2

Endodontic Treatment Procedures

ROOT CANAL THERAPY

There has long been controversy over the number of appointments it should take to complete a root canal treatment. Years ago endodontics had a terrible reputation for extended treatment time—10 or 12 appointments to complete a single tooth. Over the years this was moderated until, finally, three appointments became standard, one for examination, one for canal preparation, and one for obturation. That is, unless one kept encountering positive bacteriologic cultures. In that case, one kept medicating until a negative culture was obtained, or finally filled the canal anyway in disgust with the system.

Cases that started with vital pulp extirpation were the one exception to multiple treatments. It was assumed that if the pulp was vital but inflamed, it was okay to fill the canal in a single visit since infection was not thought to be a problem. These patients sometimes complained that the tooth was "sore" for a couple of days, but that the soreness "wore off." If treatment was done properly, follow-up radiographs usually revealed continued periapical health.

Encouraged by this success, single-visit treatment became popular. Some limited this approach to cases that were vital. Few dentists treated cases in one appointment that were acutely infected or abscessed.[1,2] Others were daring and treated virtually every case in one appointment. No one took cultures, assuming the bacteria were being destroyed during cleaning and shaping with sodium hypochlorite. Reported success rates were comforting.[3–6] However, disturbing reports started to appear. Sjogren and colleagues sounded a word of caution.[7] At a single visit they cleaned and obturated 55 single canal teeth with apical periodontitis. **Following cleaning and shaping** with sodium hypochlorite, and just **before obturation**, they cultured the canals. Using advanced

anaerobic techniques, they found that 22 (40%) of the canals tested positive and 33 (60%) of the canals were negative.

Periapical healing was then followed up for **5 years**. Complete healing occurred in 94% of the 33 negative-culture cases. But in the 22 positive cases, "the success rate had fallen to just 68%," a statistically significant difference. In other words, if a canal is still infected before filling at a single sitting, there may be a 26% greater chance of failure than if the canal is free of bacteria.[7] But who knows which canal is positive and which canal is negative?

Siqueira and colleagues recently examined the microbiota of infected root canals and found bacteria penetrating the dentinal tubuli as deeply as 300 microns (Figure 2-1).[8] These are the bacteria that might easily avoid detection and eradication. Gutierrez and colleagues "found bacteria 250 microns deep within tubules **even after root canal instrumentation.**"[9]

Bacteria harbored in the apical third of dentin could well be the source of refractory periapical infection following acceptable root canal treatment so well described by Barnett and colleagues and demonstrated by Leonardo and colleagues (Figure 2-2).[10–12]

To fill or not to fill? That is the question! Does single-appointment root canal treatment provide enough certainty of success to trust every case to one sitting?

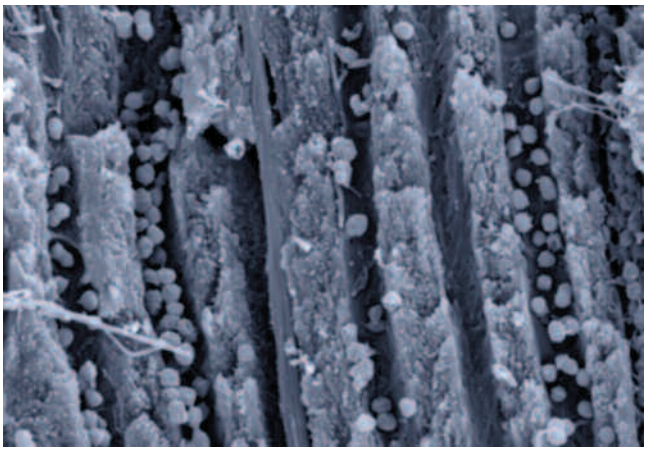


Figure 2-1 Cocci in dentinal tubules approximately 300 microns from the main root canal. Some cells are dividing (×5,000 original magnification). Reproduced with permission from Siqueira JF et al.[8]

