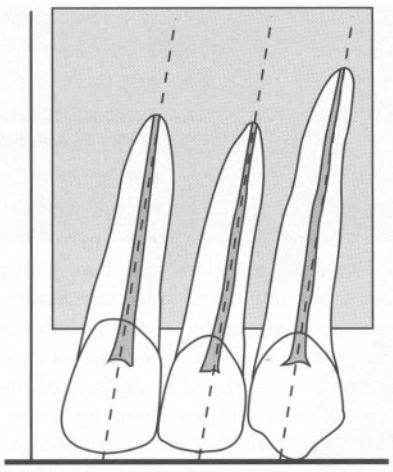


FIGURE 4-7 Long axis of each maxillary anterior tooth angles distally in patients with normal occlusion. Attempting to enter these teeth on a path perpendicular to occlusal plane will lead to perforation. Because many variations in angulation do occur, it is necessary to consult radiographs, examine topography of bone over roots, and be aware of typical anatomic conditions before picking up handpiece to start the entry.

the central incisor. However, a cross section through the cervical area shows that the canal has an oval shape, and therefore the access preparation also has that shape (Figure 4-9).

Maxillary Cuspid

The maxillary cuspid always has one root and a Type I canal configuration. The root may appear to be slender from the labial view, as seen on a typical intraoral radiograph, but is quite bulky as viewed proximally, with an irregular outline (see Figure 4-10, B). The typical length measurements, given in Table 4-1, disclose that the tooth is the longest in the arch.

A labiolingual section shows that the pulp canal comes to a point near the incisal area but is wide through the cervical and middle root until it reaches the apical third of the root, where it narrows. Frequently the canal exits short of the root tip to the labial direction. A mesiodistal section shows that the pulp canal is much narrower than in the labiolingual section, with a relatively regular, decreasing shape all the way to the apex. In cross section through the cervical area, the canal has an oval outline, which is the correct shape for the endodontic entry (Figure 4-10).

Mandibular Central and Lateral Incisors

Central and lateral incisors in the mandible are so similar in shape, configuration, and dimension that one description will hold true for both. The endodontic implications of the mandibular incisor roots and canals were extensively studied and reported by Rankine-Wilson and Henry. Much of the information concerning these teeth had never been presented in such detail before this important study. For that reason the configurations and access suggested here for these teeth differ from those recommended by earlier writers.

The mandibular incisors have only one root, which is narrow mesiodistally but relatively wide labiolingually,

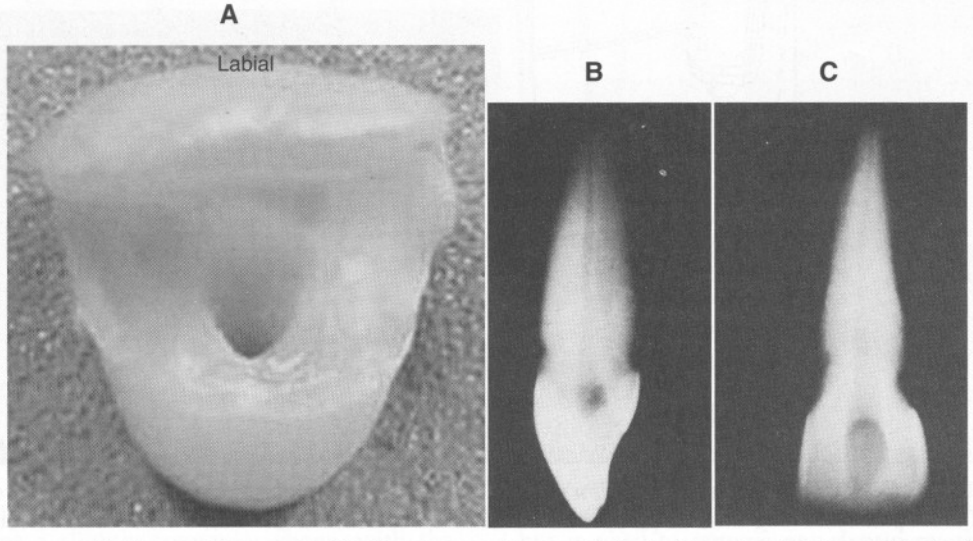


FIGURE 4-8 **A,** Access cavity for maxillary central incisor is generally round, but with extensions toward incisal region to allow for cleansing of pulp horns and for directing the bur down the long axis of the tooth. This imparts a slightly triangular shape. Triangle's base is toward incisal edge, whereas rounded apex is incisal to cingulum. Note that preparation shown is much closer to incisal edge than is usually depicted. In some cases, some of the incisal may even be removed. However, this position gives direct access to apex, as seen in labial and proximal radiographs (**B** and **C**).

