Chapter 10--Endodontics

Overview

Introduction

The following material is presented to help orient the clinician to sound endodontic principles recommended by the IHS Endodontic Consultants. The contents represent prevailing techniques and biological treatment rationale. Endodontics is currently undergoing a rapid phase of instrument and material development. Questions regarding this area are best dealt with by calling one or more of the Endodontic Consultants.

The common problems clinicians encounter continue to stem from the areas of diagnosis, tooth morphology, and cleaning and shaping techniques. Successful endodontics demands thorough diagnosis, a complete knowledge of the anatomy of the canal systems being treated, complete debridement of the canal systems, careful shaping techniques which provides for complete obturation and a coronal seal provided by a final permanent restoration. Consequently, considerable effort has been made toward addressing these areas. Again, please contact one or more endodontic consultants if further information is required.

This chapter will cover the following topics:

Tooth Morphology

Introduction

The following descriptions are to serve as an aid to visualize teeth three dimensionally. Anatomic anomalies are listed by tooth type.

Maxillary Central Incisor

In the maxillary central incisor, multiple canals are rare, but the incidence of lateral canals is high (nonvital incisors often present with lateral root radiolucencies). The apical foramen is rarely located at the exact apex but is usually found laterally and within 2 mm of the apex.

Always make a triangular access to thoroughly remove the pulp horn tissue (a common cause of coronal discoloration). Use a large Gates Glidden Drill (e.g., #5 or 6) to remove the lingual cervical ledge at the cemento-enamel junction (CEJ) area.

Maxillary Lateral Incisor

The apical portion of the root frequently curves toward the distal or distal-palatal. The apical foramen is more frequently found on the anatomic apex than the central incisor, but may vary from 1 to 2 mm from the apex. Multiple canals are rare. Anomalies may include the following:

- **Dens-in-dente.** Dens-in-dente can predispose these teeth to lingual caries and pulpal involvement. These cases are often complicated to access and treat.

- **Developmental grooves.** Developmental grooves are more frequent on the lateral incisors but can occur on central incisors also. If the tooth is nonvital and has a vertical periodontal defect adjacent to the groove which extends to the apical region, the case is generally considered to have a hopeless prognosis. If the tooth is vital and there is only limited periodontal pocketing adjacent to the groove, periodontal therapy which includes removing the groove with rotary instruments can maintain these cases.

Maxillary Canine

Most canines have working lengths of 25 mm or longer. There is frequent curvature in the apical 3 mm which can occur in any direction. The apical foramen is usually close to the anatomic apex but may be positioned laterally, especially when apical curvature is present. While rare, multiple canals can occur.

Maxillary First Premolar

The maxillary first premolar is most commonly bi-rooted, possessing two canals approximately 75 percent of the time. Apical curvature is common, frequently to the distal. Variations of the radicular forms include the following:

- two separate roots
- fused roots with separate canals
- fused roots with interconnections or "webbing"
- fused roots with a common apical foramen
- three-rooted tooth (unusual but possible)

  Note: The incidence of three canals with three foramen is approximately 6 percent.

The palatal canal is more frequently missed. It is imperative to take a working length film from a mesial or distal angulation to determine the presence and lengths of the canals.

These teeth have a high incidence of developing vertical fractures, commonly on the mesial root surface, due to the cervical "figure 8" shape of the root. Maxillary premolars must receive proper restorations following endodontic therapy to protect them from fracturing.

Maxillary Second Premolar

Radicular morphology may present two separate canals anastomosing to a single canal, or two canals with interconnections or "webbing." Approximately 75 percent have one canal at the

apex, 24 percent have two canals and two foramina, and 1 percent had three foramina. Apical curvature is common. Like the first premolar, this tooth requires coronal coverage to protect from cuspal or crown/root fractures.

Maxillary First Molar

The maxillary first molar has the highest endodontic failure rate of any posterior tooth. The tooth has three roots:

- **Palatal root.** The palatal root is the longest. It frequently curves toward the buccal in the apical third. In cross-section the canal is flat and ribbon-like, requiring attention to the "feel" of the instruments during cleaning and shaping. Due to the buccal curvature of the palatal root, careful determination of the working length will prevent over instrumentation and overfilling.

- **Distal-buccal root.** The distal-buccal root is generally conical and straight, but may curve in the apical 3 mm.

- **Mesial-buccal (MB) root.** The mesial-buccal root is undoubtedly the most difficult root to treat. At least 50 percent will have two canals (with one or two apical foramina). A recent study by Kulild indicated that histologically a second mesial-lingual (ML) canal was contained in the coronal half of 95.2 percent of the MB roots examined. It was demonstrated that when utilizing a careful "unroofing" of the ML orifice with slow-speed round burs, generally at a depth of only 0.5 to 2 mm, the orifice could be identified with an endodontic explorer an additional 30 percent of the time. This elusive canal (the ML) lies in a groove on the chamber floor which runs from the MB canal orifice to the palatal orifice. It is important to use the endodontic explorer (instead of a small file) to identify and determine patency of the "4th" canal.

  Additional time and patience must be given to negotiating this canal with small instruments and careful enlargement.

  Note: As with any small canal, the use of a lubricating agent (e.g., R.C. Prep) a #8 file and a light touch are very helpful during the initial instrumentation.

As with the premolars, a horizontally-shifted working-length film aids in determining the presence and length of the canal(s) in the MB root and the location of the foramen on the palatal root. The mesial-palatal furcation results in a cervical concavity which occasionally results in a perforation during access preparation and location of the MB orifice(s).

[1]Kulild, J.C. and Peters, D.D. "Incidence and Configuration of Canal Systems in the Mesiobuccal Root of Maxillary First and Second Molars." Journal of Endodontics 16:311, 1990.

Maxillary Second Molar

Due to early loss of the maxillary first molar, the second molar may function as the first molar. This tooth is similar in form to the first molar, but generally is slightly smaller. The buccal roots may be closer together and be difficult to identify on radiograph since they may be superimposed over the palatal root. The buccal orifices may be closer together with the distal orifice lying in a near straight line between the mesial-buccal and palatal orifices. The presence of a forth canal in the MB root is common.

Mandibular Central and Lateral Incisors

The mandibular central and lateral incisors are narrow and flat in the labial-lingual dimension. This frequently results in a ribbon or figure 8-shaped canal. The incidence of two canals can range up to 40 percent, but most will join in a single foramen. The additional canal is the most common reason for endodontic failure of these teeth. The foramen most commonly exits on the anatomic apex. Apical curvature is common.

To inspect for the additional canal structure you should--

- extend the ovoid access toward the lingual aspect of the canal
- use the DG-16 explorer to feel for a lingual canal orifice.

Caution: You should exercise extreme care during access and shaping to avoid perforation which occurs often with access burs and Gates Glidden drills.

Mandibular Canine

In the mandibular canines the occurrence of two roots is rare but can occur. The access form is ovoid and should be adequate to fully debride the canal (which is considerably broader in the labial-lingual dimension than in the mesial-distal). This is generally true of **all** canals.

If there are two canals, one will generally be easier to instrument. If two canals are suspected, care must be taken to identify both and negotiate/enlarge them together. Instrumenting one and then trying to find the second most commonly results in blockage and failure to treat the second canal. Careful flaring coronally from the orifices will allow easier obturation.

Mandibular First Premolar

While most clinicians consider the first premolar to have a single canal, studies have shown that approximately 25 percent can possess two canals at the apex. The information presented for the mandibular canine applies to the mandibular premolars which have two canals.

A relatively frequent anomaly of the mandibular premolars (which is often bilateral and may also involve the maxillary premolars) is dens evaginatus which manifests as an extra "cusp" located in the center of the occlusal surface. Microscopic exposure of the pulp can occur via--

- attrition
- fracture
- restoration of this area resulting in a nonvital pulp or (rarely) the development of internal resorption

Pain and swelling of this area can pose a diagnostic challenge for the clinician. Sinus tracts occurring on the buccal mucosa of the mandibular posterior area, when traced with a gutta percha cone, will identify the "intact" premolar with dens evaginatus as the source of the infection.

Mandibular Second Premolar

These teeth are very similar to the mandibular first premolar. The presence of two canals is approximately 12 percent, although Vertucci showed that approximately 8 percent had one apical canal.

The frequent presence of lateral or accessory canals can manifest clinically as lateral radiolucencies. An important consideration is the presence of the mental foramen's position near the apex of the second premolar. Use pulp tests to determine vitality and radiographs to locate the presence of the mental foramen.

Mandibular First Molar

These teeth most commonly have two roots, but may have three:

- **Mesial root.** The mesial root has two canals.

- **Distal root.** The distal root can have one or two canals. To determine the presence of two distal canals, take a horizontally-angled radiograph with two files in the distal canal, one on the buccal and one on the lingual. If they remain separate, there are two canals. The incidence of four canals is approximately 35 percent. The distal canal is usually broad buccal-lingually. The apical foramen often exits to the distal aspect of the distal root.

Mandibular Second Molar

The mandibular second molar is usually somewhat smaller than the first. The roots tend to be more symmetrical and may be closer together or even fused. The incidence of four canals is similar to the first molar and always should be ruled out, especially when the distal orifice is

ribbon shaped. Occasionally the roots will fuse and form what is termed a "C-shaped" canal system. These teeth will have a single orifice on the chamber floor which extends from the mesial to the distal (often from the mesial-lingual to the mesial-buccal), to the buccal, continuing to the distal-buccal, and terminating in the distal-lingual area (although this may be reversed to the lingual).

Endodontic Diagnosis

Introduction

Incomplete diagnosis results in additional clinical visits, continued pain and suffering, loss of patient confidence, and possible inappropriate treatment. It is imperative that a thorough diagnosis be performed on each case. Careful attention to the patient's symptoms is required. Once the tooth is identified, the pulpal, periradicular, periodontal, and restorative status all must be evaluated and documented.

Diagnosis

To perform a thorough endodontic diagnosis of a patient, you should perform--

- a complete medical and dental history of the patient
- a physical examination (to include periapical tests, pulpal tests, periodontal tests, and a search for cracked and fractured teeth)
- a radiographic examination
- special tests as necessary

Each of these major activities are discussed separately on the following pages.

Health History

Introduction

Before treating a patient, it is important to determine the past medical and dental history of the patient.

Medical History

A succinct yet thorough review of the medical history should take place at the beginning of each visit. If there are any questions about systemic or mental ailments that might affect the treatment you plan for your patient, you should consult with your patient's physician.

Dental History

To perform a thorough dental history of the patient, you should--

- review the past dental history
- review the patient's chief complaint
- review aspects of pain
  - **Nature of pain.** Identifying the nature of the pain can help to differentiate pain of dental origin from pain stemming from other tissues. Pain which is very indicative of endodontic pathosis is irreversible in nature, intense, spontaneous, and continuous.
  - **Referred pain.** Referred pain is most commonly manifested in other teeth in the same or opposing quadrant. It almost never crosses the midline of the head. However, referred pain is not necessarily limited to other teeth. It may be unilaterally referred to the preauricular area, down the neck, or up to the temporal region. In these cases the source of the referred pain is almost always a posterior tooth.
  - **Pain of nonodontogenic origin.** Pain of nonodontogenic origin includes pain from a broad range of sources:
    - organic (e.g., sinus disease and tumor)
    - functional (e.g., myofacial pain dysfunction and TMJ dysfunction)
    - vascular (e.g., migraine headache)
    - neurological (e.g., trigeminal neuralgia)
    - psychological

Extraoral Examination

Extraoral Examination Procedures

Follow these steps to perform a thorough extraoral examination.

Step	Action
1	Observe the patient's coloring.
2	Observe for facial asymmetry or distention.

	Note: These are indicative of swelling of odontogenic origin or systemic disease.
3	Observe the patient's eyes for dilation or constriction. **Note:** These are indicative of systemic disease, premedication, or fear.

Intraoral Examination

Intraoral Examination Procedures

Follow these steps to perform a thorough intraoral examination.

Step	Action	
1	Perform a soft tissue examination as follows:	
	Substep	**Action**
	a	Dry each area to be examined.
	b	Look for changes in the following: • color • contour • consistency **Note:** The presence of a sinus tract may indicate that a periapical suppuration has resulted from pulp that has undergone necrosis in at least one root. All sinus tracts should be traced with a gutta percha point to locate their source since occasionally the source can be remote.
2	Examine the dentition for the following: • discoloration • fractures • abrasions • erosion • caries • large restorations **Note:** All of these can be clues to the offending tooth. (For example, a discolored anterior crown is often pathognomonic of pulpal disease or may be the sequela of earlier root canal therapy.)	

Periradicular Tests

Percussion Test

A percussion test does not give an indication of the health or integrity of the pulp tissue; it only indicates whether there is inflammation around the periodontal ligament.

Percussion Test (Responses)

A positive response to percussion can be caused by a variety of factors:

- teeth undergoing rapid orthodontic movement
- high restoration
- periodontal disease
- partial or total necrosis of the pulp (that has inflamed the PDL)

Palpation Test

The index finger is rolled while pressing the mucosa against the underlying bone. If the mucoperiosteum is inflamed, this motion will reveal the existence and the degree of sensitivity caused by the periapical inflammation. If a site that feels tender to palpation is found, its location and extent should be recorded as well as whether or not the area is soft or firm. This provides important information on the possible need for incision and drainage.

