.
Class 4: Patient with severe systemic illness that immobilizes and is sometimes life threatening.
Class 5: Patient will not survive more than 24 hours whether or not surgical intervention takes place.

www.asahq.org/clinical/physicalstatus.htm