

FIGURE 4-21 **A,** Preoperative radiograph of maxillary second bicuspid with three roots. **B,** After canal filling with laterally condensed gutta-percha and Kerr's antiseptic sealer. **C,** Twelve years later. (Restorations by Dr. Herman Gornstein, formerly of Chicago Heights, Ill.)

problems occur during treatment of teeth, consider the possibility of a Type IV canal when a maxillary second bicuspid is not responding to seemingly correct therapy (Figure 4-23, *A* to *C*). When the extra apical canal is located, prepared, and filled, the problems suddenly cease (Figure 4-23, *C* to *E*).

When re-treating failing cases on this tooth, consider the possibility of a Type IV canal. Take an angled view from the distal similar to the projection used for a maxillary molar (see Figure 4-37, *C*), and the Type IV canal may become apparent (Figure 4-24, *A*). The further treatment plan for the tooth becomes obvious (Figure 4-24, *B*).

When a preoperative film (Figure 4-25, *A*) indicates the possibility of the Type IV system and this important fact is verified at initial exploration (Figure 4-25, *B* and *C*), a very desirable result can be obtained (Figure 4-25, *D* to *F*).

Mandibular First Bicuspid

The mandibular first bicuspid may cause great problems during treatment because of the relatively frequent existence of a bifurcated canal dividing in the middle or apical third (Type IV) into a buccal and a lingual branch. Although these teeth usually have one root and one canal, Types II and IV configurations also may be present. The condition of two separate roots, each with one canal, is rarely present, although a single-rooted first bicuspid may bifurcate.

For many years this tooth was considered to have only one root with a single canal. However, there is no question that a single root that divides apically or a Type IV canal system is present in a very significant number of cases, ranging between 15% and 25%. Table 4-5 lists the studies discussing the various canal configurations typically found in this tooth.

The crown is bulky when compared with that of anterior teeth, giving the appearance of a very large total tooth. However, the root or roots are slender buccolingually by comparison and generally shorter than the root of the adjacent cuspid. The narrower root should be kept in mind when the dentist is attempting to locate a canal that is difficult to find. It also may cause a problem when a post is required. If the canal or canals are widened too greatly, too close to the tip of the root, a strip perforation

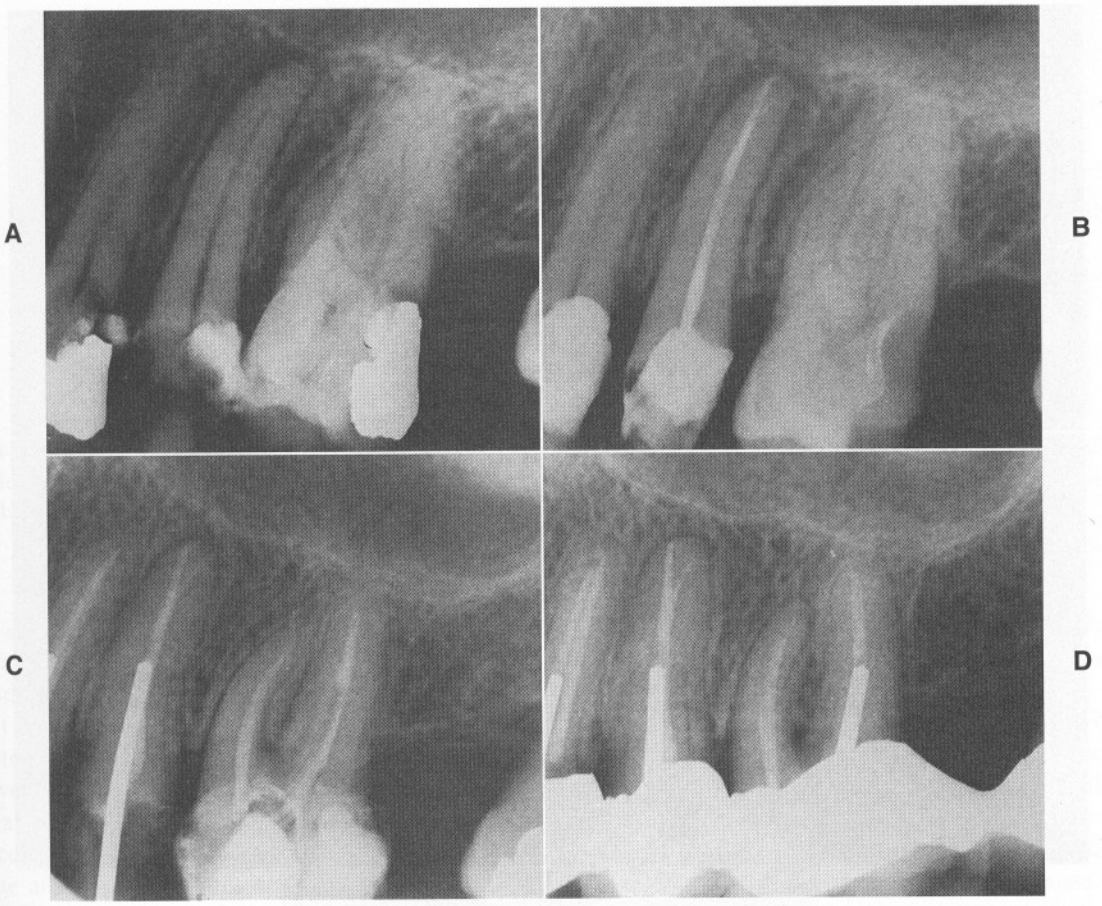


FIGURE 4-22 **A,** Preoperative radiograph of maxillary left side. Second bicuspid has periapical lesion and requires endodontic therapy, as do first bicuspid and first molar. **B,** Canal filling in the second bicuspid completed with laterally condensed gutta-percha and Kerr's antiseptic sealer. It appeared that a lateral canal was picked up to the distal portion of the root. **C,** Six months later, healing underway. **D,** Two years later, areas well healed. Although I thought at the time that the second bicuspid had a lateral canal, I realize now that it was a Type IV canal. (Restorations by Dr. Ascher Jacobs, formerly of Chicago.)

may result. In bicanaled mandibular first bicuspids, only the buccal canal should be considered to hold a post.