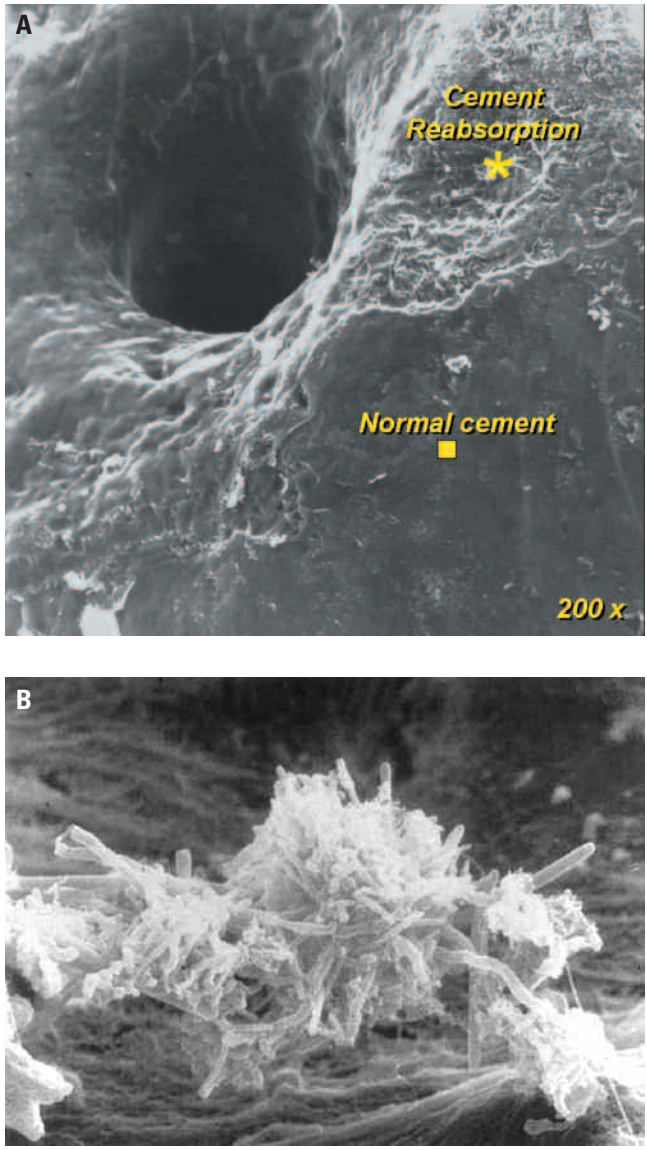


Figure 2-2 ***A,*** Root apex with morphologic changes in the apical cementum close to the apical foramen showing areas of intact cementum between areas of resorption. ***B,*** Apical biofilm on external root surface with the presence of filaments and bacilli. ***A–C*** reproduced with permission from Leonardo MR et al.[12] ***Continued on next page.***

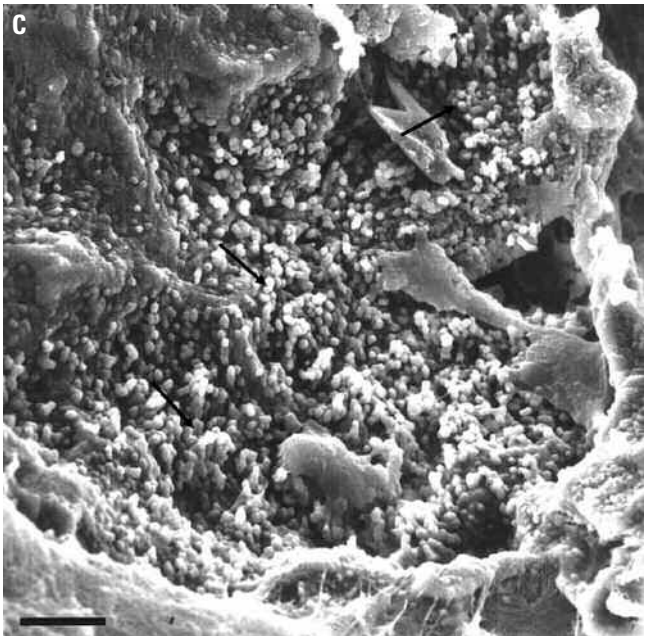


Figure 2-2 ***Continued.*** ***C,*** Higher magnification of image ***B*** showing the presence of cocci forming apical biofilm. ***A–C*** reproduced with permission from Leonardo MR et al.[12]

Root canal treatment consists, in major part, of cleaning and shaping the root canal with files and reamers, either hand driven or motor driven, disinfecting the canal, and then obturating the canal space. On occasion endodontists also prepare post space and place posts for the referring dentist. Bleaching discolored teeth (Figure 2-3), performing surgery to correct periradicular problems (Figure 2-4), reimplanting traumatically avulsed teeth as well as endosseous implants, treating traumatically damaged teeth, diagnosing and treating intraoral pain, and restoring endodontically treated teeth all fall under the purview of endodontics.

