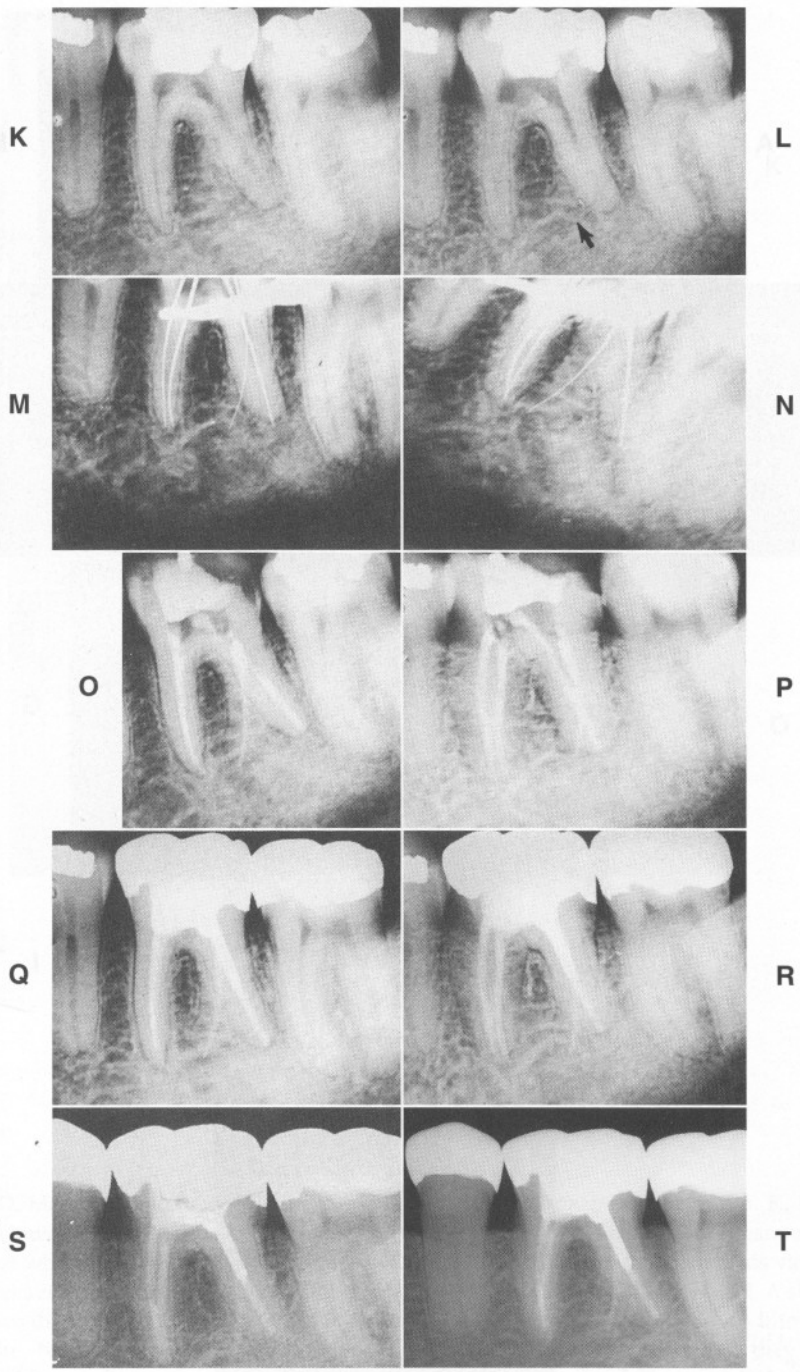


FIGURE 4-47, cont'd **K** to **T,** Very long-term result, four canals, three roots, with distobuccal root very curved. **K,** Straight view as shown in Figure 4-46, *A*. **L,** Angled view as shown in Figure 4-46, *B,* with very curved distolingual root *(arrow)*. In cases with separate distolingual roots, the canal is smaller and generally more curved than the distobuccal canal. Initially the distolingual canal curves to the distolingual and then turns to curve back to the mesiobuccal. **M** and **N,** Views of files in place, straight and angled from the distal. Note extreme curvature of the distolingual canal. **O** and **P,** Straight and angled views after canal filling with laterally condensed gutta-percha and Wach's paste, post space prepared in the distobuccal. **Q** and **R,** Four years after treatment, area remains normal. **S,** Twenty years after original treatment, excellent result. **T,** Thirty-one years after original treatment, still excellent result. (Restorations by Dr. Arnold Wax, Chicago.)

and ribbon shaped, whereas the mesial canals are thin. The cervical cross section shows that the chamber floor is trapezoidal. This means that the access cavity for this tooth is also trapezoidal, not triangular.

Access preparations for both first and second mandibular molars are essentially identical. The general outline is trapezoidal with rounded corners. The shortest side is to the distal aspect, with the mesial side being slightly longer. The buccal and lingual sides are of approximately the same length and taper toward each other distally. The mesiolingual canal lies beneath the mesiolingual cusp. The mesiobuccal canal is the most difficult to locate, but