The pulp canal size and shape of the tooth with a single canal is similar to the mandibular cuspid and mandibular second bicuspid as visualized in buccolingual and mesiodistal section. In cervical cross section the canal is slightly oval, and thus the access preparation has the same shape (Figure 4-26). When divided canals are present, the entry must be widened considerably buccolingually (Figure 4-27).

This Type IV canal is difficult to treat. In many cases the lingual canal cannot even be located and only the buccal is prepared and filled, a situation prone to failure. The buccal canal must be approached from the lingual direction and, conversely, the lingual canal from the buccal (Figure 4-28, *B*). These canals have an original curvature that is usually straightened by the time the preparation is completed. This leads to some over-extended canal fillings (Figure 4-28, *C*). Because the canals are still small at the apex, there is an excellent chance for success (Figure 4-28, *D*).

Because of the difficulties involved in preparing and filling this system, some cases require alternatives to the most routine therapy. In several instances I have used minimal canal enlargement at the apex and then canal filling with chloropercha (see Chapter 7) in order to treat Type IV mandibular bicuspids with narrow, curved canals (Figure 4-29). Attempting to widen these canals to sizes needed for routine lateral condensation may lead to severe alteration of canal shape and resultant problems.

Mandibular Second Bicuspid

The mandibular second bicuspid has far fewer variations than the first bicuspid, usually having one root and one well-centered canal. Rarely are Type II, III, or IV canal configurations present (see Table 4-2). In such teeth, endodontic treatment usually is quite simple, following only the maxillary anteriors in ease of therapy. The access