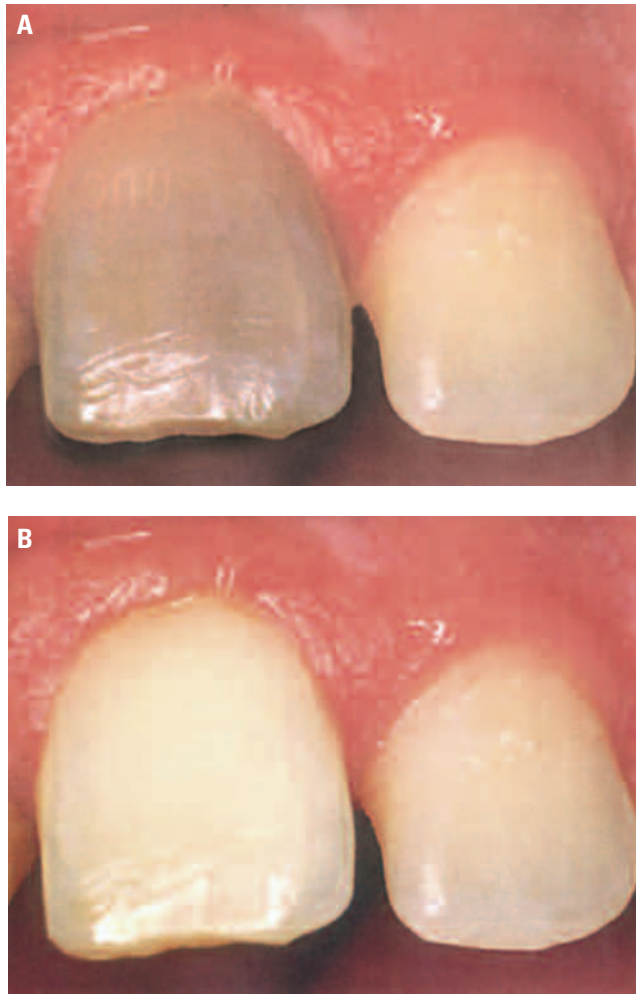


Figure 2-3 ***A,*** Post-traumatic discoloration of a maxillary left central incisor. ***B,*** A mixture of perborate and distilled water placed in the chamber two times over 3 weeks achieved a lightening of the tooth to its natural color. Courtesy of A. Claisse-Crinquette.