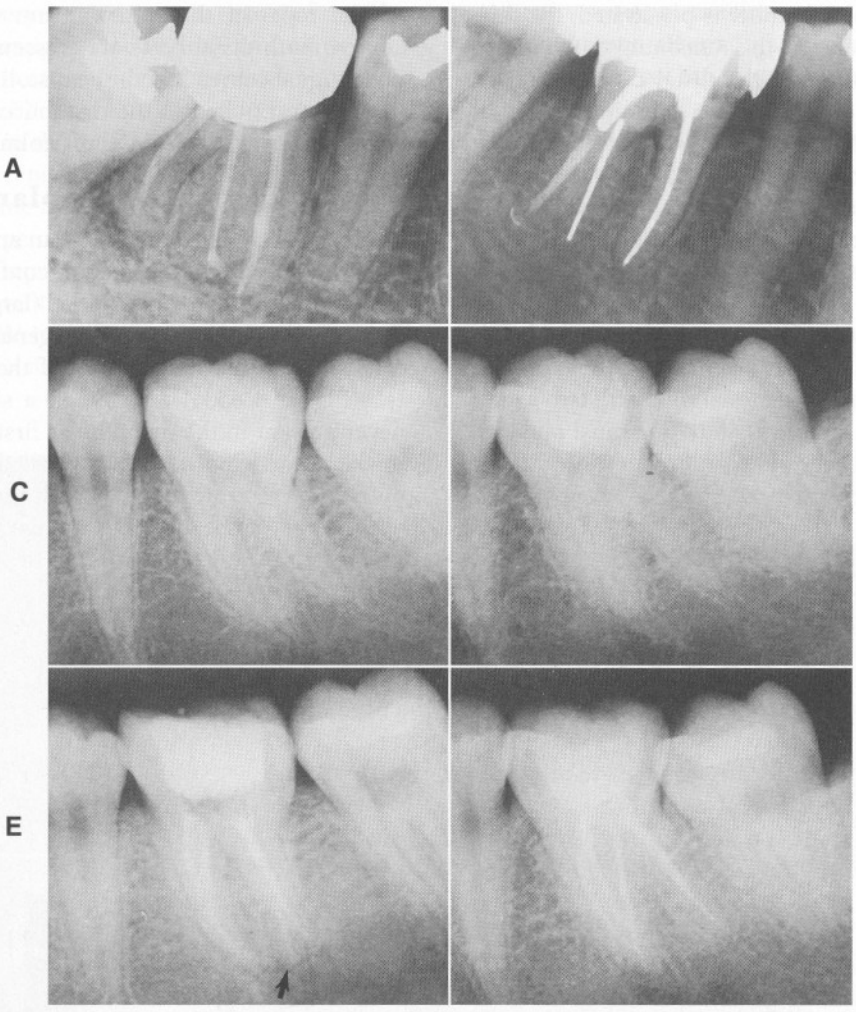


FIGURE 4-48 **Unusual mandibular first molars. A,** Immediate postfilling film, two mesial canals close together and two separate and distinct distal roots. **B,** Ten years postoperative film of a mandibular first molar with a similar configuration. Most of the patients in whom I have treated such teeth have been Asians. **C** and **D,** Straight view and angled view from the distal of preoperative film of mandibular first molar with four separate roots, the two mesial roots being very close together but the distal roots far apart. **E** and **F,** Straight view and angled view from the distal, immediate postfilling films; four canals filled with laterally condensed gutta-percha and Wach's paste. The distolingual root *(arrow)* is the most curved, although it seems relatively straight on the film. That is because the root curves first to the lingual and then sharply to the buccal, both in the plane of the x-ray cone. This patient was Caucasian, so this combination is not limited to Asians.

it is usually found on a straight line to the buccal from the mesiolingual orifice and often is tucked deeply beneath the mesiobuccal cusp. The orifices may be connected by a corridor extending part or all the way to the apex. When difficulty is encountered in locating the mesiobuccal canal, the operator should have no qualms about cutting down the mesiobuccal portion of the tooth, even as far as the height of the gingiva, to aid in visualization. If the canal is not properly found and debrided, the case might be a failure, and conservation of tooth structure would be useless. If endodontic therapy is successful, the reduced cusp is easily built up with a casting.

Many authors have suggested the triangular-shaped entry for this tooth. However, the distal canal is kidney shaped in most cases, with the greatest width buccolingually. Also, two canals exiting the floor of the chamber are found in the distal root approximately 30% of the time, one on the buccal aspect and the other toward the distal and lingual aspects. Attempting to enlarge the single large canal or to locate the possibly present second canal requires a much wider access than that afforded at the apex of a triangle. However, by widening this area buccolingually to produce a trapezoidal opening, sufficient space is made available for examination of the chamber floor, and a desirable canal preparation can be achieved (see Figure 4-45).

The distal canal is the largest and easiest to find. Therefore it should be located first, lying slightly distal to the buccal groove, closer to the buccal than the lingual wall. A tapered fissure bur is used in the central pit and the preparation increased in depth by moving the bur mesially and distally from the central pit to the mesial pit.

Once the roof of the pulp chamber is penetrated, the safe-tipped bur is used to remove the remaining overhanging tooth structure. The orifice of the distal canal is located with the endodontic explorer. The safe-tipped bur is placed in this area and moved mesially and slightly to the lingual side to uncover the mesiolingual canal. After the latter is located, the safe-tipped bur is moved buccally to expose the mesiobuccal orifice. The entire preparation is confined to the mesial two thirds of the crown (see Figure 4-45).

There is a rare variant of the typical two mesial plus one or two distal canals that is seen in some mandibular first molars. This type has one mesial root with two canals close to each other that almost file into one canal plus two separate and distinct distal roots (see Figure 4-48). In my experience, most of these cases, but not all, have occurred in Asian patients.

The roots in this situation are very short but quite curved. Both distal roots are crescent shaped; that is, the distolingual curves first to the distolingual and then to the mesiobuccal, whereas the distobuccal curves first to the distobuccal and then to the mesiolingual.

Mandibular Second Molar

This tooth has more variants than any of the molar teeth, even though the most common configuration is the same as that of the first molar—one (larger) distal canal and two (smaller) mesial canals. In general the correct access cavity to be used mimics that of the adjacent first molar (see Figure 4-45, *A*). Although a single mesial canal is never present in the mandibular first molar, it does occur in the second molar. This bicanaled tooth has a slightly different access preparation, with the trapezoid narrowed to the mesial to be more rectangular (Figure 4-49, *A*). The