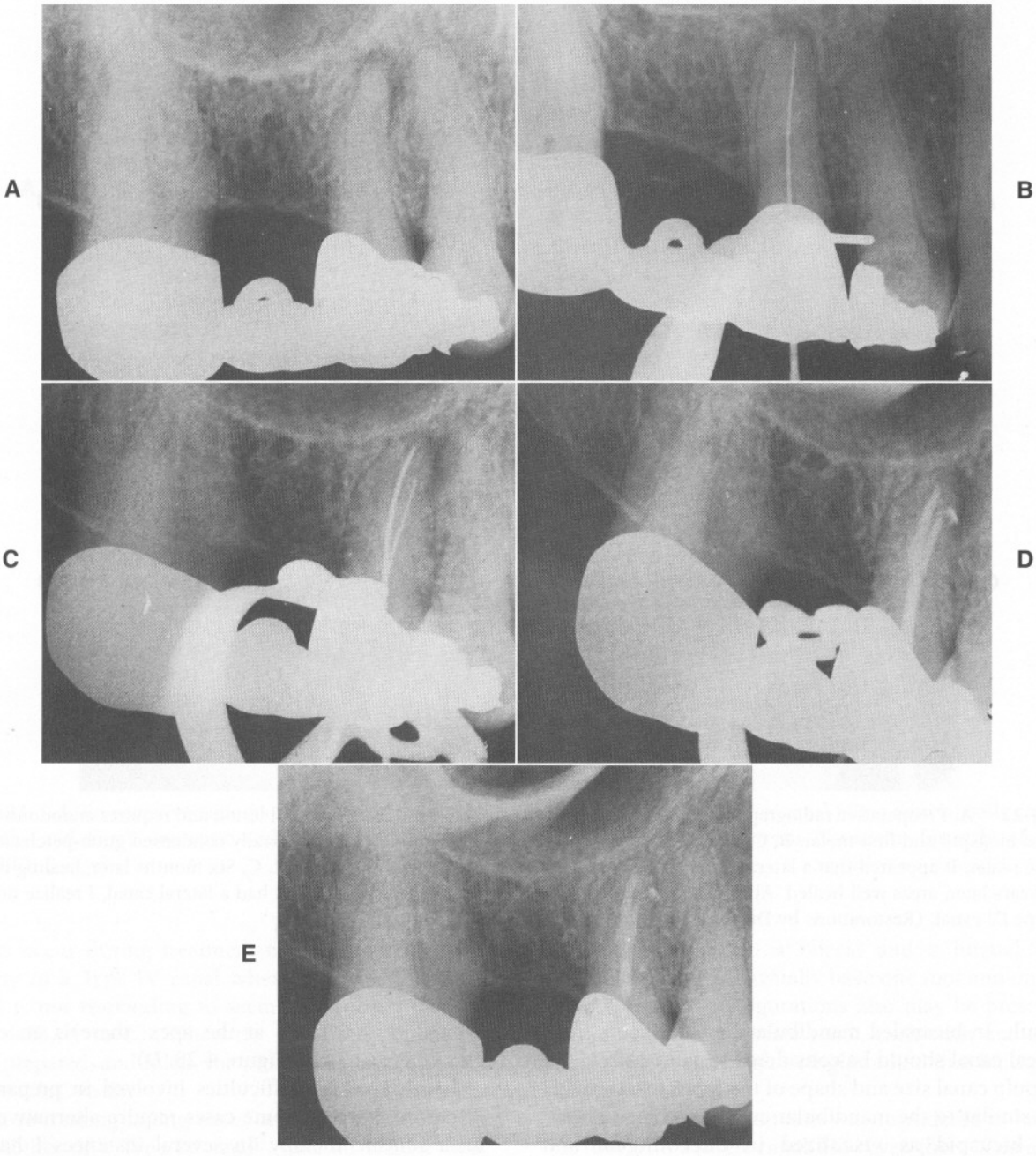


FIGURE 4-23 Treatment of maxillary second bicuspid with Type IV canal. A, Preoperative radiograph of maxillary second bicuspid with periapical lesion and associated sinus tract. **B,** Tooth had a large canal well centered in root, and I assumed that only one canal was present. Film of file in canal seemed to confirm that view. However, sinus tract would not close. **C,** I enlarged access more and finally located a second canal, branching off in a Type IV configuration. **D,** Once the second canal was located, the sinus tract healed. Canal filling completed with laterally condensed gutta-percha and Wach's paste. **E,** Four years later, area looks excellent.

preparation is generally round but may be slightly oval (Figure 4-30). When two canals are present (Figure 4-31), the entry is the same as for the bicanaled mandibular first bicuspid (see Figure 4-27).

A low percentage of mandibular second bicuspids, still less than 1%, are tricanaled, with two buccal canals and one lingual. This configuration is extremely difficult to treat and requires great skill plus some good fortune. Because of the small tortuous canals that are difficult to enlarge, filling with a chloropercha technique is recommended (Figure 4-32).

Maxillary First Molar

The maxillary first molar always has three separate roots, two buccal and one palatal. The distobuccal and palatal roots always have one canal each, although on very rare

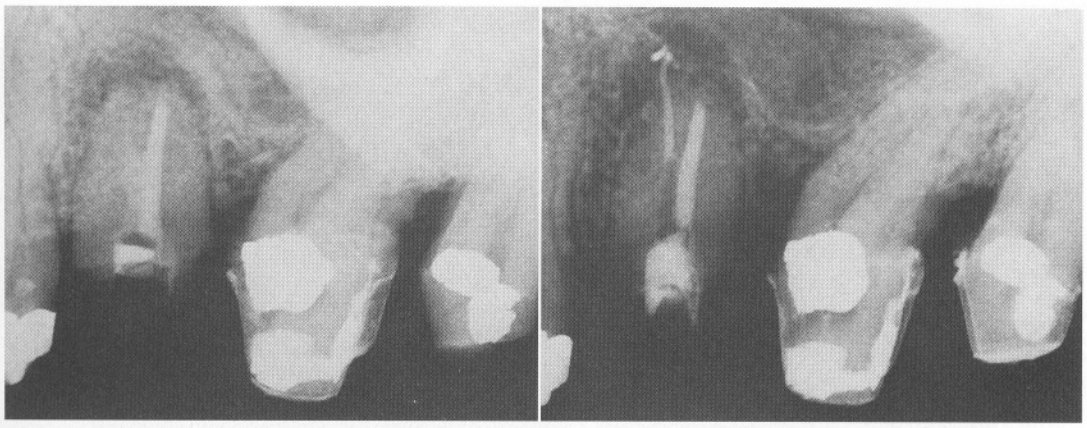


FIGURE 4-24 **Re-treatment of failing maxillary second bicuspid with straight view not offering reason for failure. A,** However, sharply angled preoperative view from distal divulges Type IV canal with some sealer in buccal canal. **B,** On basis of this information, location, enlargement, and filling of second canal are performed.

occasions either may have a second canal, too. The mesiobuccal may have a configuration of Type I, II, or III, and, according to several studies, Type IV. The mesiobuccal root is similar in shape and canal configuration to single-rooted maxillary bicuspids, although slightly smaller. Evenot did an exhaustive study concerning the mesiobuccal root and stated not only that it was the most difficult root to treat endodontically, but also that some of the anatomic variations seen in this root defied any successful treatment available at that time (written in 1980). Some of the newer products (dental operating microscope, rotary files for flaring) and many studies on this root have greatly reduced the failure rate of treatment.

A mesiodistal section through the buccal roots shows that the buccal canals are thin and well centered in their respective roots but with both orifices on the mesial three fifths of the crown. The palatal canal is much wider mesiodistally than either buccal canal. Buccolingual section also shows the palatal canal to be wider than either buccal canal and usually with a buccal curve occurring near the apex. The orifice of the palatal root is more prominent than either buccal orifice and is located beneath the mesiopalatal cusp. The orifice of the mesiobuccal canal is located beneath the mesiobuccal cusp, but the orifice to the distobuccal canal has no direct relation to its cusp. The distobuccal orifice is usually located by means of its relation to the mesiobuccal orifice, with the former found approximately 2 to 3 mm to the distal and slightly to the palatal aspect of the mesiobuccal orifice. The distance between the two buccal orifices will be greater when considerable dentinal sclerosis has occurred. Because the buccal roots diverge as they leave the crown, the canals form a V shape and approach each other near the floor of the chamber. As reparative dentin fills in the chamber and decreases the true canal length (not the endodontic working length) and diameter, the orifices are found farther up their respective roots and thus are farther apart. This is an important consideration when the dentist is attempting to locate these canals in patients with heavy dentinal sclerosis from large restorations and/or decay.