Palpation Test (Responses)

A positive palpation test indicates inflammation in periapical tissues into the bone and mucosa in the apical region.

Pulpal Tests

Thermal Tests

The response to thermal tests often provides information about whether the pulp is healthy or inflamed.

Caution: Response to a stimulus does not guarantee a pulp's vitality or its health, but only indicates the presence of some nerve fibers capable of carrying sensory impulses.

To obtain reliable information, similar tooth types should be tested and compared. Additional

meaningful information can be obtained when stimuli similar to those that provoke pain in the teeth are used during the clinical tests. You must carefully explain the procedures involved and sensations expected during each test to the patient. Teeth to be tested should be isolated and dried with 2 by 2-inch gauze.

Thermal Tests (Responses)

The following responses typically occur:

- Thermal testing on a vital tooth usually results in a sharp sensation of pain. This response may occur regardless of pulp status (normal, reversible, or irreversible pulpitis).
- When the response becomes more intense and prolonged, this is indicative of irreversible pulpitis.
- Teeth with necrotic pulps for the most part will not respond to thermal stimulation.

Electric Pulp Test

Warning: If the patient's medical history indicates that a cardiac pacemaker has been implanted, the use of an electric pulp tester is contraindicated.

The electric pulp tester is designed to stimulate a response by exciting the neural elements within the pulp. It does **not** provide information about the tooth's vascular supply which is the real determinant of vitality.

Electric Pulp Test responses

False positive and negative results often occur.

- The main reasons for **false positive responses** are as follows:
  - conductor/electrode contact with large metal restoration or gingiva allows current to reach the attachment apparatus
  - patient anxiety
  - liquefaction necrosis (may conduct current to the attachment apparatus)
  - failure to isolate and dry the teeth
- The main reasons for **false negative responses** are as follows:

- patient heavily premedicated with analgesics, narcotics, alcohol, or tranquilizers
- inadequate contact with enamel (i.e., insufficient conductor or contact with composite restoration)
- recently traumatized tooth
- excessive calcification of pulp chamber
- recently erupted tooth with immature apex
- partial necrosis

Periodontal Evaluation

Introduction

When the periodontium is involved it must be determined whether the condition is of--

- endodontic origin
- periodontal origin
- a combination of both

In endodontic diagnosis the vitality of the tooth in question should be determined first.

Determining the Origin of the Condition

If:

- the pulp is vital, then it may be ruled out as the source of the problem
- the pulp is necrotic or partially vital, then it is either the cause of the problem or a contributing source
- radiographically, when only a portion of the root is involved or if the furcation is involved when the mesial and distal crestal bone is intact, an endodontic lesion is suspected
- the defect can be probed, it is usually a narrow tubular defect as compared to a wider

periodontal defect, an endodontic origin is suspected

- the gingiva is inflamed and bone loss is widespread and present on adjacent teeth, periodontal disease is suspected

- upon probing, plaque or calculus is encountered and the defect is diffuse and crater-like, periodontal treatment may be indicated. If the defect is of periodontal origin, the tooth will probably test within normal limits.

Treatment Planning

If both periodontal disease and endodontic disease are present, endodontic therapy should be completed first followed by periodontal therapy as soon as possible. If periodontal therapy is completed first and the endodontic lesion is not treated, the defect may not heal. If the endodontic therapy is adequate, the prognosis rests with the periodontal therapy.

Radiographic Evaluation

Introduction

Multiple diagnostic radiographs, taken from various angles, should be interpreted carefully. You should not automatically anticipate radiographic change in a tooth when examining a patient in pain.

- Soft tissue changes in the pulp will not appear on a radiograph.

- Not all periapical lesions will appear on a radiograph. A lesion must involve the cortical plate to be detected on a radiograph.

- Once a lesion does appear on a radiograph, the actual area involved and the amount of bony destruction are greater than the extent shown on the film.

Evaluating the Radiograph

For purposes of discussion, consider dividing the radiograph into a coronal and a radicular segment. Then evaluate their contributions to endodontic diagnosis.

Coronal Aspect Features

Consider the following features when examining the coronal aspect of the radiograph:

- the relationship of the pulp horns to the existing restoration or caries

- the presence of prior pulp cap or pulpotomy
- the presence of retrogressive changes of the pulp chamber (e.g., recession, resorption, or pulp stones)

  Note: Pulp stones are not always pathologic.

- crestal bone levels and the presence of calculus
- often canals separate at the coronal root level, so additional canals can be detected here

Radicular Aspect Features

Consider the following features when examining the radicular aspect of the radiograph:

- separated roots
- position of the canal within the root
- root pathology (e.g., calcification, resorption, and fracture)
- periapical pathology including osteosclerosis and condensing osteitis
- intracanal aberrations resulting from previous treatment (e.g., ledging, perforations, and instrument fragments)
- location and type of radiolucency (A lateral radiolucency may indicate a large lateral canal. A teardrop or "J" shaped radiolucency may indicate a linear fracture.)

Angulated Radiographs

Additional angulated radiographs can be indispensable in locating additional roots and canals. The following are some examples of their usage:

- When a canal disappears abruptly near the apex on a straight-line radiograph, it should be presumed that the canal is branching into extra canals. This can often be verified by an additional angulated film.
- Normal anatomical landmarks may appear as pathosis when their image is superimposed on an apex. Additional radiographs at different angles will show that these landmarks change position. If in fact periapical pathosis does exist, its radiographic image will not change from its apical position in the various radiographs.

Special Tests

Introduction

Occasionally the following tests are indicated to provide additional diagnostic information:

- test cavity
- caries removal
- selective anesthesia
- transillumination

Test Cavity

When other tests are inconclusive (especially on fully crowned or splinted teeth) a test cavity can be performed without the use of local anesthesia. A small preparation is made into the lingual surface of an anterior tooth or the occlusal surface of a posterior tooth. If the tooth is vital, the patient will experience pain as the bur nears the dentino-enamel junction. A necrotic or inflamed pulp will not yield a comparable response.

Caries Removal

Determining if a tooth is reversibly or irreversibly inflamed may be difficult. Caries removal should be performed to determine the extent of the disease process (i.e., clinical exposure requiring root canal therapy or extraction or no exposure with placement of a sedative restoration).

Selective Anesthesia

Selective anesthesia is useful in diagnosing painful teeth particularly when the patient cannot isolate the offender to a specific arch. To test within the maxillary arch, anesthesia should be from anterior to posterior because of anatomic distribution of the nerve fibers. Studies have shown that the PDL injection does not predictably anesthetize a single tooth. This method should **not** be used to identify a suspected tooth.

Transillumination

Transillumination with fiber optics is useful in diagnosing cracked or fractured teeth. Do not use the operatory light during transillumination to increase the contrast and efficiency of the fiber optic light. Remove the restoration, dry the prep, place the light source on the buccal and lingual cervical areas, and examine closely for crack lines in the dentin.

Cracked and Fractured Teeth

Introduction

Searching for cracked and fractured teeth is an important but difficult part of the patient's physical examination. Structural cracks may result from occlusal or accidental trauma and restorative procedures. A vertical fracture may result in a periapical lesion that fails to resolve after a root canal filling and apical surgery.

Definition

A **structural crack** is a break or split in the continuity of the tooth surface without a perceptible separation.

Diagnosing Structural Cracks

Structural cracks deep in the dentin and close to or involving the pulp are a perplexing cause of dental pain. The crack cannot be wedged, separated, or seen on a radiograph, although it may be a precursor to a fracture. Structural cracks by definition involve the dentin approaching the pulp.

Structural cracks may be symptomatic or asymptomatic with the exact etiology difficult to establish. Symptoms may include the following:

- The pain is erratic, occurring inconsistently on mastication.
- The patient is unable to describe the complaint clearly or precisely.

Confirming a Structural Crack

Confirmation tests may include--

- a bite test
- removal of restoration and use of disclosing dye
- transillumination
- responsive testing (including the use of thermal or electric stimuli and percussion to determine the need for root canal therapy)

Structural cracks in denting must be removed. If the crack extends into the pulp, endodontic therapy is indicated. If the crack is noted on the floor of the pulp chamber, the case is usually

hopeless. If you are not sure about the prognosis, perform a complete pulpectomy, reduce the tooth from occlusion, cement an orthodontic band and observe to determine whether the pain to mastication resolves. If so, complete the endodontic therapy and restore the tooth with a full cuspal-coverage restoration (but not a crown). If the tooth remains asymptomatic for several months, then a crown can be placed, but the patient must understand that the long-term prognosis is questionable.

Bite Test

Teeth with structural cracks often are not percussion sensitive, but do exhibit pain to chewing. A bite test with either a cotton-tipped applicator, or a device like the Tooth Slooth, will produce a positive response. The device should be placed in the central groove area, plus on individual cusps, and tested for pain during or after biting.

Treatment Planning for a Structural Crack

Emergency treatment: Place a full cuspal-coverage restoration which reduces the occlusal stress in centric and lateral movements. This will reduce the pain and prevent progression of the crack.

Note: Special consideration should be given during root canal therapy. Excessive condensation forces should be avoided, and the use of posts is not advised.

Diagnosing Vertical Fractures

If a patient continually complains of pain when chewing or pain with horizontal tapping of the crown, a vertical fracture should be suspected. These symptoms can develop at anytime before, during, or after endodontic therapy. A tooth with a periapical lesion that fails to resolve after proper root canal therapy and apical surgery should be suspected of having a vertical root fracture.

Vertical crown/root fracture should be part of the differential diagnosis when conventional periodontal therapy does not resolve a sulcular defect. When an isolated sulcular defect persists in spite of repeated attempts to correct it and while surrounding teeth remain periodontally sound, a vertical fracture could be implicated.

Reflecting full thickness mucoperiosteal flap with the aid of a strong fiber optic light may reveal a fracture line. This procedure is especially helpful when the tooth in question has been covered with a full crown.

Treatment Planning for a Vertical Fracture

Extraction is required if the etiology is a vertical fracture of a single-rooted tooth or a mesial-distal fracture of a multi-rooted mandibular tooth.

Pulpal Diagnosis

Pulpal Diagnostic Terminology

The following terminology is used when discussing pulpal conditions:

- normal pulp
- reversible pulpitis
- irreversible pulpitis
- necrotic pulp

Normal Pulp

The conditions associated with normal pulp are--

- moderate response to pulp stimuli
- response subsides when stimulus is removed
- tooth is free of spontaneous symptoms
- radiograph shows an intact lamina dura

Reversible Pulpitis

The conditions associated with reversible pulpitis are--

- sharp thermal response (especially to cold)
- asymptomatic unless provoked by external stimulus
- most commonly caused by defective restoration, restorative procedures, or by dental caries

Irreversible Pulpitis

The conditions associated with irreversible pulpitis are--

- prolonged response to temperature change
- spontaneous episodes of pain
- pain from change in posture
- intense throbbing pain

Necrotic Pulp

The conditions associated with necrotic pulp are--

- the possible result of an untreated pulpitis or trauma
- total necrosis usually asymptomatic until the periodontal ligament (PDL) is affected
- no response to pulp vitality tests
- the crown will darken occasionally with anterior teeth
- possible combination of responses from multirooted teeth

Periradicular Diagnosis

Periradicular Diagnostic Terminology

The following periradicular conditions can be detected using the periradicular tests:

- acute apical periodontitis
- acute apical abscess
- chronic apical periodontitis
- Phoenix Abscess
- periapical osteosclerosis

Acute Apical Periodontitis

The conditions associated with acute apical periodontitis are--

- local inflammation of the periapical tissues

- tenderness with percussion
- disease which may occur with vital and nonvital teeth (pulp tests must be performed.)
- periodontal ligament which may appear normal or slightly widened

Acute Apical Abscess

The conditions associated with acute apical abscess are--

- an advanced form of apical periodontitis from a necrotic tooth
- it may appear normal or with a widened PDL radiographically
- moderate to severe pain
- rapid onset of swelling
- some degree of swelling with extreme tenderness to percussion and palpation
- patient may be febrile
- differential diagnosis--lateral periodontal abscess (vital pulp)

Chronic Apical Periodontitis

The conditions associated with chronic apical periodontitis are--

- usually asymptomatic but sometimes tender to percussion and palpation
- nonresponsive to pulp vitality tests
- periapical radiolucency
- possibly associated with a sinus tract (if so then this is known as Suppurative Apical Periodontitis)

Phoenix Abscess

The conditions associated with Phoenix Abscess are--

- chronic apical periodontitis that becomes acute

- symptoms identical to acute apical abscess
- periapical radiolucency
- possible following treatment of a necrotic tooth

Periapical Osteosclerosis

The conditions associated with periapical osteosclerosis are--

- low-grade, relatively asymptomatic inflammation of the periapical tissues
- present with varied symptoms sometimes
- often found in posterior teeth of young people
- well-circumscribed radiopacity around root apices

If periapical osteosclerosis is asymptomatic and it responds to pulp vitality tests, root canal therapy is not needed.