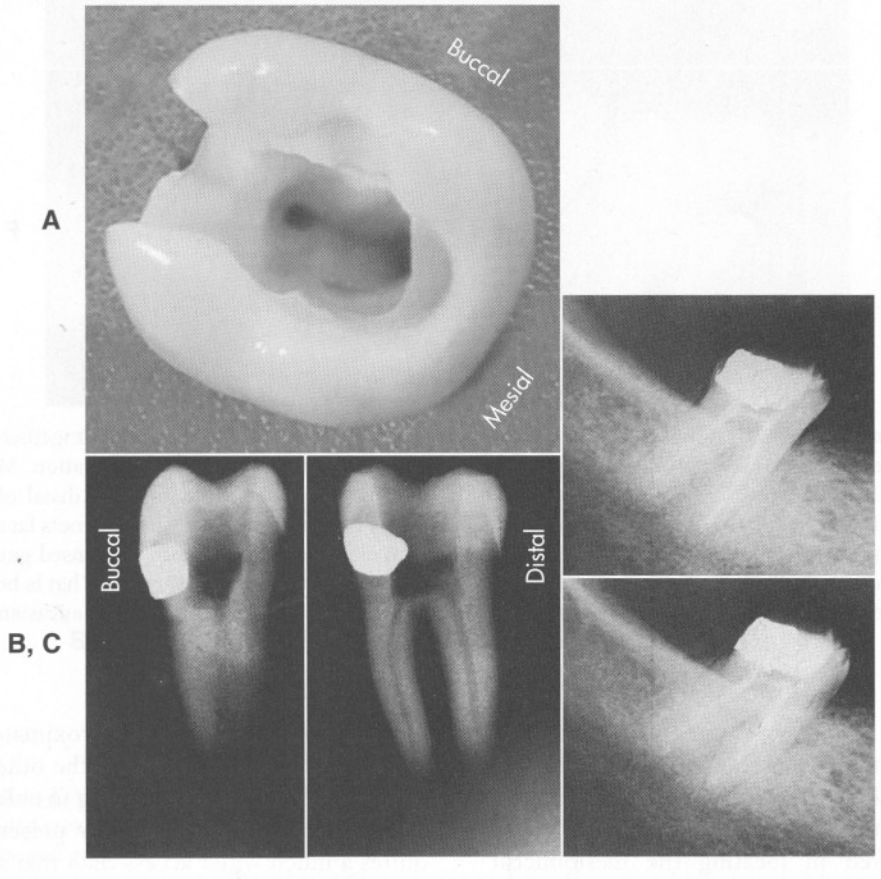


FIGURE 4-49 Access cavity preparations and canal configuration in bicanaled mandibular second molar. This is a rare configuration and, according to the study by Weine et al and others, occurs as infrequently as 4% of the time. **A,** Outline form is still trapezoidal, as in all mandibular molars, to allow for large distal canal and for careful examination of mesial portion to verify that only one canal is present. **B,** Proximal view displays large occlusal opening to allow examination for a second mesial canal, if present. In this view the two canals are superimposed. **C,** Buccal view, showing straight distal canal and mesial canal curving from the floor of the chamber first to the mesial and then to the distal. **D** and **E,** Immediate postfilling films after canal filling with laterally condensed gutta-percha and Wach's paste. To be certain that only one canal is present in the mesial root, two radiographs, angled differently from each other by at least 45 degrees, must be taken of both the initial file in place and the final filling. Film *D* was taken straight on, and film *E* was taken from the mesial at a horizontal angulation of 50 degrees. In both films the canal filling is well centered in the root. If another canal were present, in one of these two films the canal would be eccentric in the mesial root, as seen in Figure 4-50, *B* and *C*.

operator must be very certain on the basis of viewing radiographs (both straight and angled) and exploration before settling for treating only one mesial canal (see Figure 4-49, *D* and *E*). Usually when only one canal is present, it is located in the middle of the mesial half of the chamber and will accept a size 20 or larger instrument at initial attempt. Routine treatment of only one mesial canal will lead to a high percentage of failures (Figure 4-50). Some studies have reported that the percentage of one mesial canal in this tooth is greater than 50%. I disagree, and in the report of Weine, Pasiewicz, and Rice, only 4.0% were found to have a single mesial canal (see Table 4-6). When two mesial canals are present, a Type II system is more common than a Type III, which is much different than the relationship found in the mandibular first molar (Figure 4-51).

The mandibular second molar also may have only a single root with several variants: one single, large canal; two canals that merge (Figure 4-52) or remain separate (Figure 4-53); or the so-called C-shaped tooth (Figure 4-54), first described by Cooke and Cox. Although in the first two instances therapy is comparatively straight forward, the C-shaped tooth may be quite difficult to both diagnose and treat.

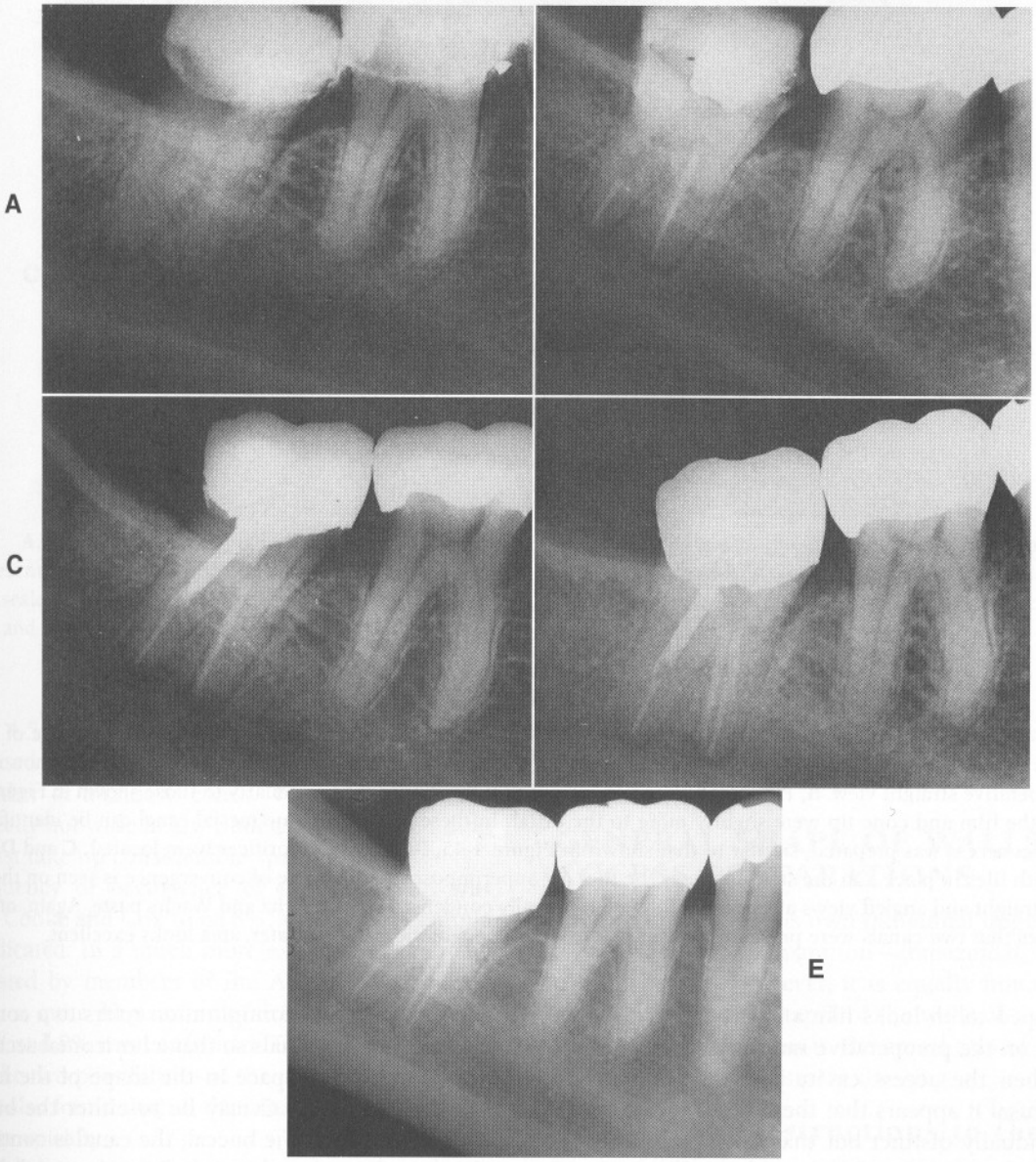


FIGURE 4-50 **Very long-term result of re-treatment of failure caused by filling only one mesial canal in mandibular second molar. A,** Preoperative radiograph of mandibular second molar. **B,** The operator assumed that there was only one mesial and one distal canal. **C,** Eighteen months after treatment, a radiolucency had developed around mesial root, and the tooth was tender to percussion. **D,** I located the additional canal, the mesiolingual, and the symptoms vanished. **E,** Twenty-two years after re-treatment, area has healed, tooth is tight and comfortable. (Restorations by Dr. Arnold Wax, Chicago.)