A cross section through the cervical area shows that the pulp chamber floor has the shape of a quadrilateral, with four unequal sides. Most writers describe access cavity preparation for molars, both maxillary and mandibular, as triangular in outline form. However, because the floor of the maxillary first molar is quadrilateral, the access cavity must have a similar shape. The large palatal canal will not receive sufficient debridement of the canal walls if prepared through the confines of the apex of the triangle; it needs the greater width afforded by a more flattened side (Figure 4-33, *A*). Therefore, for maxillary molar access preparations, a quadrilateral with rounded corners is recommended. The shortest side is the palatal, parallel to the central groove. The next shorter side is the buccal and has a slope toward the distopalatal aspect because the position of the distobuccal orifice is farther toward the palatal than the mesiobuccal orifice. The longest side is the mesial, with the opposite side toward the distal slightly shorter. Because of the quadrilateral rather than triangular shape, the mesial side does not make as sharp an angle toward the palatal, and more room is available for location of the frequently found second mesiobuccal canal. Because all the orifices of this tooth lie on the mesial three fifths of the crown, there is no need to violate the oblique ridge in preparing the access cavity (Figure 4-33, *B* to *D*).

To begin the preparation, a tapered fissure carbide bur is used to penetrate the enamel in the center of the central groove, and the access is increased in depth toward the mesiopalatal cusp. It is best to locate the palatal canal first because this is the largest and easiest to find. Once the roof of the chamber has been penetrated, a safe-tipped bur is used to complete the palatal extension of the access near

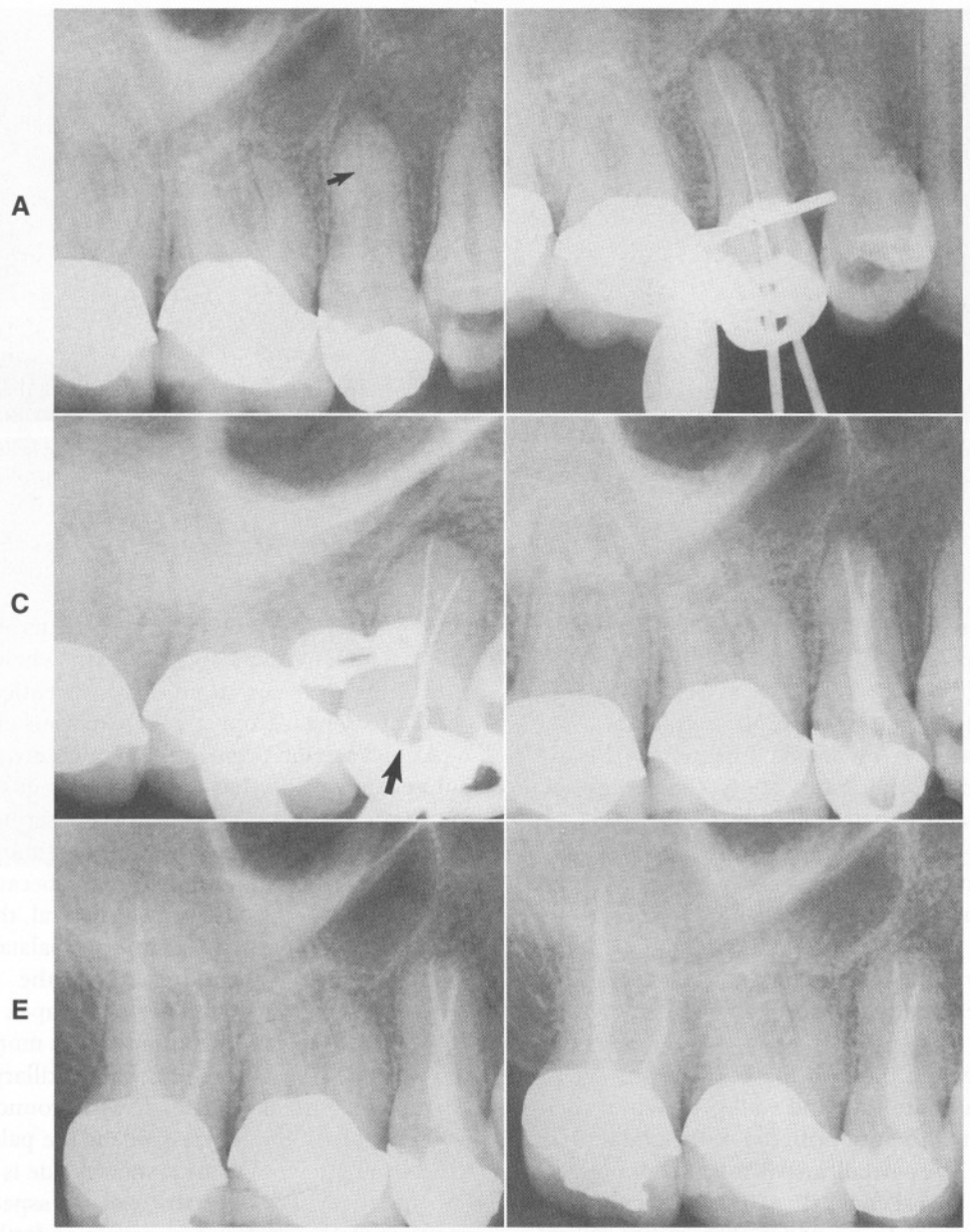


FIGURE 4-25 Long-term treatment of a maxillary second bicuspid with a Type IV canal system. A, Preoperative radiograph of maxillary bicuspid and molar area. Both second bicuspid and second molar reveal periapical lesions, large restorations, and the need for endodontic treatment. A wide canal in the center of second bicuspid root seems to divide into two apical canals *(arrow),* a Type IV configuration being possible. **B,** Size 20 Hedstrom file is in the palatal canal extension, but I was not able to locate the buccal extension in this straight view. **C,** View from the distal, indicating files in both apical extensions of the Type IV system. By going farther from the palatal *(arrow),* my file was able to enter into the buccal portion. **D,** Canal filling with laterally condensed gutta-percha and Wach's paste. **E,** One year later, treatment was completed on the second molar as well, and lesions on both teeth have healed. **F,** Nine years after treatment, healing still perfect on both teeth. (Restorations by Dr. Gary Meyers, Highland Park, Ill.)

the mesiopalatal cusp. The endodontic explorer is used in this area to locate the orifice of the palatal canal. Once found, its position will aid in the uncovering of the smaller and more difficult to locate buccal canals.