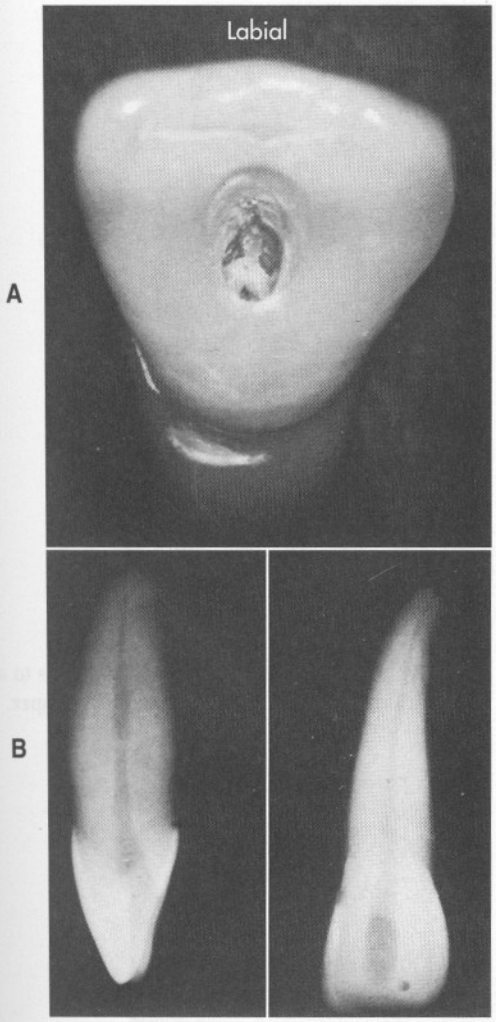


FIGURE 4-9 **A,** Access preparation for maxillary lateral incisor is oval with greatest width incisogingivally. As in central incisor, the incisal extent is placed close to incisal edge for direct access to apex. Note common finding of a distal curve and exiting of canal seen in labial view **(C),** as would be visualized in typical intraoral radiograph. However, canal exits to palatal side in proximal view **(B),** which would ordinarily be missed in a clinical case. Exiting short of tip of apex is a common occurrence in lateral incisors.

and may have a distal and/or lingual curvature. The canal configuration may be of Type I, II, or III, in that order of frequency. Of the 111 teeth examined by Rankine-Wilson and Henry, 60% had Type I, 35% showed Type II, and 5% were classified as Type III. Furthermore, noting a correlation between crown shape and canal configuration, they stated that those with short, squatty crowns had blunted roots, usually with a divided or split canal.

When two canals were present, the labial canal was the straighter. The point of division for divided canals usually was in the cervical third of the root.

A labiolingual section reveals the great width of the pulp canal, never visualized by the routine intraoral radiograph, which allows room for two separate canals or one wide canal with an island of dentin in the middle (see Figure 4-11, *C* and *D*). A mesiodistal section shows that the pulp canal is quite narrow and is particularly constricted in the root portion of the tooth, with both the root and the canal taking a gradual distal curve (see Figure 4-11, *B*). Because of this narrow mesiodistal dimension, the access preparation must be extremely precise to avoid root perforation. Developmental depressions are found on both the mesial and the distal surfaces of the root, decreasing the mesiodistal dimension in the middle of the root. Therefore canal enlargement past size 70 or 80 or with the wider tapering rotary instruments may lead to lateral perforation in thin incisors.

A cross section in the cervical area demonstrates that the canal is a long, thin oval, very constricted mesiodistally. Because of the implications of canal configuration, the access preparation suggested is oval but is wide labiolingually to allow for proper instrumentation (Figure 4-11). Rankine-Wilson and Henry demonstrated that the routine entry ordinarily used allows for the instrumentation of the labial canal only in teeth with two canals or the labial wall of a single-canaled tooth.

The uninformed dentist may believe that mandibular incisors are relatively simple teeth on which to perform endodontic therapy. Nothing could be further from the truth. These teeth come right behind the molars and the multicanaled mandibular bicuspids in degree of difficulty. The major reason for this is the narrow mesiodistal dimension compared with buccolingual width, which makes it almost impossible to enlarge the canal or canals evenly in every direction. Also, the 40% of teeth with two canals reported by Rankine-Wilson and Henry is almost never reached by practitioners during clinical situations.

To add to the problems, because of their proximity, it is virtually impossible to radiograph these teeth from a sufficient angle to know in advance that two canals are present (Figure 4-12). Interestingly, I have had a low percentage of two filled canals in mandibular incisors. However, in teeth in which the crowns have been badly decayed or in trauma cases when much of the crown is missing, I have cut the teeth down to slightly above the gingival margin and then have had a high percentage of two canals treated, even greater than the reported percentages.

Therefore, if I encounter difficulty with a case involving a mandibular incisor, I will decoronalize the tooth. Invariably, I discover a second canal (see Figure 4-12, *B*) and generally any problems early in the preparation desist after canal orifice widening. Follow-up films on these cases have been extremely satisfying (see Figure 4-12, *D*).