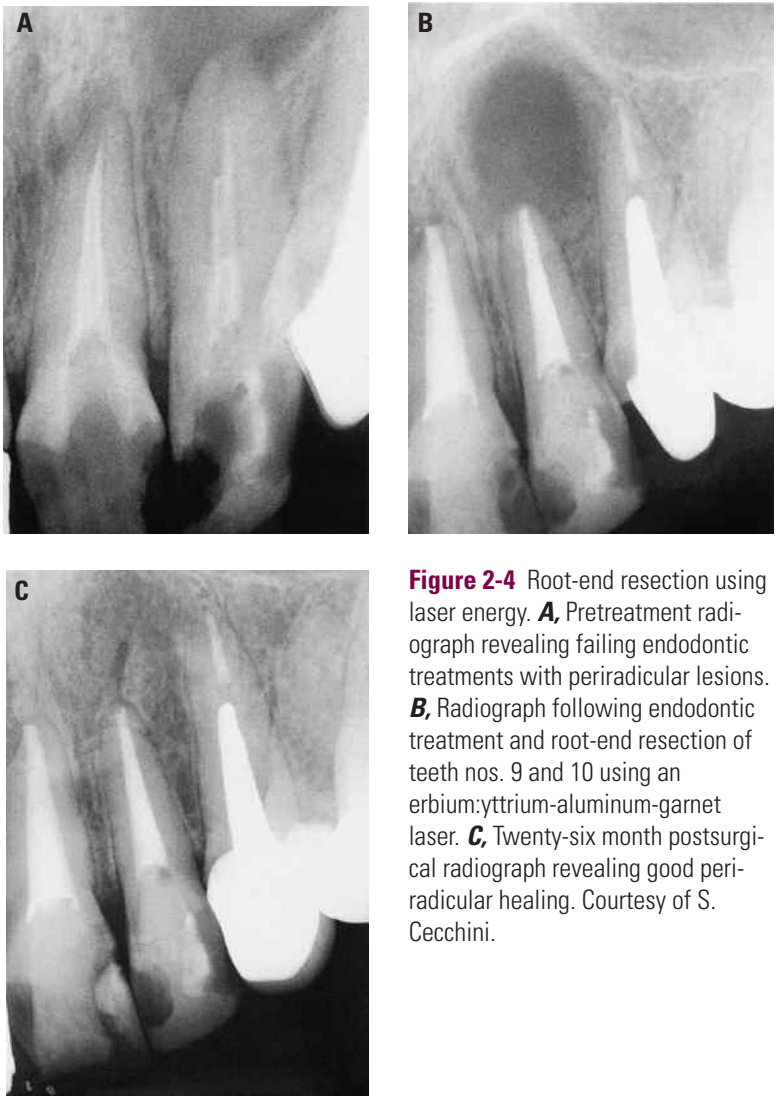


Figure 2-4 Root-end resection using laser energy. ***A,*** Pretreatment radiograph revealing failing endodontic treatments with periradicular lesions. ***B,*** Radiograph following endodontic treatment and root-end resection of teeth nos. 9 and 10 using an erbium:yttrium-aluminum-garnet laser. ***C,*** Twenty-six month postsurgical radiograph revealing good periradicular healing. Courtesy of S. Cecchini.

VITAL PULP THERAPY

There are occasions when one feels a pulp is salvable, its "sick" condition reversible. At these times **vital pulp therapy** is employed. This might consist of the so-called **indirect pulp capping** procedure, **direct pulp capping,** and **coronal pulpotomy,** as well as **apexification** in partially formed teeth. Most of these latter procedures are carried out in children.

Indirect Pulp Capping

Indirect pulp capping has long been a controversial procedure. The technique is confined primarily to primary or young permanent teeth. It is defined as placing a medicament over a thin layer of carious dentin left after deep excavation, with **no pulp exposure**. The rationale is based on the fact that decalcification of the dentin precedes bacterial invasion and that the pulp is not infected. It might be inflamed, but the inflammation is reversible if the cause (infected caries) is removed and time allows healing**.** To properly determine the pulpal status of these teeth, the following criteria must be followed: no apparent radiologic damage, no history of spontaneous pain, no pain from percussion, no pain from mastication, and no degree of mobility.

The most popular form of this procedure is the so-called **one-appointment technique**. Under anesthesia and with the use of a rubber dam, the soft, necrotic, infected dentin is removed with a slow round bur. The remaining dentin is covered with a **hard-setting** calcium hydroxide cement, which is then protected with a reinforced zinc oxide–eugenol (ZOE) cement (IRM Dentsply-Caulk, York, PA) or glass ionomer. It is most important that the treatment be protected from microleakage of bacteria (Figure 2-5). Do not disturb for 6 to 8 weeks. Some dentists place a final amalgam restoration or stainless steel crown at this juncture. Success ranges from 62% to 98%[13,14]; however, the success rate for adults is discouraging.

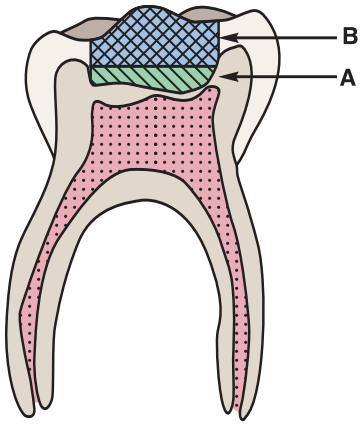


Figure 2-5 Indirect pulp-capping technique. A, medicament of zinc oxide–eugenol cement, calcium hydroxide, or both is placed against the remaining caries. B, lasting temporary restoration is placed. Following the repair, both materials are removed along with softened caries, and final restorations are placed.