Endodontic Emergencies

Introduction

General dentists at IHS facilities will often be responsible for treating/managing endodontic emergencies. This section discusses the diagnosis and treatment of common endodontic emergencies and the treatment techniques used in the management of these emergencies.

Diagnosis

The key to successful management of endodontic emergencies is to correctly diagnose the etiology and provide efficient treatment. The majority of symptomatic teeth are relatively easy to diagnose.

Wait-and-Watch Approach

Occasionally, the patient and you will be unable to identify the offending tooth. Under these circumstances it is often judicious to use wait-and- watch approach. If the condition worsens to

a true irreversible pulpitis and once the inflammatory process spreads to the periodontium, the tooth can be localized and treatment provided. If you are unsure of the diagnosis or source of the symptoms, give the case more time. This is also true for cases in which there is borderline reversible/irreversible pulpitis. If you are still uncertain of the pulpal status after performing the appropriate clinical tests, perform palliative therapy and give the case time to resolve.

Generally, a wait-and-watch approach is recommended when the following conditions are present:

- short-term sensitivity or discomfort for a few days
- a history with any of the following conditions:
  - recent dental treatment
  - gingival recession
  - loss of restoration
  - possible coronal fracture

Pulpal Diagnosis and Treatment

Reversible Pulpitis

With reversible pulpitis the pulp is inflamed and removal of the causative factors will alleviate the patient's discomfort. These factors may be--

- a high restoration
- incipient or recurrent caries
- a fractured cusp
- a fractured restoration
- exposed cervical dentinal tubules

Recommended Treatment for Reversible Pulpitis

Sedative restorations (or full coronal coverage with a cusp-protected amalgam or a temporary crown in the cuspal fracture case) should allow the pulp to recover and the symptoms to subside.

If the symptoms persist for weeks, the patient may desire to proceed with endodontic therapy to be pain free. A calcium hydroxide liner and a reinforced ZOE temporary is still the recommended sedative restoration.

Irreversible Pulpitis

Cases of irreversible pulpitis can be localized or nonlocalized. As was stated, when unable to localize, the wait-and-watch approach is the best plan. The patient should be informed that you are doing this in his/her best interest and are not refusing treatment.

Recommended Treatment for Irreversible Pulpitis

Treatment of irreversible pulpitis involves removal of the bulk of inflamed tissue (especially when there is pain on percussion).

- Incisors, canines, and most bicuspids are best treated with a pulpectomy.

  Warning: A poorly performed pulpectomy may result in increased inflammation and possible ledging.

- A vital multicanaled bicuspid or molar (especially those with small and tortuous canals) may be best treated with a pulpotomy. One option is to perform a pulpectomy on the larger canals (palatal or distal) and leave the radicular pulpal tissue in the smaller canals. However, in vital cases with acute percussion pain, a complete pulpectomy is indicated. Copious amounts of irrigant (sodium hypochlorite)small files used in a serial sequence #8 through #20, RC Prep and an **accurate working length** are utilized to chemo-mechanically clean the tissue from the canals.

Necrotic Teeth

Unlike teeth with vital pulp, necrotic tissue must be completely removed from the canal system.

Recommended Treatment for Necrotic Teeth

The recommended treatment for teeth with necrotic pulp is a pulpectomy. There are two methods for performing a pulpectomy on an emergency visit:

- **Method A:** The ideal method is to obtain accurate working lengths and instrument the canals to their apical constrictions. However, the demands of our emergency clinics may not allow the practitioner adequate time to determine working lengths and instrument the canals. While the use of electronic apex locators can be an efficient and accurate adjunct, many clinics do not possess them.

- **Method B:** Due to these restrictions, an alternate pulpectomy method is suggested. This method involves canal debridement slightly short of the root length.

The procedures for performing each of these methods follow.

Method A Procedures

When conditions allow, perform the following steps:

Step	Action
1	Establish proper access to all canals
2	Irrigate thoroughly with NaOCl.
3	Debride pulp chamber.
4	Debride the coronal and middle portions of the root canal with Flex-R (or other safety tip)-files **Note:** Use copious NaOCl irrigation and RC Prep while performing this step.
5	Determine accurate working lengths with radiographs and or apex locator.
6	Complete canal debridement and initial shaping. **Caution:** Do **not** force debris apically and avoid ledging
7	Dry canals with paper points, syringe Calcium Hydroxide down into canals and temporarily seal the access opening. **Note:** Commercially available Calcium Hydroxide in syringes is the easiest, most effective and safest method of placement

Method B Procedures

Perform the following steps when unable to use Method A:

Step	Action
1	Establish proper access to all canals.
2	Irrigate thoroughly with NaOCl.
3	Debride pulp chamber.
4	Use an accurate start film (e.g., XCP) to estimate tooth length
5	Debride the coronal and middle portions of the root canal with Flex-R (or other safety tip) files. Stay 2 to 3 mm short of the estimated root length. Use small files #8 #10 with a gentle watchwind motion and RC Prep. Do not file against resistance or search for a binding point. Avoid ledging ! **Note:** Use copious NaOCl irrigation and RC Prep while performing this step.

6	Dry canals with paper points, syringe Calcium Hydroxide down into canals and temporarily seal the access opening. **Note:** Commercially available Calcium Hydroxide in syringes is the easiest, most effective and safest method of placement.

Using Intracanal Medications and Temporaries

Introduction

The use of traditional intracanal medicaments such as formocreosol or CMCP has decreased in popularity over the past decade. The general reason is the level of toxicity (inflammatory potential) versus the effectiveness of the medication.

Calcium Hydroxide

Currently, calcium hydroxide is the recommended intracanal medicament. This can be either a commercial preparation or USP calcium hydroxide powder mixed in either sterile saline or anesthetic. Calcium hydroxide is a very good antimicrobial agent due to its pH.

IRM

IRM is recommended for temporarily sealing the canal system during endodontic treatment due to its durability. While Cavit provides a good seal in the short-term, it does not possess the compressive strength to stand up to mastication forces. Once the canal system has been debrided, protection from coronal leakage is imperative. If a delay in completion of the endodontic therapy is anticipated a more durable temporary such as Glass ionomer or bonded composite should be considered.

Treating Flare-Ups After Initiation of Endodontic Therapy

Introduction

Patients may return to the emergency clinic with continued pain after initial therapy has been provided. Symptoms associated with flare-ups include the following:

- thermal sensitivity
- percussion pain
- swelling

A review of each of these symptoms, their causes, and recommended treatment follows.

Thermal Sensitivity

Symptoms indicating a reversible or irreversible pulpitis after initiation of endodontic therapy suggests another tooth. However, this pain may, to the patient, manifest as referred pain to another tooth.

Treatment: Repeat the diagnostic tests to identify the source. However, if the initially-treated tooth contained vital tissue, consider the possibility of a missed canal.

Percussion Pain

Confirm the source of the pain. If it is from the initially treated tooth, possible causes could be--

- occlusal prematurity
- inadequate debridement
- overinstrumentation
- periapical extension of infected pulpal debris
- resistant infection
- missed canal
- vertical fracture

Treatment: Unless the symptoms are mild and consistent with normal posttreatment discomfort, the tooth should be reaccessed. At this point it is recommended to determine the actual working length(s) and fully debride the tooth (if not originally done). Unless excessive drainage is obtained from the tooth, close the access with a temporary seal after recleaning. Do not leave the tooth open in anticipation of drainage since it only allows the cleaned canal system to rapidly become reinfected with oral pathogens.

Swelling

Confirm the source of the infection.

Treatment: The tooth should be reaccessed to ensure complete debridement. A small (#10 or #15) K-file can be gently passed 1 to 2 mm through the apical foramen to ensure

patency and check for drainage through the tooth. This should be done using an apex locator to determine when you pass through the foramen first with a #8 file then the #10 and finally the #15. RC prep is a great aid in obtaining an accurate working length with the apex locator as well as preventing canal blockage. Aggressive instrumentation through the apical foramen is never indicated.

Emergency Treatment by Symptoms

Acute Alveolar Abscesses

Patients with acute alveolar abscesses require effective emergency treatment. Again, the goal is to provide the most effective treatment while causing the least harm.

Treatment Options

Treatment options include--

- apical trephination
- incision and drainage (I&D)
- cortical trephination

The selection of the treatment option is dependent upon various factors. The treatment of periradicular pain is determined by the severity of the signs and symptoms and the necessity for establishing a drainage route. These are discussed in detail on the following pages.

Mild to Moderate Pain Without Intraoral/Extraoral Swelling

Patients with mild to moderate pain and no evidence of intraoral or extraoral swelling generally are best treated with chemo-mechanical debridement of the root canal system and, if necessary, apical trephination.

Apical trephination: Gently pass a #15 or #20 K-file 1 to 2 mm through the apical foramen to ensure patency. This will allow periapical drainage if present. Be sure that the #8, and #10 pass first to prevent a blockage or ledge with the #15 and #20.

Warning: Under no conditions is aggressive intentional overinstrumentation indicated.

Patients with more severe symptoms, with or without intraoral or extraoral swelling, require more aggressive treatment.

Moderate to Severe Pain With Intraoral Swelling

Patients with moderate to severe pain and intraoral swelling need to be categorized depending on the type of swelling.

- Patients with localized, fluctuant swelling respond rapidly to incision and drainage (I&D).

- Patients with more diffuse swelling also respond to I&D but not as rapidly. If the swelling is diffuse and not indurated (cellulitis), delay the I&D procedure for 24 hours and prescribe antibiotics, analgesics, moist heat compresses, and intraoral warm saline rinses to localize the swelling.

Caution: Patients with diffuse swelling must be monitored closely since these cases can escalate quickly. If the swelling continues to spread, refer the patient to an oral surgeon immediately. Do **not** attempt to manage these cases yourself. These patients may require immediate hospitalization and aggressive antibiotic therapy, followed with complicated I&D procedures.

Patients with intraoral swelling that are not medically compromised do not need antibiotic therapy if the swelling is localized and there are no symptoms of systemic involvement. Medically compromised patients (especially diabetic patients) should receive immediate presurgical antibiotics. For both categories, you should--

- initiate analgesic therapy prior to the emergency surgical procedure if possible

- access and chemo-mechanically debride the tooth

- perform I&D

- perform apical trephination to check for residual drainage in the apical area

  Note: Once discernible intraoral swelling has developed, apical trephination alone is not adequate to effectively treat the condition.

Moderate to Severe Pain With Intraoral and Extraoral Swelling

Patients with moderate to severe pain and with intraoral and extraoral swelling are treated the same as those with only intraoral swelling, but because of the extraoral swelling, they need to have antibiotic therapy initiated immediately. Establishing drainage is absolutely necessary. During the I&D procedure, it may be necessary to extensively probe with an instrument (hemostat or curette) into tissues to open the spaces and allow isolated infection pockets to drain. With proper drainage and effective antibiotic therapy, resolution of the patient's signs and symptoms should be apparent in the first 24 hours.

Moderate to Severe Pain Without Swelling

Patients with moderate to severe pain, but no intraoral or extraoral swelling have a different problem. They are in acute pain, but the absence of swelling does not allow establishment of drainage via I&D. The absence of swelling indicates that the inflammatory exudate has not perforated the alveolar cortical plate. In these cases, the involved tooth should be--

- accessed
- chemo-mechanically debrided
- apically trephinated

Cortical trephination may be indicated if there is no drainage through the canal(s) and the degree of pain dictates.

Medically compromised patients who are susceptible to bacteremia should receive prophylactic antibiotic coverage prior to I&D, apical trephination, or cortical trephination procedures.

Incision and Drainage

Introduction

Incision and drainage (I&D) is used in treating acute alveolar abscesses. Prior to starting this surgical procedure, you should initiate antibiotic therapy on--

- medically compromised patients
- healthy patients exhibiting signs of a spreading infection (e.g., extraoral swelling, elevated temperature, or lymphadenopathy)

Also, initiating analgesic therapy prior to surgical treatment will allow the drug to reach peak serum levels prior to the loss of anesthesia.

Procedures for I&D

The following steps are used to complete an I&D:

Step	Action
1	Obtain anesthesia with nerve blocks.

	Note: Additional anesthesia can be obtained with infiltration. Inject anesthesia peripheral to the swollen area but not into the swollen tissues. **Caution:** The latter would only be painful, not produce anesthesia, and potentially spread the infection into surrounding tissues.
2	Make a horizontal (not vertical) incision along the inferior base of the swelling so that gravity can assist in the drainage. **Note:** A #11 or #15 scalpel blade is directed through the mucoperiosteal tissues until it contacts bone. Forewarn the patient that he may experience increased pain as the incision reaches the largest pocket of infection. This is temporary and will subside in approximately 5 minutes. This is often the case in large, fluctuant intraoral swellings and is likely due to relaxation of pressure on the distended tissues causing stimulation of the sensory nerves.
3	Obtain a sample of exudate for culturing and sensitivity testing (especially in medically compromised patients).
4	Probe into the wound. **Note:** When the swelling is localized and fluctuant, the majority of exudates is easily obtained. However, in more diffuse swellings, probing and opening tissue spaces with a hemostat or curette will increase the effectiveness of the procedure.