The safe-tipped bur is kept in contact with the floor of the pulp chamber and moved buccally to uncover the entire chamber. Once the mesiobuccal orifice is located beneath its cusp, the distobuccal canal will be uncovered by moving the safe-tipped bur distally and slightly toward the palatal surface. The second mesiobuccal canal either occurs as a separate canal or merges with the main canal toward the apex in approximately 50% of all maxillary first molars and, with some frequency, in the maxillary second molar as well. To uncover this fourth canal, the safe-tipped bur is moved from the mesiobuccal orifice toward the palatal canal a distance of 2 to 5 mm. If present, the additional canal's orifice will be located in that area.

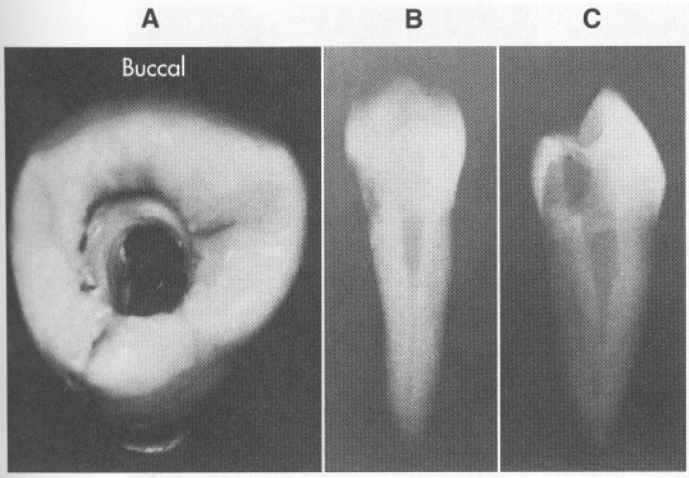


FIGURE 4-26 Access preparations for typical mandibular first bicuspids. A, Entry for single-canaled tooth is slightly oval with buccolingual dimension only slightly wider than mesiodistal width. **B** and **C,** Buccal and proximal views show that canal is well centered. Direct access to apex is obtained with such an entry.



FIGURE 4-27 Access preparation and canal configuration for mandibular first bicuspid with two canals. A, When two canals are present, oval preparation normally used for mandibular first bicuspids is widened buccolingually to afford access to both canals. Contrast this with access shown in Figure 4-26, *A*. **B** and **C,** Lingual canal is usually smaller than buccal canal. When two canals are present, chamber is wide buccolingually, a factor unnoticed in usual periapical film taken from a normal projection. **D,** In straight-on preoperative radiograph, the canal in first bicuspid seems to disappear in midroot *(arrow)*. This is an important indication that two canals are present. **E,** In angled view the divided canals are more clearly seen. **F,** Postoperative film shows the two canals filled and post room prepared.

As with most molar roots, the buccal roots of the maxillary first molar are curved, although the mesiobuccal root is generally more curved. When viewed from the buccal, the mesiobuccal canal curves first to the mesial as it leaves the floor of the chamber and then to the distal, often quite abruptly. This is an important reason why this canal generally is so difficult to treat. The degree and abruptness of the curve causes frequent problems during canal preparation for loss of curvature, straightening of the canal, decrease in working length, and/or strip perforation.

From the mesial, the mesiobuccal canal curves initially to the buccal and then to the palatal. The buccolingual curvature is generally less than the mesiodistal curvature.



FIGURE 4-28 Treatment of bicanaled mandibular first bicuspid. A, Preoperative view angled from mesial of mandibular bicuspid area indicates knobby curved roots of first bicuspid with the canal image fading out in midroot, indicative of a Type IV system. Note similarity to Figure 4-27, *C*. **B,** Files in place. Note that file in lingual canal *(left)* is sharply curved. **C,** Canals filled with vertically condensed gutta-percha and Kerr's antiseptic sealer, and post room prepared. Some sealer has escaped past the apex. **D,** Three years later. (Restorations by Dr. Sherwin Strauss, Chicago.)