Direct Pulp Capping

Direct pulp capping is carried out on healthy pulps that have been inadvertently exposed during caries excavation or from trauma. The treatment objective is to seal the pulp against bacterial leakage by placing a biocompatible agent on the exposure site that will encourage the formation of a dentin bridge. The criteria for treatment are the same as those listed for indirect pulp capping—any sign of pulp disease.

The protocol for direct pulp capping involves the following steps. A rubber dam should be placed, the bleeding controlled, the cavity wiped clean with a mild disinfectant agent, and the pinpoint exposure covered with the capping agent. This should then be sealed in place with a dentin bonding agent and covered over with a thick layer of hard-setting cement (Figure 2-6). Prevention of bacterial microleakage is imperative, so an amalgam restoration or a stainless crown should be placed in posterior teeth or a composite sealed with dentin bonding in the anterior. Months later, if there have been no overt signs of pathologic change, a permanent restoration may be placed in adults. Success is actually better in adults than in children.

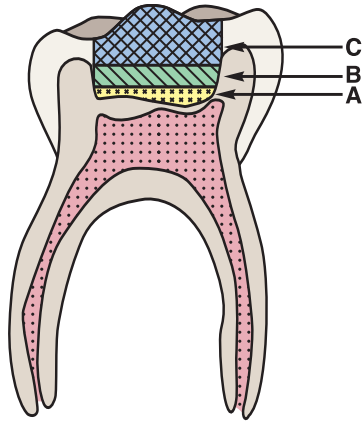


Figure 2-6 Direct pulp-capping technique. A, capping material covers the pulp exposure and floor of the cavity. A protective base of zinc oxide–eugenol is placed, B, and covered with an amalgam restoration ,C.

The agents used to stimulate dentin formation are legion. The two favorites, however, are calcium hydroxide and mineral trioxide aggregate (MTA, Dentsply/Tulsa). Zinc oxide–eugenol has not been successful. Recent success reports with MTA have be most encouraging.[15] The sealant of choice could be C & B MetaBond (Parkell Co.).

Pulpotomy

Pulpotomy is the most widely used technique for carious pulp exposures in primary and young permanent teeth. It is also the most abused—wishful thinking, wishful waiting. Pulpotomy is the surgical removal of the entire coronal pulp presumed to be inflamed and/or infected. A germicidal medicament is then placed over the stumps of the pulp left in the roots. Again, there should be no signs of pathologic change in the radicular pulp or periradicular area. Bleeding that is profuse and unstoppable, or absent, sluggish, or purulent is a contraindication, as is sensitivity to percussion.

A number of medicaments have been tried, but there is no panacea. The favorite over the ages appears to be formocresol. The traditional one-appointment pulpotomy for primary teeth involves the follow-

ing steps. The tooth is anesthetized, and a rubber dam is placed. All carious material is removed, and the coronal pulp is completely removed with a slow-speed, large, round bur. Bleeding is arrested, and diluted formocresol (1:5) is applied for 3 to 5 minutes. A hard ZOE cement base is placed, and the tooth is restored with a stainless crown (Figure 2-7). A 3-year survival rate study showed a decreasing rate of success—91% success at 3 months and 70% success at 3 years[16]—a decrease that may have been due to bacterial microleakage. Calcium hydroxide and zinc oxide–eugenol are **not** recommended. On the other hand, MTA and glutaraldehyde have both been used successfully.[17,18] Research has also been carried out using dentin adhesives to cover the stumps.