Use of Drains

The use of drains following an I&D procedure is a controversial subject. According to Gutmann and Harrison, patients with localized or diffused intraoral swelling do not require drains following the I&D procedure. They state that healing will occur more rapidly without the presence of the drain. The tissues should be allowed to close at their normal wound-healing pace, which is about 24 to 48 hours. The use of warm saline rinses and any residual drainage will keep the surgical opening patent until it is appropriate for the tissues to close. They further state that a drain is only indicated in cases with moderate to severe cellulitis and other positive signs of an aggressive infective process.

Practically speaking, there is a tendency for the general practitioner to not incise the area adequately for drainage. Too small of an incision is made, and the incision is not carried through the periosteum. If you feel that a drain is indicated, a Penrose drain should be placed to the depth of the incision and anchored with a suture. The drain should be left in place for 24 to 48 hours.

[2]Gutmann, J.L. and Harrison. Surgical Endodontics. J.W., Blackwell Scientific Publications, 1991.

Cortical Trephination

Introduction

Patients with moderate to severe pain, but no intraoral or extraoral swelling require drainage of periradicular exudate to alleviate acute symptoms. The treatment of choice is apical trephination. In some cases, apical trephination may not be possible (e.g., ledged, curved, or blocked canals). The next choice for treatment would be cortical trephination.

The procedure involves an incision through mucoperiosteal tissues, exposure of the surface of cortical bone, penetration of the cortex, and access to the periapical tissues.

Warning: ***This procedure should only be performed by practitioners with adequate experience since clinical judgment is necessary to prevent damage to and involvement with anatomic structures.*** The maxillary sinus and the neurovascular contents of the mandibular canal and the mental foramen must be avoided.

The cortical trephination site is determined by radiographic and clinical examination. Apical trephination approaches directed toward the apex of the tooth are not recommended. One must operate through thicker tissues and there is the possibility of penetrating the root with the bur. The site should be at the midroot level in the interdental bone which is between the roots of adjacent teeth. The mesial or distal area which provides the most space between the roots is selected.

Procedures for Cortical Trephination

The following steps are used to complete a cortical trephination (after initiating analgesic therapy and antibiotic therapy, if indicated):

Step	Action
1	Obtain anesthesia with nerve blocks or infiltration.
2	Make a horizontal or vertical incision at the midroot interdental area. The incisional site is separated with a periosteal elevator
3	Attempt to tunnel under the periosteum with the elevator (Woodsen periosteal elevator) to the vicinity of the root apex.
4	Attempt to perforate the apical cortical bone with a Woodsen elevator. If the infection is close to the surface of the cortical plate, you often can perforate this area with the elevator. Flush the area with copious amounts of saline, then close with sutures. **Note:** If you cannot perforate the apical cortex, you will need to use a handpiece. The cortical bone in this area is penetrated with a #6 or #8 bur at a

	high-speed (or straight surgical if available) utilizing copious sterile saline irrigation. Use careful tactile sense to note when the resistance of the cortical plate is lost indicating that the bur has entered cancellous (trabecular) bone. If unsure of the location, place a sterile piece of lead foil from a radiographic packet in the anticipated perforation area and expose a radiograph. Insert a sterile new #40 or 45 K-file (not a Hedstrom) into the cancellous bone and extend it into the vicinity of the periradicular tissues. **Note:** It is not necessary to place the instrument exactly to the end of the root. The length that the file is extended should be calculated from the radiographs.
5	Take a radiograph to confirm that the instrument has penetrated into the periradicular region of the involved tooth. Be sure to use a throat pack and floss tied through file handle to prevent aspiration of file. **Note:** There will be no evidence of purulent drainage. Bleeding will occur and this provides the drainage necessary for the symptoms to resolve over the next 12 hours.
6	Flush the area with saline.
7	Close the surgical wound with sutures. **Note:** The maxillary anterior area is the least challenging area for this procedure. The maxillary posterior area and the mandibular teeth present special anatomic considerations.

Leaving Teeth Open

Introduction

The goal of endodontics is to debride the canal of all irritants and infectious material. Unnecessarily leaving a tooth open only invites the pathologic microbes and infectious debris to enter the canal system. Studies have documented that leaving teeth open can make an acute problem become chronic and can cause repeated flare-ups during further attempts to close the tooth.

Necrotic teeth which produce voluminous amounts of drainage should be gently irrigated and given time for the drainage to stop (usually 5 to 10 minutes).

Procedures for Treating Teeth with Drainage Through the Canal(s)

The following steps are used to treat teeth with drainage through the canal(s):

Step	Action
1	Gently irrigate the affected tooth. **Note:** Allow time for the drainage to stop, which will usually occur within 5 to 10 minutes.
2	Gently debride the canal(s) with files and copious amounts of sodium hypochlorite.
3	Dry the canal(s) with paper points.
4	Leave the tooth alone for 3 to 5 minutes.
5	Recheck the tooth with a paper point for further drainage.
6	**If** minimal to no drainage is obtained (especially if the drainage has changed from purulent to hemorrhagic) **then** place calcium hydroxide into the canals and close the access.
7	**If** teeth continue to produce drainage beyond 20 minutes **then** leave teeth open, reappoint patient for the next day, and inform patient not to not eat with that tooth and not to insert anything into the canal (e.g., a toothpick which could break and lodge). This should be a very rare if ever occurrence.

Hemorrhagic Canals

Hemorrhagic canals should be treated with calcium hydroxide paste and the patient reappointed to be seen within 1 week. The hemorrhage should be under control after the removal of the calcium hydroxide. Causes of hemorrhage from the canals are--

- incomplete tissue removal or missed canal
- overinstrumentation into periapical tissues
- an acute periapical infection
- perforation

Note: Continued hemorrhage after calcium hydroxide treatment is cause to suspect a perforation.

Instrumenting the Root Canal System

Introduction

Cleaning and shaping the root canal system is the most challenging, time consuming, and important step in endodontic therapy. **Do not rush through it!** Take the time to do it well. Remember the first steps of cleaning and shaping begin at the emergency visit, be very careful not to block or ledge the canal at this visit. Your speed will increase with experience.

Sequence of Canal Preparation

The following is provided as a guide in sequencing the steps of canal preparation. No longer is it recommended to prepare the apical portion of the canal first. Follow the steps as listed, and with time you will notice improvement in your technique. Please contact any endodontist if you have questions regarding instrumentation.

Step	Action
1	Remove ALL caries and determine restorability
2	Obtain straight-line access.
3	Identify all canals.
4	Explore the entire root canal system and establish patency. **Note:** Use RC Prep for small file sizes #6,#8, #10.
5	Improve the radicular access by flaring the mid and coronal root areas.. **Note:** Use Hedstrom, Flex-R (or other safety tip) files ,Gates Glidden burs or NiTi rotary files.
6	Locate the canal terminus and shape the apical one third. **Note:** Irrigate and recapitulate with a patency file between each file size.
7	Flare in a step-back manner with Flex-R (or other safety tip).

Straight-Line Access

Sufficient coronal tooth structure must be removed to allow straight-line access to **all** canals. This requires the removal of the entire roof of the pulp chamber.

Warning: While conservation of tooth structure is important, do **not** compromise your root canal therapy by failing to obtain straight-line access. Coronal tooth structure interference is the most common cause of incomplete canal debridement and transportation of the root canal system.

During instrumentation if your file contacts tooth structure coronal to the canal orifice or if you file a groove in to an axial wall, it is an indication that insufficient coronal tooth structure has been removed.

Once the pulp chamber has been penetrated, long-shanked, slow-speed round burs and tapered FG diamond burs are good for access preparation.

Note: A number of companies also make a FG carbide bur with an extended cutting

surface and a rounded noncutting tip (e.g., ENDO Z by Caulk). Theses are also excellent for making access preparations.

Identification of All Canals

Look for additional canals in mandibular incisors and in maxillary and mandibular molars and premolars. If the file does not appear centered in the canal on the radiograph, examine for an additional canal. If the patient's symptoms do not resolve after instrumentation, consider a missed canal.

> **Note:** In many Native American populations, anomalies such as extra canals and extra roots occur with greater frequency than in the general population. Please refer to tooth morphology for details.

Canal Exploration and Patency

Use small files (#8 through #15) well lubricated with RC Prep or a similar agent to explore the entire root canal system and establish apical patency. The most predictable method to ensure apical patency is to set a file length (use a #15 file) which extends 0.5 mm beyond the apical constriction (the constriction will be the working length for apical preparation) so the patency length is .05 mm longer than the working length. Radiographically, the patency length will extend to the radiographic root edge (PDL).

The patency file is used gently to remove debris which gets packed apically during instrumentation, thereby keeping the canal patent to its terminus. Avoidance of apical blockage allows better apical control of instruments and minimizes the chance of apical damage (e.g., ledging or perforation). Use of a #15 file as the patency file will not damage the apical constriction. An apex locator is a more accurate way of measuring canal length, location of foramen and therefore patency, than is a radiograph.

Radicular Access

Once the canal has been explored and patency established, radicular access can be enhanced by the use of Hedstrom files ,Gates Glidden Burs or NiTi rotary files. Size 15 through 35 Hedstrom files (set 2 to 3 mm short of working length and used in a step-back manner) can improve access and create a guide path for the Gates Glidden burs. Use copious irrigation and test patency between Hedstrom file sizes. Hedstrom files remove tooth structure quickly and efficiently but should be used with caution. They should be placed passively to length and used to cut only on the withdrawal stroke and in an anticurvature motion. Away from the furcation and toward the root line angle in molars and towards the buccal and lingual in the case of bicuspids.

> **Note:** Standard files may be used in place of Hedstrom files.

Caution: Rotating, twisting, or forcing a Hedstrom file will cause it to break.

Radicular access can further be improved by the use of Gates Glidden burs. The IHS Endodontic Consultants recommend the use of Gates Glidden burs sizes 2 through 6.

- The #1 Gates Glidden bur breaks easily and often at the cutting head making retrieval difficult, if not impossible.
- The #2 bur should be used to its full **passive** length.
- The #3 bur should be used to about 1/2 of the length obtained by the #2 bur
- The #4 through #6 burs should be used at the orifice or in coronal access.

Like the Hedstrom file, the Gates Glidden bur should be taken to its length passively and used to cut on withdrawal and in an anticurvature motion.

Caution: Gates Glidden burs are not designed to negotiate curves in roots.

Apical Preparation

Previous mention of taking a patency file to or through the apical constricture does not suggest the use of larger files through this point. Larger files would destroy the apical resistance form. You should--

- determine the working length of the canal using radiographs, electronic apex locators, tactile sensation, and paper point measurement
- continuously taper the apical region beginning with a size 20 or 25 file (This is usually accomplished with file sizes 20 through 35 or 40.)

With proper coronal and radicular access and the use of good patency and irrigation techniques, the apical 3 mm does not need to be over enlarged.

Stepback Flaring

Once the apical region has been prepared, step back flaring with standard Flex R files in 1/2 or 1 mm increments until it completes the root canal preparation. Flaring usually continues up the canal until it blends with the portion reached by the #2 Gates Glidden bur. Again copious irrigation and recapitulation with patency files should be performed between file sizes. Note the #2 Gates Glidden bur is equivalent to a #70 file, #3 equivalent to a #90, and the #4 equivalent to a 110.

Perforations

Introduction

There are two types of perforations, those resulting from a resorptive process and those which are iatrogenically produced. Iatrogenic perforations can occur during the mechanical canal shaping or during post preparation.

Perforations in the Apical Region

Perforations in the apical region offer the best prognosis and can occur by over enlargement of the apical foramen or by perforation of the root in the apical one third short of the canal terminus.

Perforation of the apical foramen can be avoided by establishing and maintaining an accurate working length. Radiographs, paper points, and an electronic apex locator are helpful in establishing a proper working length.

Sudden bleeding from a previously dry canal or a pain response from a patient who has been comfortable during instrumentation may suggest that the foramen is being enlarged. Once you recognize that the foramen has been perforated, a new shorter working length must be used to establish a stop within tooth structure. Alternatively, if a stop cannot be established, dentin filings may be packed to close the foramen (as long as the apical portion of the canal has been adequately cleaned. Success is usually dependent on being able to control the filling material and sealer from being extruded beyond the apex.

Perforation of a root in the apical one third can be the result of an overzealous attempt to bypass a ledge, failing to instrument in a manner designed to maintain the curvature of a canal in a tooth with a curved root, or misjudgment in establishing a final size for instruments that are suitable for a particular root shape.

The prognosis for these teeth, in one respect, is similar to that of a tooth that has a ledged canal, in that an uninstrumented and unfilled portion of the original canal usually exists apical to the perforation; however, the prognosis is poorer than that of a ledged canal alone because an iatrogenic opening also exists between the root canal system and some portion of the periodontium.