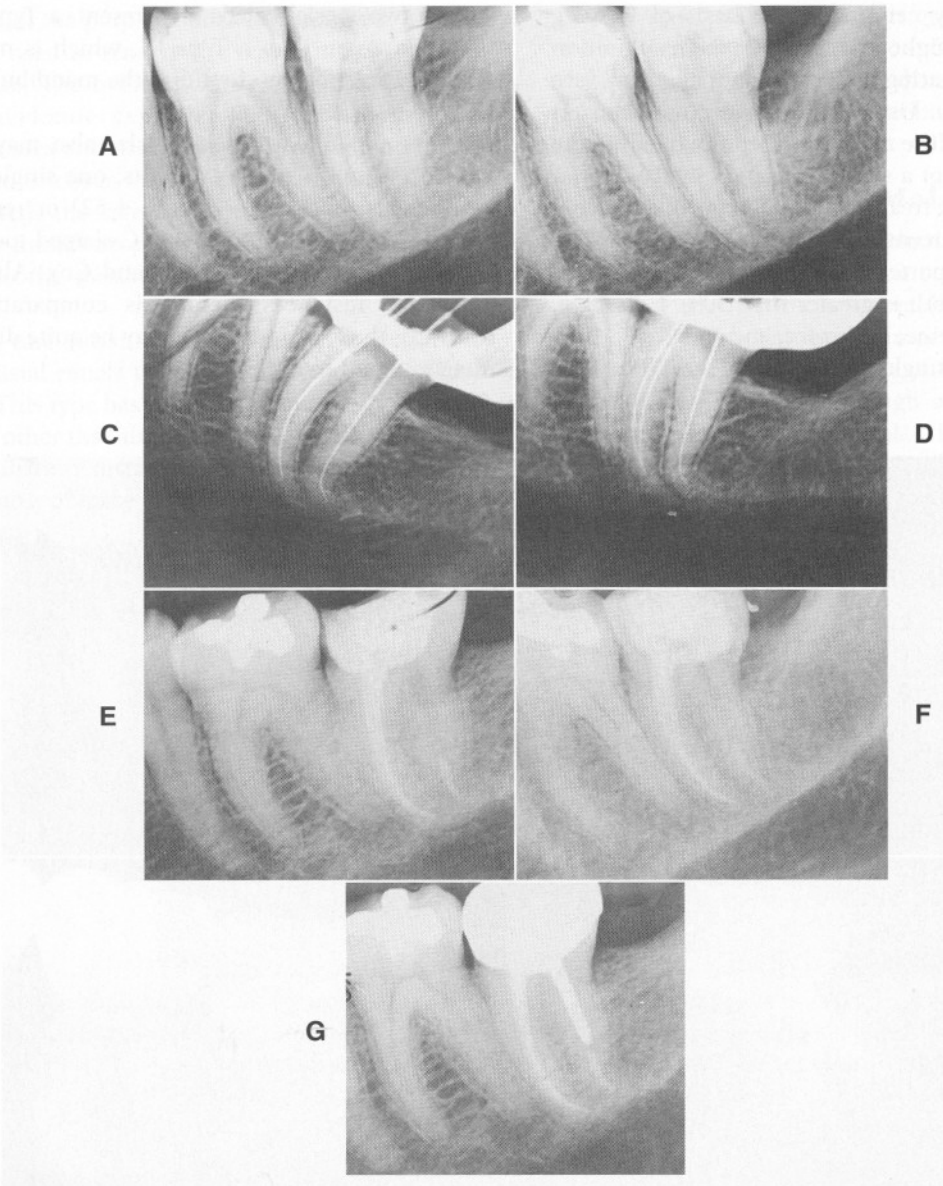


FIGURE 4-51 Mandibular second molar with Type II canal system in mesial root. The variance in percentage of Type II canal systems differs between mandibular first and second molar, being less common in the first molar and more common in the second molar. **A,** Preoperative straight view. **B,** Preoperative angled view. These films were taken similarly to those shown in Figure 4-46, *A* and *B,* except that the film and cone tip were slightly more to the distal. In these views only one mesial canal can be identified. However, when the correct access was prepared, similar to that shown in Figure 4-45, *B,* three canal orifices were located. **C** and **D,** Straight and angled view with files in place. On the straight views the files are superimposed, but the site of convergence is seen on the angled view *(D)*. **E** and **F,** Straight and angled views after canal filling with laterally condensed gutta-percha and Wach's paste. Again, only the angled view, *F,* indicates that two canals were present in the mesial root. **G,** Straight view, 2 years later, area looks excellent.

The C-shaped tooth looks like a routine second molar when viewed on the preoperative radiographs (see Figure 4-54, *A*). When the access cavity preparation is made, from the occlusal it appears that the orifices of the canals are not individually distinct but that there is a C-shaped trough on the floor of the chamber. If one file is placed in the mesial canal and one in the distal, the radiograph may reveal that both files are in the same canal or that the more mesial file has, perhaps, caused a perforation (see Figure 4-54, *B*).

The C-shaped configuration refers to a continuous slit between all the canals so that a horizontal section through the root yields a space in the shape of the letter *C*. The closed area of the C may be to either the buccal or the lingual. If it is to the buccal, the canal is continuous from the mesiobuccal to the mesiolingual around the lingual to the distolingual to the distobuccal. The more common closure is to the lingual, the slit going from the mesiolingual to the mesiobuccal along the buccal to the distobuccal to the distolingual. When the canals are filled



FIGURE 4-52 **A,** Preoperative radiograph of mandibular second molar with a large, single root, two canals, and a periapical lesion. **B,** Two canals are present, merging into a single apical site of exiting. **C,** Canal filling with laterally condensed gutta-percha and Wach's paste. Some excess sealer was pushed out of the apex due to the relatively wide apical exit. **D,** Excellent healing 2 years after treatment, all excess sealer and periapical lesion are gone without periapical surgery. (Restorations by Dr. Neal Baigh, LaGrange, Ill.)