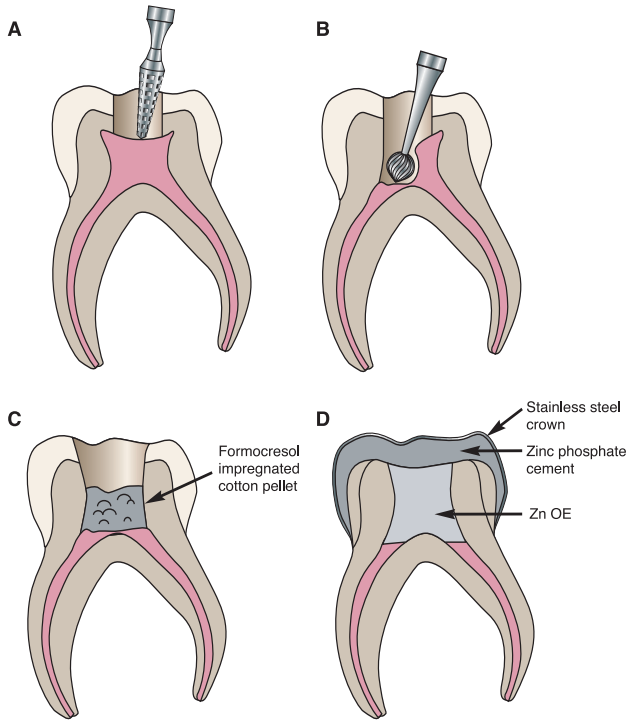
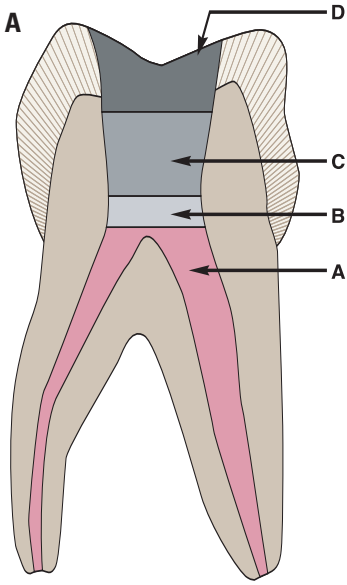


Figure 2-7 Step-by-step technique of one-appointment formocresol pulpotomy. ***A,*** Exposure of pulp by roof removal. ***B,*** Coronal pulp amputation with a round bur. Hemostasis with dry cotton or epinephrine. ***C,*** Application of formocresol for 1 minute. (Excess medicament is expressed from cotton before placement.) ***D,*** Following formocresol removal, zinc oxide–eugenol base and stainless steel crown are placed.

Pulpotomy in Young Permanent Teeth

Pulpotomy in young permanent teeth, particularly those with incompletely formed roots and open apices, has been recommended using calcium hydroxide as the agent of repair. The procedure is similar to that outlined above, except that in young adult teeth, calcium hydroxide or **MTA** is substituted for formocresol and is left in place (Figure 2-8). If infection is not allowed to intervene, apexification should take place to complete root growth and form



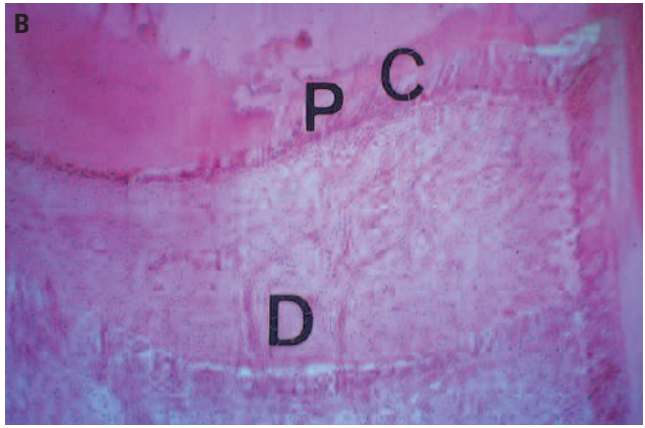


Figure 2-8 ***A,*** Calcium hydroxide pulpotomy in a young permanent molar. The cavity is prepared, caries and the chamber roof are removed, and the pulp is amputated to the canal orifices. Following hemostasis, commercial calcium hydroxide is placed and protected with zinc oxide-eugenol and an amalgam filling or stainless crown. ***B,*** Mineral trioxide aggregate (MTA) used as a covering following pulpotomy; *(P)* and *(C)* indicate the remnants of MTA at the pulpotomy site. Note the formation of odontoblasts immediately below and the formation of new dentin *(D).* Courtesy of M. Torabinejad and I.L. Soares.

and close the apical orifice. Amalgam fillings or stainless steel crowns are recommended to prevent microleakage that eventually leads to failure.