Success in treating this type of perforation depends on--

- the ability of the operator to bypass the perforation and clean and fill the remaining apical portion of the canal
- being able to seal the perforation.

Since instruments generally perforate the root surface at an oblique angle, the opening in the root surface is usually oval shaped. Attempts at filling such perforations usually result in overfilling or deficiencies in the seal around the perforation.

Perforations in the apical one third are most successful when filled immediately and offer the best prognosis when the perforation is within a few millimeters of the original working length. In the event that continued bleeding prevents immediate filling of the canal, a temporary canal dressing of calcium hydroxide paste can be placed until the canal can be renegotiated without encountering hemorrhage.

Since conservative attempts to obturate the perforation and the canal segment apical to the perforation are often unsuccessful, the ultimate prognosis for these teeth depends upon--

- the surgical accessibility of the perforation
- the adequacy of obturation of the apical canal segment
- the relationship of the perforation to the crestal bone and epithelial attachment

Midroot Perforations

Midroot perforations can occur from the pulp to the periodontium (or vice versa) as a result of impact or iatrogenic trauma. They also can be caused by the improper use of hand, sonic, ultrasonic, or rotary instruments perforating the canal wall or "stripping" the thin inside curve of the root structure particularly in mandibular molars.

Repair of the midroot perforation is more difficult than those in the apical region because it is frequently impossible to complete instrumentation of the root canal or to carry out obturation without profuse bleeding.

- If the perforation at the midroot level can be shown clinically to be surgically accessible, the dentist may attempt surgical repair. The perforated canal (or canals) should be blocked by placing the largest gutta percha cone possible into the canals. This will prevent the repair material from entering the canal and blocking access to the apical portion. A full thickness sulcular flap is raised and the perforation accessed. It is imperative that a cervical collar of buccal bone be left for reattachment. If this cannot be maintained, the case will likely develop a deep furcation involvement and fail. The perforation is prepared with a slot-type preparation, and the preparation is restored with either IRM, Super EBA cement or MTA (mineral trioxide aggregate). Surgical repairs are difficult at best. Access is usually extremely limited. This procedure should be reviewed with an IHS endodontist prior to being performed.

- The second method of dealing with the midroot perforation should be considered when the perforation is not surgically accessible. The second method involves the use of calcium hydroxide as described by Frank on the following page.

  The disadvantage of this technique is that treatment often lasts a period of months. This increases the likelihood that patients may not return for treatment and that the dentist cannot have confidence that the perforation is as well sealed as with a surgical repair.

Second Method for Dealing with Midroot Perforations

The following steps should be followed to perform the second method.

Step	Action
Initial Appointment	
1	Isolate the tooth with a rubber dam.
2	Biomechanically enlarge the canal just short of the radiographic apex. (It is not unusual to encounter considerable hemorrhage as a result of the perforative defect. Local anesthetic is usually needed.)
3	Dry the canal with paper points.
4	Prepare a thick paste of CaOH. Pack the paste well into the canal with a long plugger. (When fistula is present, there is a minimum of discomfort; when fistula is not present, the packing of the paste will bring about temporary discomfort.)
5	Cover the paste with a cotton pellet and a double seal.
Subsequent Appointments (4- to 6-Week Intervals)	
6	Palpate the gingival tissue for the comparative evaluation of any fluctuance that may have been present.
7	X-ray for comparative evaluation. (A decisive change is not usually apparent in this minimal period of time.)
8	Remove CaOH paste with files.
9	Refile canals
10	Repack canal with CaOH paste.
Final Appointment	
11	Evaluate and palpate the gingival tissue. (If a fistula or fluctuance persists, repeat the subsequent appointment steps; if not, proceed with the following treatment.)
12	Remove CaOH paste with files.
13	Refile the canal to clean sound dentin
14	Dry the canal. Although a minimum of hemorrhage may be present, the canal must be dry prior to filling the root canal.
15	Coat the canal walls with root canal sealer.
16	Insert a prefitted master gutta percha cone followed by spreading and a vertical

	condensation technique.

Perforations in the Cervical Area

Perforations in the cervical area can present a significant threat to favorable outcome because of the likelihood that periodontal breakdown will occur. The ideal objective of treatment is to accomplish repair of the defect without preventing reestablishment of the epithelial attachment. The ability to accomplish this depends on the position of the perforation and its size, assuming that the patient was not initially periodontally compromised.

In teeth in which the perforation has been made just apical to an intact epithelial attachment, a very delicate situation exists. An attempt to repair such perforations surgically will in most cases result in loss of the epithelial attachment; although, an occasional surgical repair of this type has been performed without loss of attachment. The problem is that there is insufficient data to allow one to predict when surgical repair can be accomplished without permanent damage to the periodontal structures. Because of the uncertainties of this type of perforation repair, the calcium hydroxide repair, previously described, or immediate repair with MTA, composite, glass ionomer, or amalgam are the best treatment alternatives at this time.

In the event that the perforation actually involves the attachment, ideal repair will depend on externalizing the defect so that reattachment can occur further apically on the root. This can be accomplished in two ways:

- The most expedient choice is to use an apically repositioned flap after appropriate osseous recontouring and root repair.

- A second tentative method of externalizing the perforation is to supererupt the tooth orthodontically until the perforation is coronal to the attachment. This technique is limited by its complexity, cost, time requirement, and the need to provide stabilization. The advantage of this technique in properly selected cases is that the repair of the perforation can be accomplished without having to alter the periodontium surgically.

The techniques described for cervical level perforations so far are best suited for single-rooted teeth and do not adequately cover instances in which perforation has occurred in the furcation of multirooted teeth. Perforation repair in such cases often produce short lived results. Once a perforation in the furcation has been recognized, every effort should be made to close the defect as soon as possible. The advantage of immediate repair, assuming that the perforation has not caused marked destruction of the adjacent bone, is that the bone can serve as a matrix to help confine the root canal filling materials. If treatment is delayed, some bone adjacent to the perforation can be expected to break down and attempts at obturation will then result in extrusion of significant amounts of filling material into the furcation.

Immediate repair of furcation perforations is usually complicated by bleeding into the canal. If

bleeding is controlled, then the repair can be accomplished at time of occurrence. However, if bleeding cannot be controlled, the treatment will have to be altered by placement of a temporary dressing of calcium hydroxide. If the perforation is readily visible and as small as 1 mm in diameter, Dycal rather than calcium hydroxide can be placed over the perforation. If the field can be kept dry, this technique provides a rapid and effective form of immediate therapy which in turn allows immediate obturation of the canals. This should be attempted only if an epithelial attachment exists at the time of perforation. Once the canals have been obturated and heme controlled final sealing of the perforation should be made with MTA, composite, or glass ionomer.

In instances in which periodontal disease has previously caused loss of the epithelial attachment and bone in the furcation, it is highly unlikely that any type of repair will be effective, in which case root amputation, hemisection, or extraction should be considered as treatment alternatives.

Diagnosing Endodontic Failure

Introduction

There are several variables to consider when diagnosing a failing endodontically-treated tooth. A common error is to immediately assume the tooth needs extraction or apical surgery without adequately determining the etiology.

"POOR PAST"

The mnemonic of POOR PAST was created for recalling the possible etiologies of endodontic failure. Each of these are described on this and the following pages. The letters are defined as follows:

P - perforation	P - periodontal disease
O - obturation	A - another tooth
O - overfill	S - split tooth
R - root canal missed	T - trauma

Perforations

Perforations can be caused by the following:

[3]Dr. Crump, "Differential Diagnosis in Endodontic Failure." Dental Clinics of North America vol. 23, no. 4, October 1979.

- Midroot perforations can occur from overenlarging the canal space (often caused from inappropriate use of the Gates Glidden Drills).

- Apical transportation of the canal can result in perforations. And perforations during access can occur.

Bitewing radiographs can be used to identify cervical access perforations. Multiple radiographs, taken from various horizontal angles, can detect midroot and apical perforations. Extrusion of the obturation materials may be apparent.

Obturation Quality

All canals are wider in the buccal-lingual plane. Consequently, our radiographs provide the least information regarding the density of the fill. Numerous studies have demonstrated that the quality of preparation and obturation is the single most important factor for endodontic success. If all other variables have been ruled out and the tooth is symptomatic, consider retreatment.

Overfilled Canals

Generally, overfills tend to have a poorer prognosis than ideal or slightly short fills. Take multiple films from different horizontal angles to detect overfills.

Root Canal Missed

Extra canals are common in certain teeth (see Tooth Morphology). Failure to identify and treat these canals is a common source for continued infection. Again, different horizontally-angled radiographs can detect the possibility of a missed canal by separating the canals in the root, or separating the roots. If a fill is not centered in the canal in an angled view, suspect another canal.

Periodontal Disease

One must determine whether the symptoms are of endodontic or periodontal origin. Careful, complete pocket probing will produce a contour of the pocket. In addition to probing, careful pulpal diagnosis is mandatory.

- **Endodontic origin.** In general, isolated vertical defects indicate either an endodontic sinus tract, vertical fracture, or developmental groove.

- **Periodontal origin.** Broad, horizontal pockets are usually of periodontal origin.

Another Tooth

Always consider an adjacent tooth as a possible source of the symptoms. Percussion, palpation, and thermal and electric pulp testing should always be performed on adjacent teeth. Always trace a sinus tract with a gutta percha cone to determine the source.

Split Tooth

Chronic, low-grade pain can indicate a vertical fracture. Careful probing may reveal an isolated vertical periodontal pocket. The restoration may be removed to examine the remaining tooth structure for a fracture using a fiber optic light. Staining the dentin with methylene blue, disclosing solution, or food coloring can also identify the fracture.

Trauma

Evaluate for occlusal prematurities and adverse oral habits (clenching and bruxism). Evaluate the proximal contacts for the possibility of food impaction (since many endodontically-treated teeth will be restored with complex coronal restorations).

Integrity of the Coronal Restoration

Another variable to evaluate when diagnosing an endodontically failing tooth is the quality of the coronal restoration. Coronal leakage has become a major consideration in endodontic failure. If the coronal restoration is defective, leakage into and through the canal system can result in the development of periradicular infection. At this stage, the tooth must be evaluated for restorability. Also, you must consider retreatment of the canal system if significant leakage has occurred.

Trauma to the Permanent Dentition

Procedures for Examining Traumatized Teeth

The following steps should be performed:

Step	Action
1	Clean the traumatized area.
2	Obtain history of the accident to include-- • how • where • when

<table>
<tr><td>3</td><td colspan="2">Determine if there is or has been any--

• loss of consciousness
• headache
• nausea
• vomiting

Note: These could indicate a severe head injury and needs immediate medical evaluation.</td></tr>
<tr><td rowspan="3">4</td><td colspan="2">Perform clinical examination as follows:</td></tr>
<tr><td>Substep</td><td>Action</td></tr>
<tr><td>a</td><td>Perform soft and hard tissue examination. Look for occlusal discrepancies, enamel fracture, and dentin or pulpal exposure. Check the tooth for abnormal mobility, tenderness to percussion, and percussion tone (ankylosis).</td></tr>
<tr><td></td><td>b</td><td>Perform base line thermal and electric pulp tests.</td></tr>
<tr><td rowspan="4">5</td><td colspan="2">Perform radiographic examination as follows:</td></tr>
<tr><td>Substep</td><td>Action</td></tr>
<tr><td>a</td><td>X-ray soft tissues (in cases of penetrating wounds).</td></tr>
<tr><td>b</td><td>Obtain an occlusal view of anterior region.</td></tr>
<tr><td></td><td>c</td><td>Obtain a periapical radiograph of each traumatized tooth and those in the opposing arch.</td></tr>
</table>

Classification of Traumatic Injuries

The following injuries are classifications of traumatic injury:

- crown fracture without pulp exposure (closed injury)
- crown fracture with pulp exposure
  - immature rooted teeth
    - vital pulp
    - necrotic pulp
  - complete root development
- crown-root fracture
- root fracture

- luxation injuries
  - concussion and subluxation
  - extrusion and lateral luxation
  - intrusion
  - avulsion
- alveolar process fracture

Also refer to http://home.ihs.gov/MedicalPrgms/DentalTrauma/index.asp **for up-to-date treatment recommendations.**

Crown Fracture

Crown Fracture with No Pulpal Exposure

Crown fractures involving enamel or enamel and dentin, but without direct pulpal exposure, can be restored with an acid etched composite material. Protect the dentin with a calcium hydroxide liner as you would for a routine restoration. The patient should be advised to return PRN if any symptoms or irreversible pathosis or necrosis occur. These teeth should be examined radiographically to exclude the possibility of a horizontal root fracture. The overall prognosis for this type of injury is good.

The overall prognosis for a closed injury is good, but certain precautions must be taken to prevent any further damage. The procedures used with permanent teeth with or without complete root development are very similar.