(see Figure 4-54, *D*), no individual canal really appears well condensed despite deep penetration of spreaders and a high number of auxiliary cones. This is because the canals are really not wide in any dimension, and the filling material must take up considerable space.

The frequency of occurrence of this condition was reported by Cooke and Cox to be 8%, although no sample size was indicated. In a much more exhaustive report by Weine, assisted by members of the Arizona Endodontic Association, a quite large sample size—811 teeth—was investigated, and 8% was confirmed. The latter study also confirmed the two possibilities of the open/closed section of the C but also found that all the canal segments did not always merge apically.

Two roots being present is the most common condition for the mandibular second molar (96% in the study by Weine, Pasiewicz, and Rice). In the mesial root, Type I, II, or III configurations may be present. In the distal root a Type I canal is very dominant, but Types II and III systems also are possible, although rare. Three separate roots may be found (Figure 4-55), but only rarely.

GENERAL SHAPE OF WALLS IN ACCESS PREPARATIONS

Each tooth requires its own individual lingual or occlusal shape for access preparation—trapezoidal, quadrilateral, oval, or round. However, it is equally important to have the correct shape or taper of the walls of the preparation to give maximal access to the apical area of the canal and to retain the intertreatment dressing.

Removal of Obstructions to the Apex

Many of the errors in access cavity preparation are due to the dentist's desire to limit the removal of tooth structure. Believing that conservation of enamel and dentin will aid in the stability of the tooth during treatment and better retain the future restoration, the dentist prepares an access

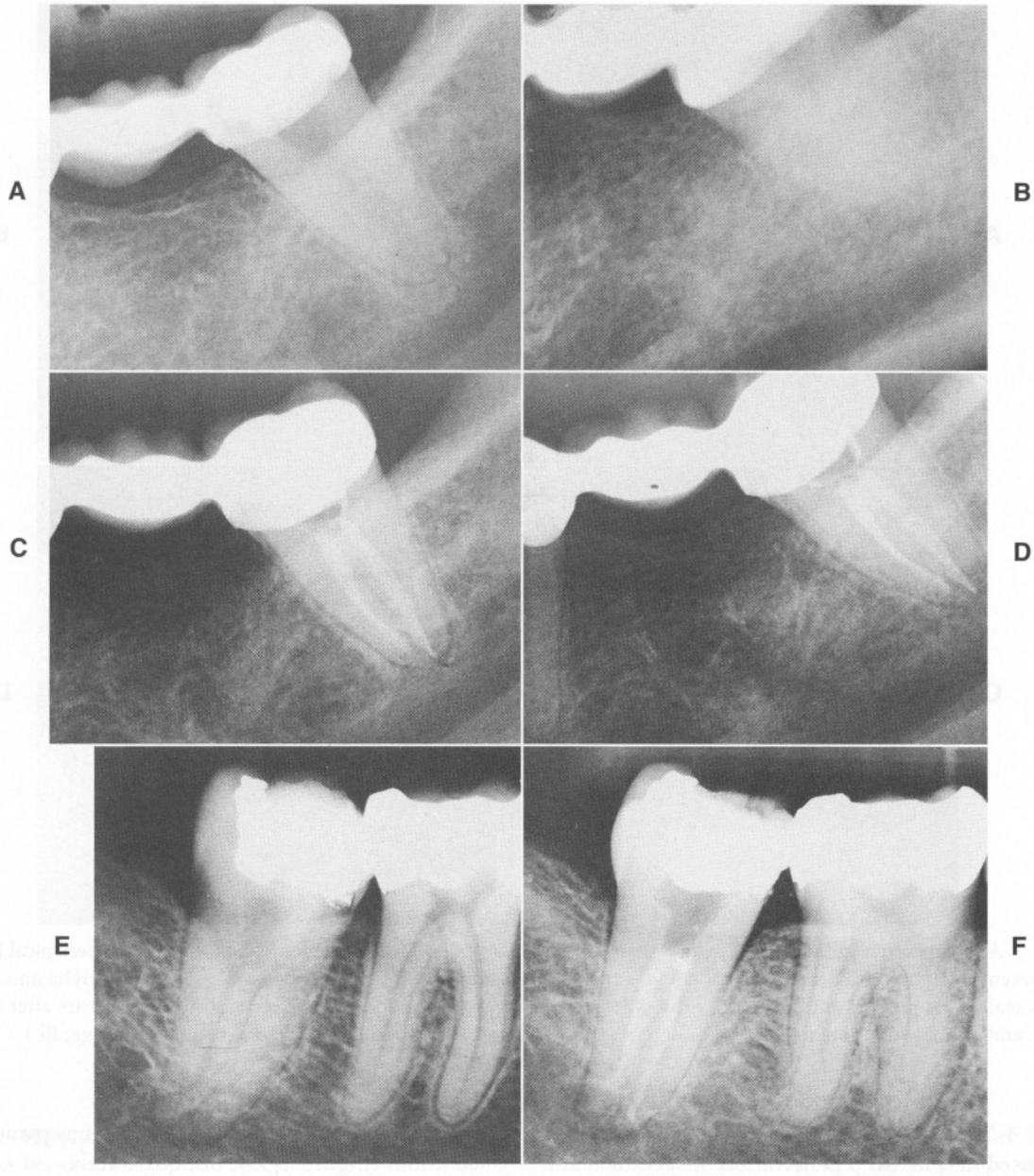


FIGURE 4-53 One root with two separate canals in mandibular second molar. A, Preoperative straight view, indicating a single root, but individual canal shape difficult to identify. It might have a single canal, two merging canals, or two separate canals. **B,** Preoperative angled view gives no additional information. **C** and **D,** Postoperative views, two separate canals, each filled with laterally condensed gutta-percha and Wach's paste. (Restorations by Dr. Sue Klyber, Chicago.) **E,** Preoperative view. **F,** Immediate postfilling film, canals filled with laterally condensed gutta-percha and Wach's paste. Both these teeth are similar to the C-shaped mandibular second molar (see Figure 4-54), only the canals have remained separate instead of merging.

of minimal size. Unfortunately the result of such a philosophy is to restrict the direct access to the apex, causing incomplete removal of debris, insufficient preparation of dentin walls, failure to discover additional canals, and inability to produce maximal condensation of the canal filling (Figure 4-56).

Most teeth require extensive restoration after endodontic therapy. The dentist should never hesitate to remove tooth structure if doing so will aid in producing a more nearly optimal endodontic result. Even if a satisfactory restoration is present before treatment but access and visibility are limited as long as that restoration is present, it must be understood that retaining the tooth is the priority. Such a restoration must be removed.