Apexification

Apexification of incompletely formed roots and apex, the so-called blunderbuss canal, can be accomplished by restoring root growth and apical closure. The genetic potential is there if only the infection and inflammation can be arrested. It is also believed that this phenomenon can be initiated by introducing a stimulating agent such as calcium hydroxide or MTA. Unfortunately, $CaOH_2$ tends to make the dentin brittle; hence, there is the potential for later root fracture.

A better way to bring about apexification is as follows:

1. The necrotic pulp and open divergent apex are gently cleaned with large blunted files, being careful not to reduce the thickness of the dentin. Plentiful irrigation with NaOCl removes debris and bacteria.
2. The canal is filled with calcium hydroxide sealed in place for 2 weeks. This should effectively disinfect the canal but not damage the dentin.
3. The CaOH is removed, and the apical portion of the canal is plugged with MTA.
4. When the MTA has cured the, root canal filling is completed with gutta-percha and a bonded resin restoration that extends below the cervical level of the tooth to strengthen the root's resistance to fracture. Follow-up radiographs should reveal the progression of the root growth and apex closure (Figure 2-9).

Pulpectomy

Pulpectomy, or pulp extirpation, is the removal of a vital pulp, diseased though it may be. **Total pulpectomy** is the removal of the pulp in fully formed roots, where the apical "portal of exit" is sufficiently closed to form an "apical stop" in obturation. **Partial pulpectomy** indicates that pulp extirpation terminates short of the apical orifice. It is used in those cases in which the apex has not fully formed and one hopes that the remaining pulp tissue will continue to fully form the root (Figure 2-10). Pulpectomy is indicated in all cases of irreversible pulp disease including internal resorption. In the event of acute pulpalgia, pulpectomy extends blessed relief to a suffering patient.

Figure 2-9 The use of mineral trioxide aggregate (MTA) for apexification. ***A,*** A combination of luxation injury and crown fractures led to pulp necrosis in the central incisors. ***B,*** After pulp extirpation the canals were medicated with calcium hydroxide for 2 weeks, followed by the placement of MTA in the apical portion of the canals. After the MTA had cured, the coronal portions of the canals were filled with bonded resin and access cavities were restored with composite. ***C,*** Two years later the radiograph shows good periradicular repair and evidence of apical hard tissue.***(Continued on the next page).***

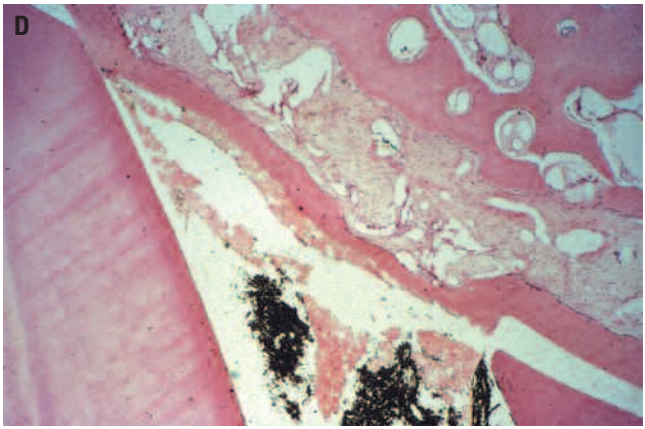


Figure 2-9 ***Continued. D,*** MTA used as a root-end filling material in a monkey. Note the band of cementum formed to close the root end. Courtesy of M. Torabinejad.

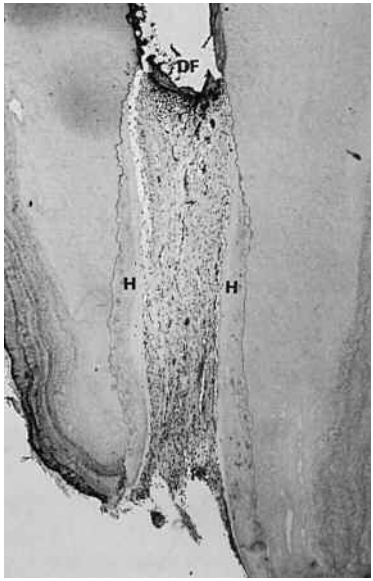


Figure 2-10 Partial pulpectomy. An observation period of 6 months is needed. There is only a slight accumulation of lymphocytes adjacent to a plug of dentin particles and remnants of Kloropercha. Cell-rich fibrous connective tissue occupies the residual pulp canal. Large deposits of hard tissue *(H)* are present along the walls. Courtesy of P. Horstad and B. Nygaard-Ostby.