Procedures for Treating a Closed Injury in Permanent Teeth with Incomplete Root Development

The following steps are used for treating a closed injury in permanent teeth with incomplete root development:

Step	Action
1	Obtain two radiographs. Vary vertical angle by 10 degrees to check for horizontal root fractures.
2	Evaluate-- • percussion response • palpation response

	• perio probings (gentle) • degree of mobility • presence of sinus tract • coronal discoloration
3	Perform a pulp vitality test. **Note:** The **electric pulp test** (EPT) is unreliable on immature-rooted teeth due to the degree of sensory pulpal nerve development. A **cold test** is more reliable in determining pulpal status. A traumatized tooth may not respond normally to vitality testing for weeks to months.
4	**If** there are no clinical indications of pulpal necrosis, but the tooth fails to respond to vitality testing, **then** wait and watch (evaluate using periodic recall to rule out pulpal necrosis). **If** the tooth develops symptoms indicating pulpal necrosis **then** perform a pulpectomy and apexification procedure

Crown Fracture with Pulpal Exposure

Crown fractures exposing the pulp are divided into two categories:

- **Completely developed teeth.** Teeth with complete root development which have had a traumatic pulpal exposure should be treated with conventional endodontic therapy. Attempting a pulp cap in this situation could result in chronic pulpal inflammation or necrosis. A chronically inflamed pulp has the potential to undergo extensive calcific metamorphosis or develop internal resorption. Both of these conditions render the tooth difficult or impossible to treat with nonsurgical endodontics. Since the procedure is relatively easy to perform and the prognosis is good, conventional endodontic therapy is the best treatment for injuries of this type.

- **Immature rooted teeth.** Immature rooted teeth which have a traumatic pulp exposure may be treated in one of several ways. Ideally, if some vital pulpal tissue can be maintained, the tooth will complete root development, resulting in normal root length and dentinal wall thickness. This is termed **Apexogenesis**.

Apexogenesis

Apexogenesis procedures are performed to maintain the vitality of the tooth. Apexogenesis is the preferred treatment in cases of traumatic pulp exposure in permanent teeth with incomplete root development since it results in a fully formed root. However, the pulpal tissue must be healthy.

The two types of apexogenesis procedures used in endodontic treatment of teeth with vital pulp are--

- Cvek Pulpotomy
- Cervical Pulpotomy

Treatment Planning Factors

Different treatment programs involving apexogenesis are recommended for each of the following endodontic conditions:

If there is vital pulp with small exposure (pulphorn) or horizontal-type exposure across pulp chamber**, then perform** a Cvek Pulpotomy. **If there is** vital pulp with diagonal pulp chamber exposure (more of a vertical-type exposure), **then perform** a Cervical Pulpotomy.

Cvek Pulpotomy

The Cvek pulpotomy is a simple procedure with a very good prognosis. It works best on smaller pulphorn-type exposures. Teeth having had a Cvek pulpotomy should be evaluated periodically to assure that vitality is maintained and that no undesirable sequelae are occurring (e.g., internal resorption).

Procedures for Performing Cvek Pulpotomy

The following steps are used for performing a Cvek Pulpotomy:

Step	Action
1	Isolate with a rubber dam.
2	Gently rinse exposure site. **Note:** Do **not** air syringe dry. Blot dry with moist cotton pellets
3	Remove 1 to 2 mm of tissue at exposure with round-ended diamond bur in high speed handpiece with water spray. **Note:** It is important to remove all pulp tissue coronal to the exposure site.
4	Control hemorrhage with saline-moistened cotton pellets gently pressed against exposure site.
5	Place calcium hydroxide liner (Dycal, Life, etc.--not calcium hydroxide powder or paste) over exposure site. **Note:** If unable to control hemorrhage, repeat Step 3 until healthier tissue is encountered.
6	Restore crown with permanent restorative material (composite, amalgam, or glass

	ionomer--depending on tooth type). **Note:** Do **not** restore these teeth with a temporary material as leakage will result in failure of the procedure.
7	Follow up on the treatment. **Note:** Evaluate the teeth clinically and radiographically to rule out degenerative pulpal changes (necrosis and internal or external resorption). Generally, 3 to 6 month recalls are sufficient. Pulp vitality testing is unreliable in teeth with pulpotomies.

Cervical Pulpotomy

The cervical pulpotomy is recommended when there is extensive exposure which involves the full width or length of the pulp chamber.

Procedures for Performing Cervical Pulpotomy

The following steps are used for performing a Cervical Pulpotomy:

Step	Action
1	Isolate with a rubber dam.
2	Gently rinse exposure site. **Note:** Do **not** air syringe dry. Blot dry with moist cotton pellets
3	Amputate the pulp to the CEJ with either a large, round-ended diamond or a large round bur. **Note:** The pulpotomy must not leave any coronal pulp tissue or it will undergo necrosis and result in failure of the procedure.
4	Control hemorrhage with saline-moistened cotton pellets gently pressed against exposure site.
5	Place calcium hydroxide liner (Dycal, Life, etc.--not calcium hydroxide powder or paste) over exposure site. Alternatively MTA can be placed over exposed site and a moist cotton pellet sealed into the access. 24 hours later the cotton pellet should be removed and the tooth restored see #6 below. **Note:** If unable to control hemorrhage, repeat Step 3 until healthier tissue is encountered.
6	Restore crown with permanent restorative material (composite, amalgam, or glass ionomer--depending on tooth type).

	Note: Do **not** restore these teeth with a temporary material as leakage will result in failure of the procedure.
7	Follow up on the treatment. **Note:** Evaluate the teeth clinically and radiographically to rule out degenerative pulpal changes (necrosis and internal or external resorption). Generally, 3 to 6 month recalls are sufficient. Pulp vitality testing is unreliable in teeth with pulpotomies.

Follow-Up Considerations

Controversy exists whether the tooth should receive conventional endodontic therapy (root canal therapy) once the root has completed development.

- **Cvek.** Most commonly the Cvek pulpotomy does not require an endodontic procedure after root development. The pulp may undergo degenerative changes (necrosis, internal resorption, or dystrophic calcification) after root development which may make conventional endodontic therapy difficult or impossible at a later date should symptoms of radiolucency develop. Therefore, if the tooth is eventually to receive a post and core, endodontic therapy should be performed. Otherwise, if the tooth is clinically and radiographically asymptomatic, continue periodic evaluations, and do not initiate endodontic therapy unless indicated.

  Inform the patient (or parent/guardian) of the potential for pulpal necrosis, internal resorption, or dystrophic pulpal calcification as a result of pulp capping procedures. They should seek treatment immediately if they experience any symptoms.

- **Cervical.** Some controversy exists as to whether these teeth require root canal therapy once the root as fully developed. The literature has shown that the pulps and canals of these teeth tend to undergo calcific changes which may make conventional endodontic therapy difficult or impossible at a later date should symptoms or a radiolucency develop. Since the majority of these teeth will require the use of a post for the permanent restoration, the IHS endodontic consultants recommend the reentering of the canal and completion of the endodontic therapy once the root appears to have completely developed.

Apexification

Apexogenesis is the preferred treatment in cases of traumatic pulp exposure since it results in a fully formed root. However, the pulpal tissue must be healthy. If the pulp tissue is necrotic, a pulpectomy and an apexification procedure must be performed.

Limitations of Apexification

Apexification will only result in the formation of an apical barrier. No further root length or thickness can be expected. If the root is less than half formed, the prognosis becomes very guarded.

Procedures for Performing Apexification Procedures

Apexification involves a complete pulpectomy and the stimulation of an apical barrier. The following steps are used for performing apexification procedures:

Step	Action
1	Isolate with a rubber dam.
2	Perform a pulpectomy. **Note:** Take working-length film. Use copious amounts of sodium hypochlorite during pulpectomy, but irrigate **gently** to avoid expressing the irrigant into the periapical tissues. Sonic or ultrasonic endodontic devices can be of benefit in canal debridement for these cases
3	Perform treatment as follows: **If there is** purulent drainage through the canal, **then** attempt to close tooth after debridement. (If unable to control drainage, leave open for 24 hours and attempt to close the following day.) Prescribe appropriate antibiotic therapy. **If there is** hemorrhagic drainage, **then** place calcium hydroxide paste in canal. Reappoint patient within 1 week to remove paste and repack with dense, fresh mix. **If there is** serous or straw-colored drainage, unable to close, **then** leave open 24 hours, treat as if purulent drainage. If drainage stops, then treat as if hemorrhagic drainage.
4	Completely dry canal with paper points, being careful to not extend point beyond the root terminus. **Note:** Using the blunt end and measuring the length is often the best method.
5	Pack a dense mix of calcium hydroxide paste to the apical terminus. (See Preparing Packing Mix.) Commercial premixed Calcium Hydroxide in a syringe delivered using a blunt end #22 or #23 irrigation needle with a rubber stopper set to your desired length is the easiest and most predictable method . **Note:** If a commercial brand is not available Placement of a chairside paste mix can be aided by utilization of lentulo spirals, pluggers, large files spun counterclockwise, blunt ends of paper points, cotton pellets, etc. You should if possible use a radiopaque mixture. Pure calcium hydroxide will make the canal disappear on radiograph if packed densely. Eliminate obvious voids.

<table>
<tr><td>6</td><td>Take a PA to evaluate the fill and to use for comparison at the next appointment.</td></tr>
<tr><td>7</td><td>Place a cotton pellet over the paste fill.

Note: Cavit can be used as a secondary seal over the paste fill.</td></tr>
<tr><td>8</td><td>Restore the access with a composite resin restoration.

Note: Do not use a temporary restorative material since leakage can occur between appointments.</td></tr>
<tr><td>9</td><td>Follow up on the treatment as follows every three months:

Note: Apical barrier formation can take from 6 to 24 months. Radiographically, the canal may appear closed apically but may still be open in the buccal-lingual direction since this is always the widest dimension of all canals.
<table>
<tr><th>Substep</th><th>Action</th></tr>
<tr><td>a</td><td>Take a new PA prior to reaccessing the canal(s).</td></tr>
<tr><td>b</td><td>Reaccess and remove the calcium hydroxide with files set short of the apex and sodium hypochlorite.</td></tr>
<tr><td>c</td><td>Dry the canal and repack with a fresh mix.</td></tr>
<tr><td>d</td><td>Restore the access and take another radiograph</td></tr>
<tr><td>e</td><td>At recall if apex appears to have closed, <u>gently</u> probe the apical barrier with a size 35 or 40 file.
If resistance is felt then complete canal preparation and proceed with the gutta percha obturation.

If resistance is not felt then continue to treat with calcium hydroxide.</td></tr>
</table></td></tr>
</table>

Packing Mix

The canal is packed with a calcium hydroxide paste and sealed with a durable temporary (IRM **not** Cavit). The calcium hydroxide can be a commercial preparation (i.e., Multi-Cal, Hypocal, Calisept, or Tempcanal) or you may mix your own paste of calcium hydroxide powder mixed with sterile saline or anesthetic solution. Do **not** use a hard-setting liner (e.g., Dycal and Life). Do **not** use CMCP, Eugenol, or other medicaments to mix with the CaOH since these preparations can be cytotoxic and do not contribute to the healing process.

Because the paste washes out of the canal and tends to break down chemically over time, the CaOH should be replaced every 3 months.

Gutta Percha Obturation

Obturating the "blunderbuss" canal is difficult with conventional laterally condensed gutta

percha. A custom cone can be made by--

- softening the tip of the largest cone to go to length. Acceptable techniques are--
  - use eucalyptus as a softening agent
  - dip the tip of the master cone in hot water (3 to 5 seconds)

  Warning: Chloroform is not recommended for use due to the FDA's classification of it as a carcinogenic material.

- seating the cone against the apical barrier to deform it into the form of that area.

Warm gutta percha techniques (vertically condensed, thermoplastic techniques) are also options for obtaining an apical seal.

Crown-Root Fractures

Introduction

A crown-root fracture usually results in pain from mastication due to movement of the coronal fragment, but is otherwise often without symptoms. The pathologic consequences of no treatment include inflammatory changes in the pulp, periodontal ligament, and the gingiva due to plaque accumulation in the line of the fracture. The clinical diagnosis is apparent when the coronal fragment is mobile. The extent of the fracture is often difficult to determine radiographically since the fracture line is usually perpendicular to the central x-ray beam.

Treatment Options

There are four treatment options:

- **option 1.** removal of the coronal fragment with subsequent restoration above the gingival level
- **option 2.** removal of coronal fragment supplemented by gingivectomy/osteotomy and subsequent restoration with a post-retained crown
- **option 3.** removal of the coronal fragment and surgical extrusion of the root
- **option 4.** removal of coronal fragment and subsequent orthodontic extrusion of the root

Option 1

Removal of the coronal fragment with subsequent restoration above the gingival level is limited to superficial fractures that do not involve the pulp. To complete this treatment, you must--

- construct a temporary crown until the gingiva heals
- place a composite restoration during final treatment
- follow up on pulpal and periodontal status

Option 2

Removal of coronal fragment supplemented by gingivectomy/osteotomy and subsequent restoration with a post-retained crown should be used only when aesthetics (i.e., palatal and lingual aspects) are not compromised. To complete this treatment, you must--

- remove 2 mm of bone below the fracture and extirpate the pulp

  Note: Complete the root canal filling at this time or at a later visit.