Typical of this situation is a mandibular molar in which there is a full gold crown and the mesiobuccal canal is not located through ordinary preparation because of dentinal sclerosis. If the crown is removed, the underlying dental



FIGURE 4-54 **A,** Preoperative radiograph of C-shaped mandibular second molar. Tooth looks like any routine mandibular second molar. **B,** One file was placed in distal and one in mesiobuccal area. However, when film was developed, both files were in distal area. It was further feared that the file closer to the mesial might have resulted in a perforation. **C,** Additional efforts left one file in distal and one in mesial areas. **D,** Immediate postoperative film indicates fillings of only moderate density despite heavy lateral condensation and many auxiliary cones. **E,** Three years later, area looks excellent. (Restorations by Dr. Robert Lauren, Chicago.)

structures are more easily viewed; then such landmarks as dentin rings, root shape, and the other canal orifices generally will lead to the missing canal. Teeth with unusual root size and shape under large restorations similarly can be better treated when there is nothing to hamper direct visualization (Figure 4-57).

Need for Divergent Walls

In the desire to provide a good temporary seal between appointments, the dentist may shape the access preparation to be wider toward the floor of the pulp chamber than to the occlusal (or lingual) surface. With the philosophy that such a preparation will better retain silicate and resin restorations, the dentist utilizes this incorrect taper.

The difference is that in endodontic treatment there is no solid base for the temporary filling to butt against, but merely a pellet of cotton and an empty chamber. As forces of mastication are applied to the temporary seal, there is no resistance to inward dislodgment, and exposure of the canals to contamination results. However, if the walls of

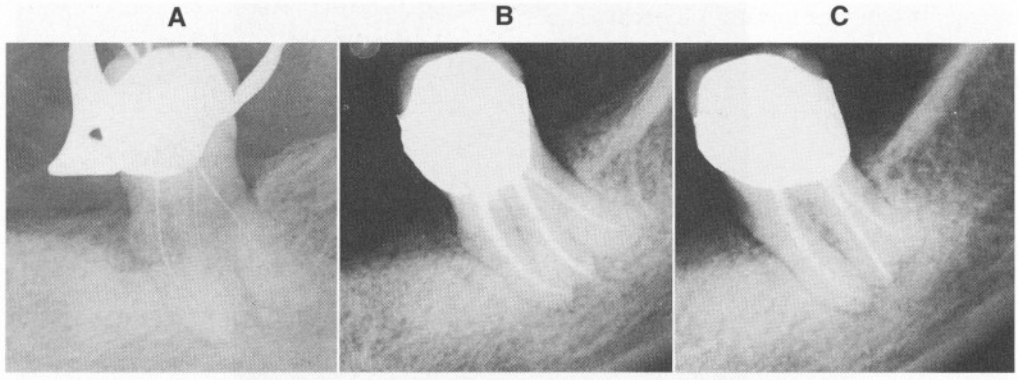


FIGURE 4-55 Three separate roots in mandibular second molar. A, Files in place, indicating three separate roots, each quite curved. **B** and **C,** Immediate postfilling films, canals filled with laterally condensed gutta-percha and Wach's paste.

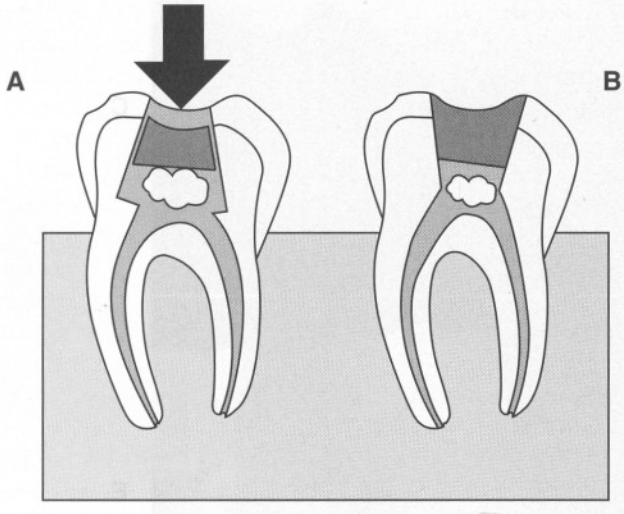


FIGURE 4-56 A, Incorrect access is prepared with greatest width toward floor of chamber, according to philosophy that such a preparation will give greater retention to intertreatment seal. However, without a solid floor to butt against, vertical force *(arrow)* pushes cement into preparation and results in contamination of canals. **B,** Correctly tapering preparation is widest at occlusal edge. Vertical forces will only serve to further seat the temporary seal.

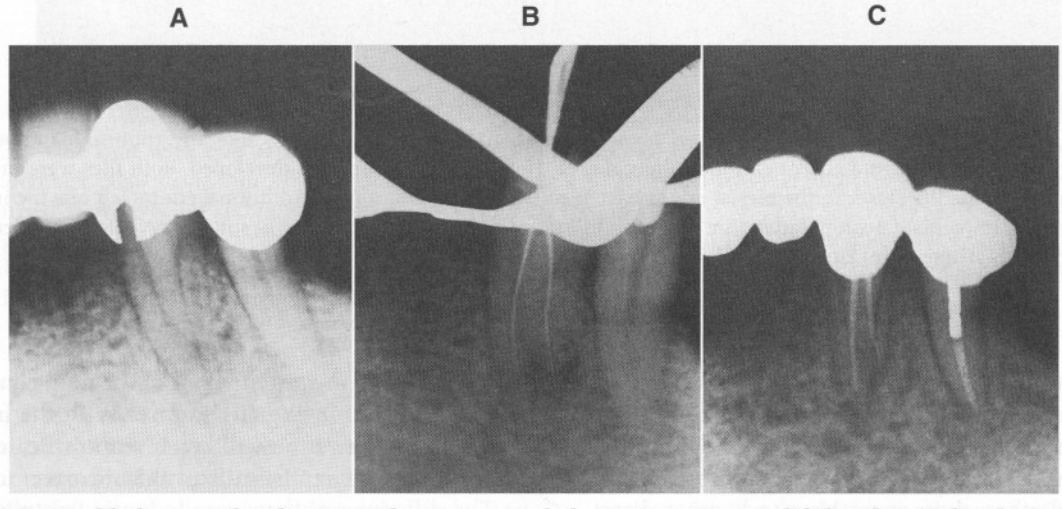


FIGURE 4-57 Mandibular cuspid with two canals requiring endodontic treatment, as did the adjacent first bicuspid. A, Attempting to locate and enlarge two separate canals through a large restoration is extremely difficult. Understanding the situation, the cooperative referring dentist removed the crowns, even though it was part of the precision case. It was more important to ensure that the endodontics could be done in the best environment than to retain the crowns and risk perforation or inadequate therapy. **B,** Crown is sacrificed, but the canals are located and direct access to the apices is obtained. **C,** Two years after treatment, the periapical lesions have healed, and a new splint is in place. (Restorations by Dr. Joe Morros, formerly of Chicago.)

the entry are prepared to diverge toward the occlusal (or incisal) aspect, the forces will tend further to seat the temporary filling. Even if some of the material at the periphery is lost, the seal is retained and contamination prevented (see Figure 4-56).