The following are the steps for performing pulpectomy:

1. Obtain regional anesthesia.
2. Open into the pulp and test for depth of anesthesia.
3. If necessary, inject anesthesia pulpally.
4. Extirpate the coronal pulp.
5. Extirpate the radicular pulp with barbed broaches.
6. Control bleeding and clean and shape the canal.
7. Obturate the canal. In these cases it is deemed appropriate to fill the canal at the same appointment since infection is not a problem. The patient may experience slight postoperative discomfort from the pulp amputation. Restoration of the crown may follow immediately.

Pulpectomy in a Large Canal

A pathway for the broach is formed by sliding a small anesthetic needle to the apical third and depositing a drop of anesthesia to control bleeding. A broach, small enough not to bind, is passed down the pathway to the apical third, twisted slowly to engage the fibrous pulp tissue, and slowly withdrawn. If fortunate, the entire pulp is removed (Figure 2-11). If not, the process is repeated. If the pulp is extra large, two or three broaches may be inserted simultaneously,

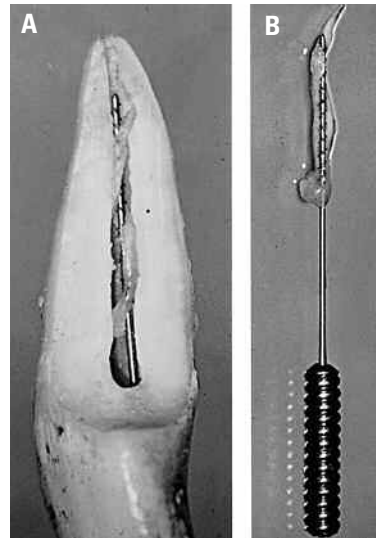


Figure 2-11 ***A,*** Total pulpectomy with a large broach that fits loosely in the canal. With careful rotation of the broach, the pulp has become entwined and will be removed with retraction. ***B,*** Total pulpectomy by a barbed broach. Young, huge pulps may require two or three broaches inserted simultaneously to successfully entwine the pulp.

twisted, and slowly withdrawn. Never lock broaches in the canal—they separate! They can be used to carefully "scrub" the walls of remaining fragments. Barbed broaches must be used with caution!

Pulpectomy in a Narrow Canal

In the case of pulpectomy in a narrow canal, broaches are not used. Small files are recommended, and the pulp is removed during cleaning and shaping. But be careful! Pulp fragments tend to pack at the apex during cleaning and shaping and block access to the apical orifice. Fine instruments and copious irrigation with NaOCl must be used to remove the blockage.

Partial Pulpectomy

The site where the pulp is to be amputated is measured on a large, blunted, Hedstrom file. At this point the file is gently "screwed" into the canal to engage the pulp, and is then slowly withdrawn. Bleeding is arrested. This should leave a stump of vital pulp tissue that may be necessary to complete root growth. The coronal portion of the canal is then cleaned and shaped, but it is probably not wise to obturate the canal at this appointment because the occasional patient continues to have pulpal pain. In this event the patient must return and a total pulpectomy be performed. If the partial pulpectomy was successful, the remaining portion of the canal is gently obturated at a subsequent appointment. Without undue pressure and with blunted gutta-percha points, obturation is limited to the point of amputation.

FINAL NOTES

Additional endodontic procedures are covered in the following chapters: access (Chapters 3 and 4); cleaning, shaping, and medicating the canal (Chapter 5); obturation (Chapter 6); endodontic surgery (Chapter 7); mishaps (Chapter 8); emergencies, acute pain, dental trauma, and dental infection (Chapter 9); restoration of endodontically treated teeth (Chapter 10); discoloration and bleaching (Chapter 11).

For more details on any of these subjects, the reader is referred to *Endodontics* by Ingle and Bakland, published by BC Decker, Hamilton, ON; e-mail: **info@bcdecker.com.**

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