- Restore with a post and crown (once the root canal filling is completed and the gingiva heals)

Option 3

Removal of the coronal fragment and surgical extrusion of the root should be used only when remaining root can support a post-retained crown. To complete this treatment, you must--

- extirpate the pulp
- luxate and move the apical segment into a more coronal position and secure it with either sutures or a splint
- after 2 to 3 weeks, complete root canal therapy
- after another 2 to 3 months, restore the tooth with a post and crown

Option 4

Removal of coronal fragment and subsequent orthodontic extrusion of the root should be used only when the remaining crown/root ratio is favorable. To complete this treatment, you must--

- move the coronal fragment and perform root canal therapy on apical portion
- complete root extrusion over a 2 to 3 week period
- retain root 2 to 3 months prior to the post-retained crown

Root Fractures

Introduction

A tooth with a fractured root may demonstrate mobility ranging from normal limits to excessive. The coronal segment may be displaced and the tooth may be tender to percussion or to palpation of the labial or lingual plate. There also may be bleeding from the sulcus. Radiographic diagnosis is greatly aided by taking two or more films at various vertical angles to identify the type and location of the fracture.

Types of Root Fractures

There are two types of root fractures:

- vertical
- horizontal

Vertical Root Fractures

The prognosis for a root with a vertical fracture is hopeless. Even today, the treatment for a single-rooted tooth with a vertical root fracture is extraction.

Horizontal Root Fractures

The majority of horizontally fractured teeth maintain their pulp vitality. **Do not immediately initiate endodontic therapy**, but rather reapproximate the segments, splint rigidly, and follow up on the pulpal status. Splint for 1 to 3 months.

> **Note:** If the fracture is in the apical 1/3 with little displacement, splint for less time. If fracture is in the coronal 1/3 with displacement, splint longer.

Pulpal necrosis occurs in about 20 to 40 percent of the cases and is related to the amount of displacement of the segments and communication with the oral cavity. Progressive root resorption (inflammatory resorption or ankylosis) is rare. If pulpal necrosis occurs (indicated by resorption of the bone at the level of the fracture), extirpate the pulp to the level of the fracture and use calcium hydroxide as an interim dressing. After hard tissue closure of the root canal at

the fracture line has been achieved (usually 6 months to 1 year), a definitive root canal filling with gutta percha should be made.

Usually, the apical segment will retain its vitality. The tooth does not need to be vital for healing. If apical pathosis develops, the apical segment may need to be removed. The critical healing factors are--

- close reapproximation of the segments
- a vital PDL

Luxation Injuries

Introduction

Luxation injuries include a broad range of injuries and symptoms. Treatment programs for these injuries are as varied as the type of injuries. The following four types of luxation injuries will be discussed on this and subsequent pages:

- concussion and subluxation
- extrusion and lateral luxation
- intrusion
- avulsion

Concussion and Subluxation

Concussion and subluxation are minor injuries to the pulp and PDL caused by acute impact.

- A **concussed tooth** is tender to percussion due to hemorrhage in the PDL.
- A **subluxated tooth** is tender to percussion and abnormally loose due to rupture of PDL fibers.

Treatment:

- occlusal relief (opposing teeth) and soft diet
- immobilization (This is for patient comfort only and splinting time is for two weeks. Studies have shown that splinting in these cases does not improve healing. A nonrigid splint is used.)

Prognosis: There is minimal risk of pulpal necrosis, and progressive root resorption is rare.

Extrusion and Lateral Luxation

Both extrusion and lateral luxation represent rupture of pulp and PDL fibers.

- With **extrusion**, the tooth is loose. It is best viewed in periapical bisecting x-ray.

- With lateral luxation, there is injury to the labial or palatal plate. It is best viewed on an occlusal film. The tooth is firmly in place and will give a high-pitched metallic tone similar to ankylosis on percussion.

In both cases healing includes PDL repair and pulpal revascularization.

Treatment: Treatment consists of--

- atraumatic repositioning and nonrigid splinting for 2 to 3 weeks (Time is important. If repositioned within 90 minutes, there is considerably less chance of root resorption.)

- reduction of a heavy occlusion (Do not remove the tooth completely from the occlusion.)

- follow-up visits at 1 month, 3 months, 6 months, and 1 year

  Note: Initiate endodontic therapy with calcium hydroxide as an interim dressing at the first sign of pulpal necrosis to avoid inflammatory resorption.

  Prognosis: There is considerable risk of pulpal necrosis (64 to 98 percent) in both extrusive and lateral luxation injuries especially if the apex is closed. Inflammatory root resorption occurs in 7 to 10 percent of the cases. Replacement resorption is rare with extrusive injuries but can occur following lateral luxation.

Intrusion

With intrusions, maximum damage has occurred to the pulp and all supporting structures as the tooth has been driven into the alveolar process crushing the PDL fibers. Diagnosis is made primarily on the difference in the height of the affected tooth and the adjacent nonaffected teeth. In mixed dentition, diagnosis is more difficult since intrusion can mimic an erupting tooth. Percussion can help you distinguish between an erupting tooth (dull) and an intruded tooth (high metallic tone). A radiograph is helpful in ruling out an avulsion or a crown fracture. Healing after an intrusion is complicated since extensive damage to the PDL can lead to replacement resorption (ankylosis), and damage to the pulp can lead to inflammatory resorption. Treatment is

directed toward eliminating or reducing the extent of these sequelae.

Treatment for Teeth with Incomplete Root Development:

- Wait for spontaneous reeruption while closely monitoring the pulpal healing. Reeruption can occur over a period of several months.

- In cases where a periapical radiolucency or inflammatory root resorption develops, you **must** extirpate the infected pulp as soon as the healing complication is diagnosed. You should dress the root canal with a calcium hydroxide paste.

Treatment for Teeth with Complete Root Development:

- Reposition the tooth immediately since spontaneous reeruption is unpredictable in teeth with complete root development. (This can be accomplished by either orthodontic extrusion or gentle repositioning with forceps.)

- Extirpate the pulp within 2 weeks of the injury and place a CaOH dressing on it until the periodontium has healed. When healed, complete the root canal therapy.

Prognosis:

Only teeth with immature root formation have shown any capacity for pulp survival (40 percent). There is a high risk for root resorption (58 percent for teeth with incomplete root development and 70 percent for teeth with complete root development). Additionally, intruded teeth have been found to demonstrate ankylosis as late as five years after the injury, therefore, requiring extended follow-up periods.

Avulsion

An avulsed tooth is one that has been completely displaced from the socket. Though revascularization of the open apex tooth is possible, pulpal necrosis is likely and is assumed in the tooth with complete root development.

Treatment:

Treatment for an avulsed tooth consists of replanting the tooth. (See Replanting a Tooth for detailed procedures.)

Follow-up for Teeth with Incomplete Root Development:

If the tooth has an open apex and has been out of the mouth for a short period of time, (ideally less than 30 minutes but not longer than 2 hours) and has been kept

moist, there is a chance for revascularization.

Remove splint after 1 week and take an x-ray 1 month after the injury to check for resorption. Initiate endodontic therapy (pulpectomy and CaOH) at the first sign of pulpal necrosis. Replace dressing every 3 months. Obturate the canal space with gutta percha when the apical barrier is present

Follow-up for Teeth with Complete Root Development:

Extirpate the pulp at the splint removal appointment (1 week). Place CaOH dressing for 2 weeks then obturate with gutta percha.

The factors affecting the success of a replantation are--

- **Extraoral time.** 90 percent of teeth replanted within 30 minutes undergo no necrosis.
- **Storage medium.** Milk or physiologic saline (contact lens solution) are best. Saliva is acceptable.
- **Preservation of the PDL.** Do not remove PDL. Do not mishandle PDL. Do not expose it to caustic chemicals.

Pulp survival is none in teeth with complete root development and poor (30 percent) in teeth with an open apex. PDL healing is infrequent: in teeth with a closed apex it is 25 percent; in teeth with an open apex it is 45 percent.

For a vital PDL (extra-alveolar **dry** time greater than 1 hour)--

- resorption preventing treatment is indicated
- remove PDL and pulp
- place tooth in 2.4 percent NaFl for 20 minutes
- obturate root canal with gutta percha and sealer
- replant tooth and splint rigidly for 6 weeks
- hope to retain the tooth by ankylosis

Replanting a Tooth

Introduction

Replantation of a tooth is performed when a tooth has been completely displaced from the socket (avulsion). Treatment begins immediately after the injury (prior to the patient's arrival) and lasts for a minimum of 6 weeks.

Telephone Instructions

Provide the patient with the following instructions:

- If dirt is on tooth, plug drain, hold tooth by crown, and rinse gently with cool water for 10 seconds. **Do not scrub!**
- Replant the tooth in the correct position (smooth surface toward the lip and edges even).
- Come to the clinic immediately.
- If you cannot replant the tooth,--
  - place the tooth in milk or saline (contact lens solution). If neither is available, use water to keep the tooth moist.
  - wrap the tooth in plastic wrap after wetting it or place the tooth in a small cloth and then in the mouth between the teeth and gums. (The cloth will protect the tooth from being accidentally swallowed.)
  - come to the clinic immediately.
- Remain calm (both parent/patient).

Procedures for Replanting a Tooth

The following are procedures for replanting a tooth.

Step	Action
1	Hold the tooth by its crown. **Warning:** Do not damage the PDL.
2	Rinse the root surface with saline to remove debris for about 10 seconds
3	Rinse the socket with saline. **Warning:** Do not curette the socket or root surface.
4	Replant tooth in correct alignment with gentle finger pressure.

	Warning: Unless you suspect debris in the socket, do not delay replantation to take x-rays. Take them after replanting the tooth (Step 7).
5	Splint the tooth with a nonrigid splint for 1 week. **Note:** See Splinting a Tooth for detailed procedures.
6	Relieve heavy interferences. **Warning:** Do not remove the tooth completely from occlusion. Removing the tooth completely from occlusion can increase the incidence of ankylosis.
7	Take a radiograph to check for foreign bodies as well as alveolar and root fractures.
8	Begin antibiotic therapy as soon as possible after injury.
9	Cover for tetanus if indicated.

Alveolar Process Fractures

Introduction

Treatment principles for fracture of the alveolar process are identical to those for bone fracture and consist of repositioning and splinting for 3 to 4 weeks.

Pulp-Related Trauma

The critical feature in healing is pulp-related trauma.

- When the fracture level is apical to the root tips, pulp necrosis is rare.
- In contrast if root apices are directly involved in the line of fracture, pulpal healing is jeopardized.

The sooner the fracture is repositioned, the less likely pulpal necrosis will occur. Root resorption is rare.

Splinting a Tooth

Introduction

The splinting of a tooth is a critical part of several endodontic procedures. Two types of splinting techniques are commonly used:

- nonrigid splint

- rigid splint

Nonrigid Splint

A nonrigid splint allows the tooth to have physiologic mobility, which reduces the incidence of ankylosis. There are several versions of the nonrigid splint. The following are practical examples:

- Acid-etched composite and either a small diameter, flexible arch wire (.014) or 20-pound monofilament fishing line

- Orthodontic brackets and a light flexible wire held in by elastics. This may not be available at some clinics, but it does allow the bar to be removed to check for healing and then be replaced if necessary.

Keep the brackets and the composite in the middle of the crown; do not impinge on the sulcular tissues as this increases gingival inflammation and results in a lower attachment. If in doubt, lean toward a firmer splint; do not allow vertical movement of the stabilized tooth.

Rigid Splint

The rigid splint immobilizes the tooth, promoting the formation of a callus between the fractured segments. The same design is utilized as in the nonrigid splint except that a firmer, larger wire or strand of fishing line is used. This type of splint is mostly reserved for stabilizing horizontally fractured roots.

Preparing Packing Mix

Introduction

The calcium hydroxide packing mix for use in endodontic treatment can be either a commercial preparation (e.g., Multi-Cal, Hypocal, Calisept, or Tempcanal), or you can prepare your own packing mix by combining USP pure calcium hydroxide powder with either sterile saline or anesthetic.

Use of CMCP

It is not currently recommended to mix CMCP, Eugenol, or other medicaments into the calcium hydroxide. It is felt that these preparations do not add any desirable qualities and that the phenolic material is inflammatory to the periapical tissues and can be cytotoxic.

Calcium Hydroxide

Calcium hydroxide is antimicrobial and promotes healing; therefore, you should utilize a sterile, neutral carrier (e.g., saline or anesthetic). For use as an intracanal medication, a thin mix is recommended. For apexification procedures, prepare a thick paste which will produce the desired effect over the 3-month period.

If you desire radiopaqueness, you can add USP barium sulfate powder to the calcium hydroxide in a 1:8 [$BaS0_4$: $Ca(OH)_2$] mixture.

Resorption

Introduction

Resorption often occurs following traumatic episodes. Depending on the severity of the trauma, resorption can begin soon after the event or (as in the case of minor trauma) resorption can be delayed by many months or even years. It is very important then to closely follow patients with both clinical and radiographic examinations at regular intervals to be able to detect changes early.

Definitions

Resorption can be defined as a physiologic or pathologic process which results in loss of calcified structure from tissues (e.g., dentin, cementum, or alveolar bone).