Access for Badly Worn or Fractured Anterior Teeth

When an attempt is made to prepare an entry on patients with badly eroded anterior teeth, some alteration in routine shaping is necessary. Because heavy dentinal sclerosis usually accompanies incisal wear, as a result of old age and/or bruxism, the most direct possible access is needed. This is accomplished by making the preparation directly through the incisal edge, rather than through the lingual edge, thus allowing the preparation to follow the path of recession of the pulp chamber, which is easily visualized by its difference in color and texture from the surrounding dentin.

Fractured anterior teeth are similarly entered through the incisal edge. The trauma has reduced crown height, and restoration by a post-and-core type of crown becomes mandatory. The fractured crown is trimmed to be parallel with the occlusal plane, and any sharp edges are rounded to prevent irritation to the lips or tongue. Then, rather than angle in from the lingual area, the entry is placed on the incisal edge to gain direct access to the apex (Figure 4-58).

PREPARATION OF AREA FOR TREATMENT

Before an entry may be begun, certain preparation of the site of treatment must be made to reach a successful result from both the dentist's and the patient's viewpoint. To ensure patient comfort, the tooth must be correctly anesthetized. Also, the tooth to be treated must be able to accommodate a rubber dam.

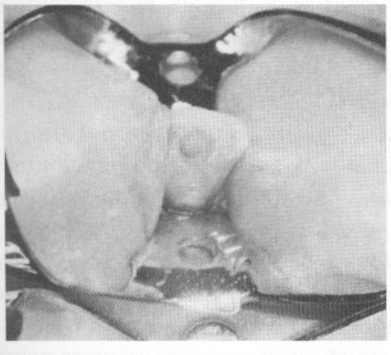


FIGURE 4-58 Entries for badly abraded anterior teeth or those with fractured crowns should be made through incisal edge rather than with routine lingual access. Such a preparation gives more direct access to the apex.

Need for Local Anesthesia during Endodontic Therapy

Correct use and administration of local anesthetics provide the best assurance of patient cooperation. When patients complain of pain during endodontic treatment, they are usually correct. The cause of the pain may be that the anesthesia is not sufficiently profound, that the injection technique did not deliver solution to the correct sites, or that not all the needed injections were given.

Pain and Nerve Pathways

The afferent–efferent nerve pathways are not precisely known, but have been widely discussed resulting in various conclusions. To better understand the more accepted basic philosophies, Figure 4-59 presents an overall picture of pain initiating in the tooth and then via neurons through the reflex arc. Pain passing from the pulp of the maxillary teeth (afferent pathway, *solid line*) goes via the maxillary divisions of the fifth cranial nerve to the pons. There it goes to the central nervous system, where it terminates in the gray matter. A second-order neuron crosses to the other side and carries the impulse to the thalamus, where it synapses in the postcentral gyrus. The efferent pathway (*broken line*) leaves the lateral horn of the upper thoracic level of the spinal cord up to the superior cervical ganglion, affecting certain blood flow via vessels closer to the site of pain. This injury, which takes miniseconds to rebound to the site of occurrence, must be covered with strong, well-placed anesthetic solution to ensure a pain-free environment during the procedure.

Deeply profound anesthesia is a must for endodontic procedures such as pulp extirpation, canal enlargement when normal periapical tissue is present, and some instances of canal filling. For some fearful patients, anesthesia may be needed for any phase of treatment and should be used if the patient is insistent, even if a large periapical radiolucency is present.

Types of Anesthetic Solutions Used in Endodontics

For profound anesthesia, two types of anesthetic solutions are widely used in endodontics: lidocaine (Xylocaine) and mepivacaine (Carbocaine). Although both drugs are more toxic than procaine (Novocain), the old standby for dentistry, they have a more rapid onset, have much greater depth, and last longer than procaine. The potential problem of toxicity rarely arises because smaller quantities of either preferred anesthetic are needed compared with procaine. Also, the qualities of onset and depth are important in endodontic treatment. For maxillary teeth and mandibular anterior teeth, usually one to two Carpules (1.8 ml per Carpule) are sufficient to gain deep anesthesia. For those mandibular posterior teeth requiring nerve block anesthesia, two Carpules, and often more, are necessary. In those cases for which profound anesthesia is