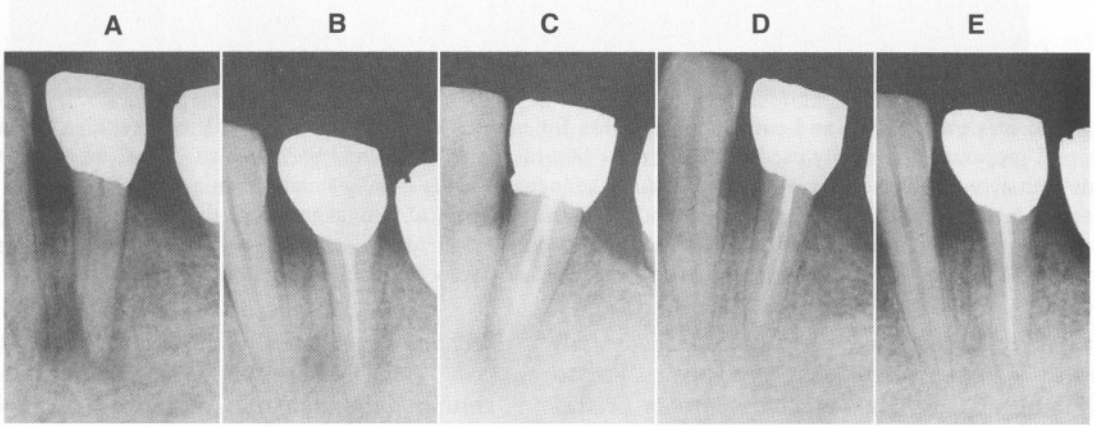


FIGURE 4-29 A, Preoperative radiograph of mandibular first bicuspid, with two canals present and large periapical lesion wrapping around both mesial and distal sides of the tooth. **B,** It was difficult to insert my files close to the radiographic apex, and the two canals were very curved. I reached the minimal acceptable apical width, widened the orifice portions, and filled the canals by the chloropercha technique. Straight view is shown. **C,** Angled view. Multiple lateral canals are demonstrated in the postfilling radiographs. **D,** One year later. **E,** Two years later, lesions have healed perfectly.

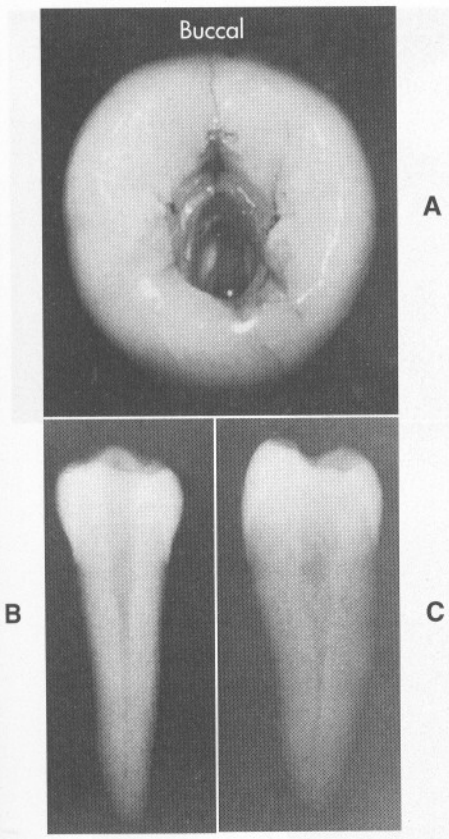


FIGURE 4-30 **A,** Access for mandibular second bicuspid is round, but it may be slightly oval if hint of two canals is present. **B** and **C,** Because canal is well centered in both buccolingual and mesiodistal dimensions, this tooth is one of easiest to treat endodontically.

The distobuccal canal is curved less frequently and is generally straighter than the mesiobuccal canal. Although the distobuccal canal usually will curve toward the mesial, giving a cowhorn appearance to the buccal roots (Figure 4-34), it may curve to the distal (see Figure 4-33, *C*).

Despite the excellent overall success ratio for endodontic cases, the mesiobuccal root of the maxillary first molar has always been implicated with an excessively high failure rate. This has been due to the frequent occurrence of a second, separate canal in this root, yet the relative rarity with which it is located and filled (see Table 4-4). The canal configuration of maxillary bicuspids usually is determined before therapy by careful examination of angled radiographs. However, the proximity of the two canals in the mesiobuccal root plus the radiopaque structures in the area of the first molar often prevent preoperative forecast by x-ray examination. The excellent reported studies of this root have greatly increased the frequency in which the second canal is treated. However, most of these studies indicate that many second canals remain elusive.

Therefore it is suggested that some attempt be made to locate the orifice of the fourth canal whenever maxillary first molars are treated. If the radiograph seems to indicate that a second canal is present in the mesiobuccal root and the tooth appears to be shorter than average, this attempt should be pursued with some vigor until the canal is located or it appears that further preparation may cause perforation (Figure 4-35). If the radiograph seems to indicate that only a single mesiobuccal canal is present and the tooth is longer than average, excessive time should not be spent attempting to locate the additional canal. Use of the Dental Operating Microscope, Orascopy, and Endoscopy (see Chapter 9) are all very useful in this problem-causing root.

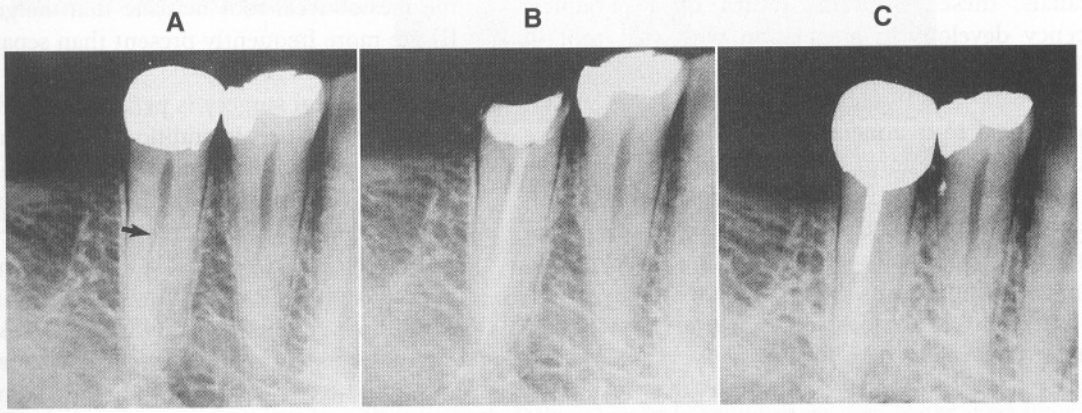


FIGURE 4-31 **Treatment of bicanaled mandibular second bicuspid. A,** Preoperative radiograph. Because the tooth has rotated slightly, the point of division of the canals is easily seen (*arrow*). Because this site is fairly close to the occlusal portion of the tooth, the treatment is not as complicated as if the division site were farther apically. **B,** Canals filled with laterally condensed gutta-percha and Wach's paste, and post room prepared. **C,** Four years later, periapical area remains normal. (Restorations by Dr. Irving Fishman, Chicago.)