Our bones are continually being remodeled by the process of resorption, closely followed by the apposition of new bone, so that the whole skeleton is being replaced on a continuing basis. Resorption takes place by unique multinucleated giant cells called **osteoclasts**. Apposition of new bone is followed by osteoblastic deposition. This resorption or apposition process is called **coupling**.

Resorption Process

Fortunately, our teeth are protected from physiologic resorption because there is no provision made in teeth for apposition of new calcified structure except in limited circumstances. On the pulp side of the root wall, the dentin is protected by osteoblasts and calcified predentin; on the other side, the dentin is protected by the PDL, cementoblasts, and cementoid. When the protective layers are damaged in any number by trauma or inflammation the calcified dentin is exposed and the clastic cells colonize the surface resulting in resorption.

Resorption Classification System

There are a number of classification systems used to describe resorption. The simple

classification described on the following pages is based on the presence or absence of inflammation.

Inflammatory Classification

Inflammatory resorptive processes are distinguished by the presence of inflammation. This classification is categorized as follows:

- **Internal Resorption**. Internal resorption is a result of chronically-inflamed pulpal tissue. It is categorized by its position in the canal. Either it has or has not perforated into the PDL. It may perforate the tooth either intraosseous or supraosseous. To have active resorption, vital tissue must be present; the inflammatory process is sustained by a more coronally located bacterial invasion. When the canal becomes totally necrotic, the internal resorption stops.

  - **Intracanal, no perforation.**

    - **Etiology:** pulpal injury (i.e., trauma, cavity preparation, pulp exposure, and pulp maintenance)
    - **Diagnosis:**
      - Round, bulbous enlargement of pulp chamber or canal (Radiographic outline of the canal is lost in resorptive lesion.)
      - Responsive pulp during active phase
    - **Treatment:**

      Root canal therapy - If treated during the active phase, brisk hemorrhage can be encountered when the defect is reached. Copious irrigation and ultrasonic instrumentation is helpful in eliminating bacterial tissue/debris. Obturation can be accomplished with warm, vertical condensation.

    - **Prognosis:** Excellent

  - **Intracanal intraosseous perforation.**

    - **Diagnosis:**

      - The bulbous enlargement extends to the PDL.
      - Radiolucency at perforation site.
      - In other instances, the only evidence of perforation will be the continued bleeding from the canal with blood on the paper point corresponding to the point of perforation.

Note: There is a common misconception that the lateral surface of the root will heal with a calcified barrier similar to that which occurs at the apex during apexification. Apparently, the lateral root does not have the same capacity to repair with a calcified barrier even in the presence of CaOH or with the complete removal of the necrotic tissue/bacteria. Instead, the PDL repairs itself in the improved environment. Collagen fibers are laid down parallel with the root surface/defect. Filling material then can be packed up against the repaired PDL.

- Nonresponsive pulp
- Fistula possible

- **Treatment:**
  - Canal debridement
  - Pack with calcium hydroxide paste until PDL repairs (no bleeding from perforation site)
  - Obturation with warm vertical condensation
- **Prognosis:** Fair to excellent depending on size and biologic repair of defect

- **Intracanal supraosseous perforation.**
  - **Etiology:**
    - Continued internal resorption until perforation
    - Perforation of cementum above the bone
  - **Diagnosis:**
    - The bulbous enlargement extends to the oral environment (CEJ or into crown).
    - Periodontal breakdown at perforation level (e.g., periodontal defect and inflammation in perforation area).
    - Nonresponsive pulp
    - Tissue may be fluctuant
  - **Treatment:**

- Root canal therapy
- Surgical repair
- Consider orthodontic extrusion to move defect coronal to attachment

o endodontics**Prognosis:** Fair to excellent depending on location and quality of repair of defect, surgical access, and remaining periodontal defect

- **External Resorption.** External inflammatory resorption is usually at the apical portion and is associated with a necrotic canal. It is ultimately caused by bacteria or bacterial products which cause the release of immunological and inflammatory mediators resulting in resorption. When the source of the inflammation is removed, the continued stimulation of the clastic cells stops and there is healing and apposition of the new bone. Cementoblasts differentiate to lay down new cementum over exposed cementum.

  - **Etiology:**

    o PA pathosis resulting from necrosis

    o Periodontal disease

  - **Diagnosis:**

    o Nonresponsive pulp
    o PA radiolucency nest to resorptive site
    o Angled x-ray shifts location of radiolucency
    o Canal maintains original form
    o

  - **Treatment:** Upon removal of the causative agents, either by--

    o root canal therapy
    o periodontal treatment
    o extraction

    the resorptive process halts and bone repair occurs.

  - **Prognosis:** Excellent

Noninflammatory Classification

Noninflammatory resorptive processes are distinguished by no bacterial involvement and can be further classified into transient, pressure, and replacement resorption. Again, trauma is the underlying theme in the etiology of resorption.

- **Transient Resorption**. Transient resorption is unrelated to inflammatory resorption and frequently occurs with minor trauma to the PDL which exposes the cementum. Osteo/dentinoclasts colonize the area for a brief period of time, then blastic cells repair the area with new cementum and PDL collagen. Cadaver studies by Weinmann and Seltzer show that 90 percent of the teeth they examined exhibited transient resorptive defects.

  - **Etiology:** localized injury to PDL or cementum from trauma

  - **Diagnosis:**

    - Microscopic root irregularities
    - Normal PDL space
    - Pulp is responsive

  - **Treatment:** No treatment is necessary.

  - **Prognosis:** Excellent

- **Pressure Resorption**. Pressure resorption is more destructive than surface resorption. The most common form of pressure resorption is the loss of primary tooth structure during physiologic tooth shedding. Pressure is provided by the formation of calcified tissue and subsequent eruption provided by Hertwig's epithelial root sheath. Two factors are associated with pressure resorption: 1) pulp is not initially involved and 2) resorption stops when pressure is removed. Treatment consists of removing the pressure source. Generally, root canal therapy is not necessary. Prevention focuses on early detection.

  - **Etiology:** pressure on root from erupting teeth (i.e., Ortho., eruption, lesions, and impactions)

  - **Diagnosis:**

    - Radiographic appearance of radiolucent lesion on root or loss of a portion of root (will have irregular root outline) occurs.
    - Pulp is responsive.
    - Resorption stops when pressure discontinued.

- **Treatment:**

  - Discontinue or remove pressure source.
  - Generally, no root canal is necessary.

- **Prognosis:** Excellent when pressure is discontinued

- **Replacement Resorption**. Once again trauma to tooth structure is the etiologic factor. Trauma results in PDL destruction with exposure of cementum/dentin. Clastic cells colonize the area, create clastic defects, and then there is an aberrant apposition of bone directly on the dentin surface. The tooth then becomes part of the continued resorption/apposition coupling process of which the adjacent alveolus is a part. This process is progressive. Teeth that are caught up in this cycle are said to be **ankylosed**. The pulp is the last thing involved. Replacement teeth undergoing this type of resorption can serve for years, even decades, before being fully resorbed. In terms of years of service, this compares favorably with a fixed or removable prosthesis.

  - **Etiology:** PDL destruction from replantation, transplantation, luxation, avulsion, or unexplained

  - **Diagnosis:**

    - No PDL at resorptive site
    - Irregular margin of defect
    - Original canal form maintained
    - Pulpal response varies

  - **Treatment:**

    - Root canal therapy is usually necessary.
    - No predictable direction
  - **Prognosis:** Poor

  - **Extracanal Invasive Resorption.** Although other classification systems separate this resorptive entity, the chapter author's training program placed it in the spectrum of replacement resorption.

    Note: There is preservation of the canal outline and continued vitality.

    - **Etiology:** Injury to PDL from trauma, periodontal inflammation, ortho., etc.
    - **Diagnosis:**

      - Irregular radiolucency within tooth is often superimposed over root canal.

- Lucency becomes more regular in advanced stages.
- Canal maintains original form.
- Pulp remains responsive.

- **Treatment:**
  - Root canal therapy
  - Debridement of defect
  - Fill defect with alloy, composite, or glass ionomer
- **Prognosis:** Depends on ability to debride defect and quality of fill

Bleaching Nonvital Teeth

Introduction

There are two techniques for bleaching nonvital teeth:

- thermocatalytic
- walking bleach (currently the only technique recommended by IHS endodontists for nonvital bleaching)

A discussion of each of these techniques follows.

Thermocatalytic Technique

The thermocatalytic technique utilizes heat and concentrated hydrogen peroxide to drive oxygen molecules into the dentin. Recently several articles have questioned the possible deleterious effects of nonvital bleaching, especially the thermocatalytic technique. Cervical resorption has been documented to be associated with a percentage of cases which had undergone thermocatalytic bleaching.

Walking Bleach Technique

The walking bleach technique also utilizes liberated oxygen to lighten the coronal tooth structure, but does so without the use of a heated instrument. The walking bleach mixture (sodium perborate mixed with water or hydrogen peroxide) slowly releases oxygen for

approximately 4 to 7 days to bleach the tooth. The walking bleach technique is considered to be ultimately as effective as the thermocatalytic technique and less potentially damaging. Therefore, the IHS endodontists are currently recommending only the walking bleach technique for nonvital bleaching.

Bleaching Factors

Prior to initiating the bleaching procedure, several factors must be considered:

- **The quality of the root canal treatment must be evaluated.**

  - Is the tooth clinically and radiographically asymptomatic?

  - Does the cleaning and shaping and the obturation appear to be properly done?

  If not, the case should first be considered for retreatment.

- **What is the apparent cause of the discoloration?**

  - residual pulpal tissue left in the pulp horn areas (This is the most common reason for discoloration of endodontically treated teeth since silver has been removed from endodontic sealers.)

  - leached metallic restorations

  - leakage and recurrent decay from composite restorations

  - hemorrhage from a hyperemic pulp (most commonly from trauma)

  - intrinsic staining (e.g., tetracycline)

Indications for Nonvital Bleaching

Nonvital bleaching is indicated if the discoloration is a result of organic debris.

Contraindications for Nonvital Bleaching

Nonvital bleaching is contraindicated if--

- the discoloration is a result of leached metallic salts

- the discoloration is a result of intrinsic staining

- the coronal structure is predominately composite restorations

Note: The technique will have no effect on the restorative material.

Caution: Only with the following last two cases, bleaching can cause extreme damage to the periodontium and should not be attempted.

- the tooth structure is severely undermined, especially in the cervical third of the crown.
- the dentin has been grossly removed such that little or no dentin remains

Procedures for Bleaching Nonvital Teeth (Walking Bleach Technique)

The following steps are for using the walking bleach technique:

Step	Action
	Protecting the Cervical Root Area
1	Seal the canal area. **Note:** This is done to prevent the bleaching agents from entering the cervical dentinal tubules and traveling into the cervical PDL area (causing inflammation and possible resorption).
2	Remove the gutta percha obturation to 1 to 3 mm below the CEJ using either-- • a warm instrument (e.g., Glick #1) • rotary instruments (Gates Glidden drills, Peso reamers, or hand files) **Caution:** The use of solvents is contraindicated as their use could disturb the seal of the obturating material.
3	Place a second seal over the fill material which extends to approximately 2 mm coronal to the CEJ. **Note:** IRM is frequently used for this purpose, but there are concerns with using a ZOE material which might interfere with the polymerization of the composite restorative materials. Cavit or Durelon can safely be used for this seal. Cavit should be moistened first prior to placement so that it will set evenly.
	Bleaching
4	Take a shade match prior to isolation with a rubber dam. (This allows you to check the progress at the beginning of each appointment.)

5	Protect gingiva with Orabase or A&D Ointment.
6	Apply rubber dam.
7	Completely remove the following: • lingual access restorative material • caries • defective restorative material
8	Ensure that all pulp horn tissue has been completely removed.
9	Remove cervical gutta percha obturation 2 to 3 mm apical to CEJ.
10	Place cervical seal material (Cavit, Durelon, or zinc phosphate) 2 mm coronal to CEJ.
11	Remove any surface stains visible on inside of preparation with a round bur.
12	Lightly freshen the dentin surface with a round bur to permit easier penetration of bleaching material.
13	Swab entire preparation with 70 percent isopropyl alcohol to remove debris and to allow penetration of bleaching material into dentinal tubules.
14	Dry preparation with air syringe.
15	Mix a thick paste of sodium perborate and water. **Note:** Instead of water you can mix the sodium perborate with 3 percent hydrogen peroxide (or 30 to 35 percent Superoxol for heavily stained cases).
16	Place the mixture into the chamber against the labial dentinal wall.
17	Remove enough walking bleach to allow a 3 mm thickness of IRM or zinc phosphate as the external seal.
Follow-Up	
18	Reappoint the patient for 1 week. **Note:** Weekly replacement of the mixture will produce the quickest results. The tooth should be slightly overbleached as some darkening usually occurs after completion. Terminate bleaching when no further change is noted.
19	Select an appropriate shade of composite for closing the access (usually a shade lighter than the tooth).
20	Use several layers of bonding agent to seal the tubules.