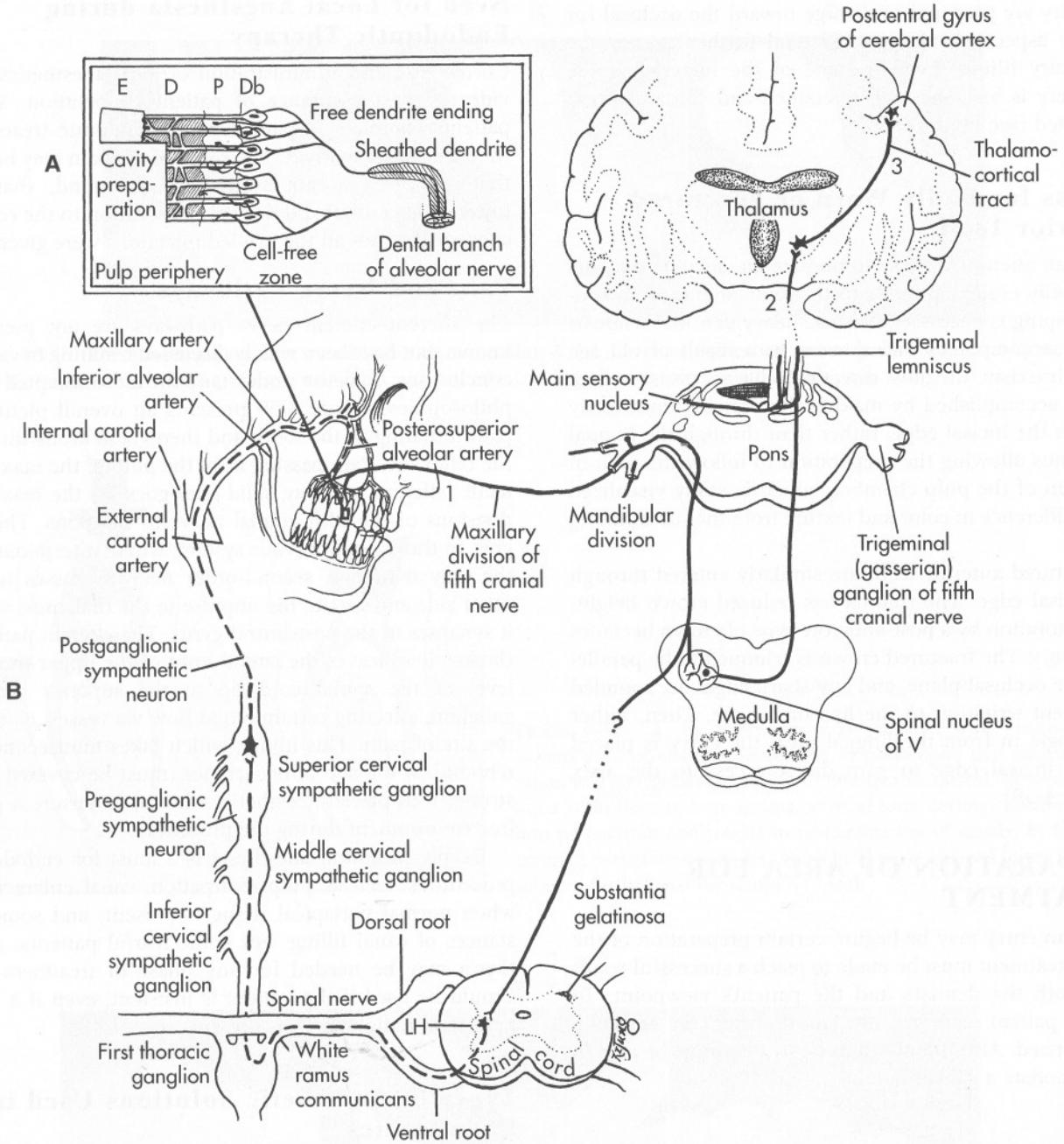


FIGURE 4-59 **A** and **B,** Afferent-efferent pathway for sensory and vasomotor impulses. *E,* Enamel; *D,* dentin; *P,* predentin; *Db,* dentinoblast; *LH,* lateral horn (upper thoracic region); *broken line,* efferent nerves; *solid line,* afferent nerves; *1,2,3,* sensory neuron sequence.

unnecessary, as for nonvital pulp removal or prevention of pain due to rubber dam clamp impingement, half a Carpule is sufficient.

Injections Needed for Removal of Vital Pulp Tissue

Root and bone anatomy, condition of the pulp tissues, and patient pain tolerance all have a bearing on the types of injections that will be needed to remove vital pulp tissue. In most cases the routine injections listed in Table 4-8 should be given. If pain is still experienced, the supplementary injections are usually sufficient to gain patient comfort. In some cases, particularly mandibular molars with considerable pulpal inflammation, only intrapulpal injections are effective.

In maxillary anterior teeth, only labial infiltration of one Carpule is necessary, deposited directly over the



TABLE 4-8 Local Anesthetic for Treating Teeth with Vital Pulp Tissue

	Injections Needed For	
Tooth	***Routine Anesthesia***	***Supplementary Anesthesia***
Maxillary central and lateral incisors and cuspid	Labial infiltration	Palatal infiltration
Maxillary bicuspids and molars	Labial infiltration Palatal infiltration	Intrapulpal injection
Mandibular incisors	Labial infiltration	Infiltration slightly from mesial
Mandibular cuspid and first bicuspid	Mental block	Lingual infiltration
Mandibular second bicuspid	Mandibular block (first appt.)	Buccal infiltration Lingual infiltration
	Local infiltration (second appt.)	Mandibular block
Mandibular molars	Mandibular block Intraligamentary injections*	Intraseptal injection Intrapulpal injection

*Optional.

apex. Some lateral incisors may have considerable thick bone over the apex and require an additional Carpule. Deposition beneath the periosteum usually ensures better anesthesia from all infiltrations. Supplementary anesthesia is rarely needed, but if necessary, a palatal infiltration to anesthetize the branches from the incisive canal is given.

For maxillary posterior teeth, local buccal infiltration and palatal infiltration to block the branches of the anterior palatine nerve are needed. One Carpule is sufficient for bicuspids, whereas two Carpules, one for each buccal root, are needed for molars with preoperative symptoms. Only a few drops are required on the palate. Once the palatal canal has been thoroughly debrided, palatal infiltration is rarely needed for succeeding appointments. Supplementary anesthesia is available only by intrapulpal injection.

Mandibular incisors are anesthetized with one Carpule given by labial infiltration. The central incisor may have thicker bony covering and require slightly more. The blood vessels from the right and left side of the mandible anastomose in the area of the central incisors. Therefore, if some pain is reported when entering these teeth, the initial source of supplementary injection is gained by injecting 0.5 Carpule just to the mesial of the tooth. In rare cases, usually when a Type II canal system is present in these teeth, a lingual injection is given as an additional supplementary.

For the mandibular cuspid and first bicuspid, the mental block injection gives extremely rapid and deep results. Lingual infiltration may be needed, particularly if two separate roots are present. The cuspid may require local infiltration as well.

The mandibular second bicuspid and molars must have a mandibular block. Whereas local infiltration may be useful for supplementary anesthesia, it alone is insufficient to remove vital pulp tissue. For supplementary anesthesia the second bicuspid may require lingual infiltration, directly beneath the tooth. Molars may need local infiltration and injections into the alveolar crest of the furcation and septum between the adjacent teeth. When the pulp extirpation and canal preparation of the second bicuspid is used at the first appointment, subsequent visits may require only a local infiltration.

For mandibular molars, ligamental anesthesia is optional but may be quite helpful, particularly when a tooth with a severe pulpitis is being treated. It is certainly much better than giving a long buccal injection, which anesthetizes the soft tissues but has no effect on the pulp.

When the patient complains of pain during access, despite the indications of good anesthesia and after the suggested injections, intrapulpal injection is needed. It should be explained to the patient that the anesthetic has not taken effect completely because of the degree of inflammation, but that more solution will soon be given and will be effective. The patient will usually cooperate for the few minutes that are required to penetrate the roof of the chamber.

For effectiveness, intrapulpal injections require a bulk of vital tissue to transport the anesthetic throughout the canals. Therefore, when it appears that intrapulpal anesthetic may be needed for any tooth, it should be administered after a small hole in the roof of the pulp chamber has been made and before any tissue is extirpated. In molars the solution is deposited in the largest canal—palatal canal for maxillary molars and distal canal for mandibular molars—and will traverse the entire canal system in a few minutes.

Many textbooks advise the use of such exotic and usually painful methods of anesthesia as pressure anes-