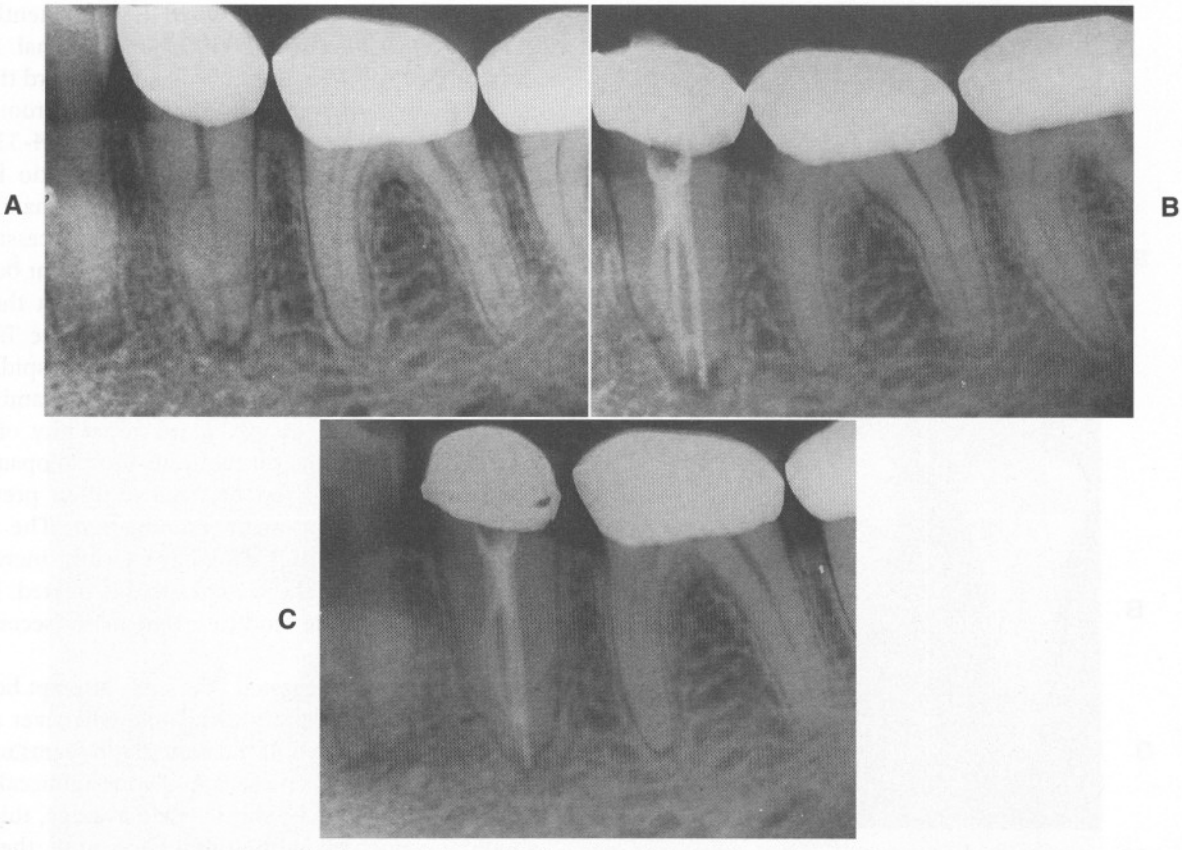


FIGURE 4-32 **A,** Preoperative radiograph of tricanaled mandibular second bicuspid. Tooth is tender to percussion and sensitive to heat. Root canal configuration seems difficult to evaluate, but at least two canals must be present. **B,** Slightly angled view of canal filling indicates three canals, two buccal and one lingual. Canals were filled by chloropercha technique. **C,** One year after treatment. (Restorations by Dr. E. Beall, Tarrytown, N.Y.)

If only a single mesiobuccal canal is located, it should be prepared and filled in a routine manner. If any preoperative symptoms such as a chronic draining sinus, sensitivity to temperatures, or apical soreness over that root persist, further efforts to locate the additional canal should be made. If, after therapy that consisted of treating three canals, these symptoms return or a periapical radiolucency develops in association with that root, it should be assumed that an undiscovered second canal is responsible.

If nonsurgical re-treatment is performed to remedy a failing case, further efforts must be made to locate the missing canal. If surgery is to be performed, the techniques used to accommodate the sealing of an additional canal by the figure-eight reverse filling preparation, including the isthmus, must be utilized (see Chapter 9).

It is not possible to locate the second mesiobuccal canal in every case, even when it is present. The percentages listed in Table 4-4 indicate that results in clinical cases treated are always fewer than four canaled first molars investigated in pure laboratory in vitro studies. Attempting to locate the fourth canal at all costs will lead to perforations and/or weakening of the tooth. Therefore it is better to avoid serious procedural problems and stop short of disaster when the second mesiobuccal canal evades serious attempts at location, especially with the newer aids. One must hope that the second canal, if present, merges with the canal already located. Performing excellent treatment on that canal will result in many such cases being successful. Remember that most studies on the mesiobuccal root indicate that merging canals (Type II) are more frequently present than separate and distinct canals (Type III).

If periapical surgery is performed on the root, another problem may arise. In addition to the many teeth with two separate canals, many more cases will display two canals from the floor of the chamber merging to form a single apical foramen. If the root is cut down for an apicoectomy and reverse fill, it is possible that the second canal will be opened to the periapical tissue half the time. If this canal is unfilled, a postsurgical failure can develop. Therefore careful examination of the beveled root must be made and the figure-eight reverse filling, including the isthmus, preparation used if there is any chance for the presence of the additional canal (see Chapter 9).

The routine periapical view of this tooth gives no additional information concerning the possibility of an additional mesiobuccal canal (Figure 4-36, *A* and *B*).

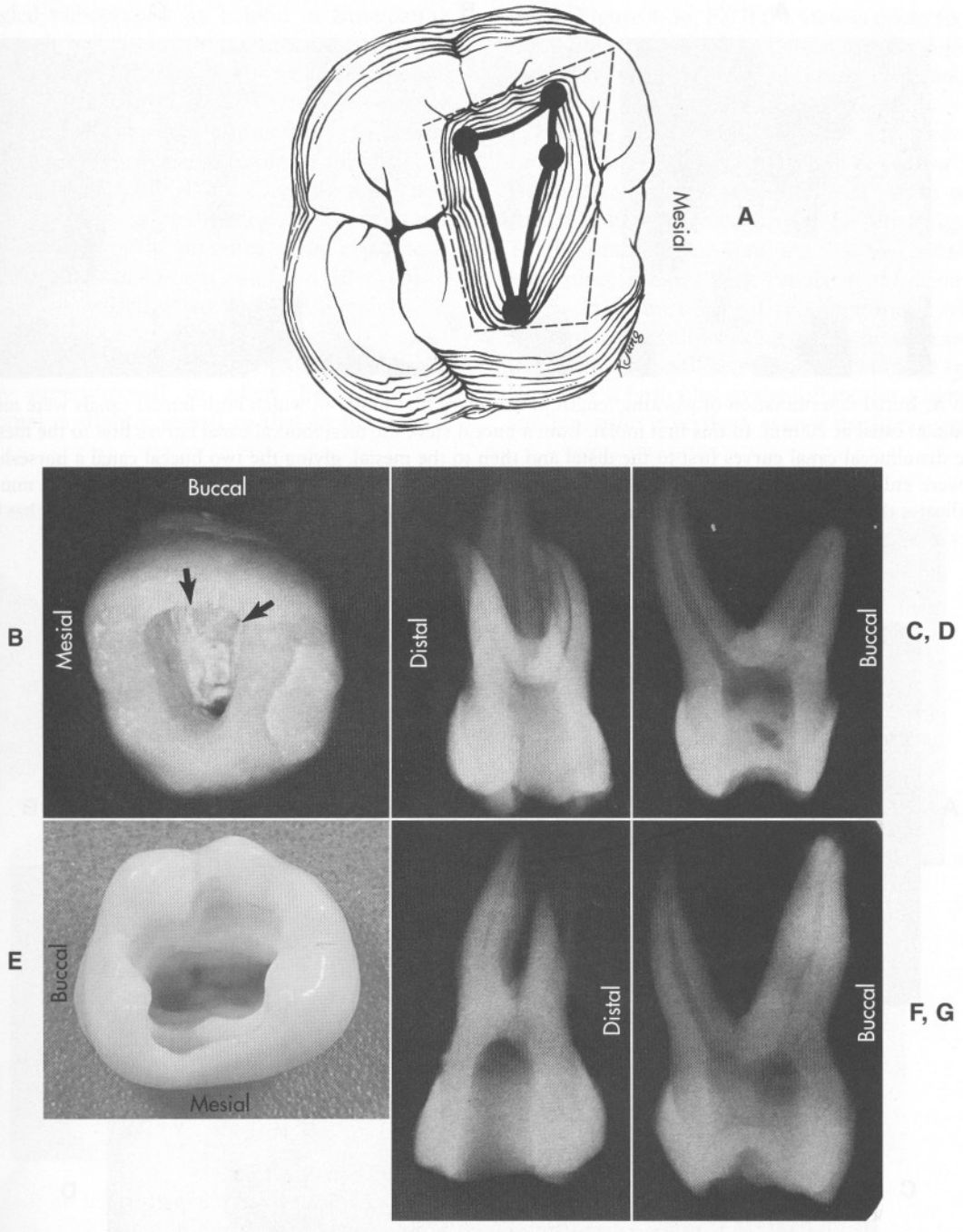


FIGURE 4-33 **Access cavity preparations for maxillary molars. A,** General outline is quadrilateral with rounded corners rather than a triangle. Large palatal canal requires flat side for its proper preparation rather than apex of a triangle. Mesiobuccal canal lies beneath the mesiobuccal cusp. Distobuccal canal is located 2 to 3 mm distally and slightly toward palatal canal from mesiobuccal canal. Second mesiobuccal canal is located 2 to 5 mm toward palatal canal from larger mesiobuccal canal. Entire preparation is on mesial three fifths of the crown. **B,** Occlusal view of access preparation for maxillary first molar. Note large palatal orifice and considerable distance between two buccal canals *(arrows)*. **C,** Buccal view shows entire entry on mesial three fifths of the tooth and verifies the distance of 2 to 3 mm between the buccal canals. Despite access being to the mesial, the opening is seen as well centered over root stock. **D,** Proximal view displays considerable width of palatal canal compared with buccal canals. Note gradual buccal curve of palatal canal, typically found in maxillary molars. **E,** Occlusal view of access preparation for a maxillary second molar. Note that buccal canal orifices are closer together than in first molar, whereas palatal canal is still quite large. **F,** Buccal view shows entire entry on mesial three fifths of tooth and proximity of two buccal roots and canals. **G,** Proximal view shows palatal canal to be widest, with a frequently present gradual buccal curve.