The reason why these teeth do not cause us as many problems as they might is that a high percentage of the two-canal cases rejoin near the apex (Figure 4-13). In these teeth, if one of the canals is well prepared and the

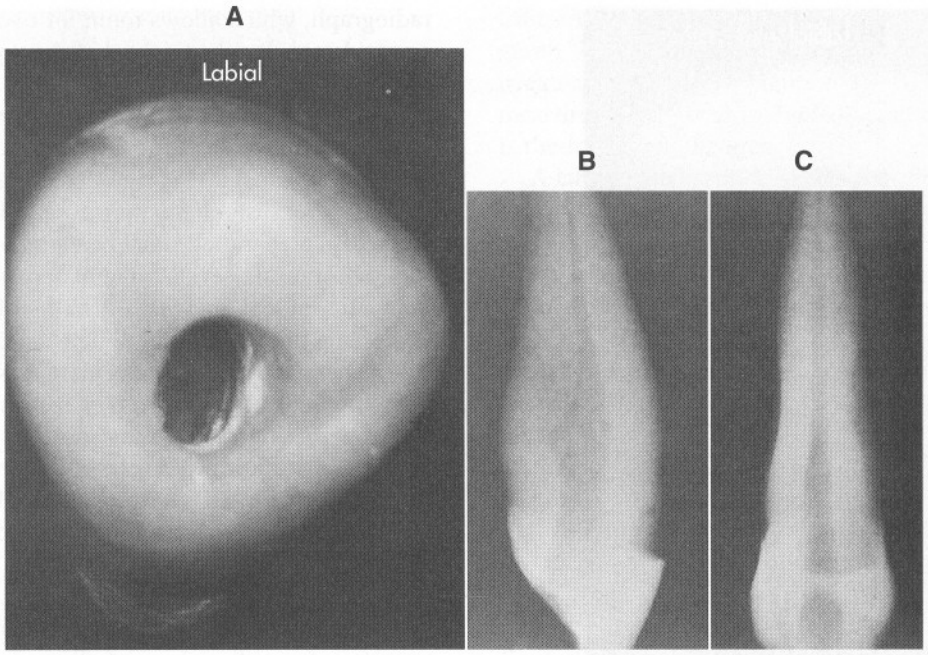


FIGURE 4-10 **A,** Access preparation for maxillary cuspid is oval with widest diameter incisogingivally to give direct access to apex. Proximal view **(B)** shows great width of canal in middle third of tooth, which tapers down to a rather small diameter near apex. This taper is much more gradual as viewed labially **(C).**

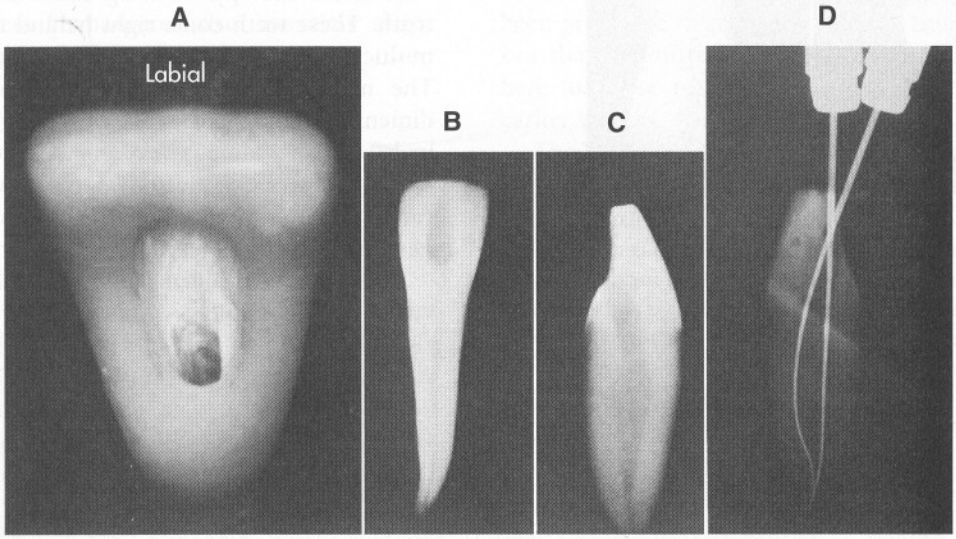


FIGURE 4-11 **A,** Access preparation for mandibular central or lateral incisor is a long oval with greatest width incisogingivally and incisal extent close to incisal edge. Even though canal appears extremely narrow in typical intraoral radiograph, as seen from the labial aspect **(B),** proximal radiograph **(C)** shows wide canal that demands a wide access preparation from incisal to gingival areas to gain proper intraradicular preparation. **D,** Width of tooth as viewed proximally indicates files in the labial and lingual canals, merging near the apex. This canal configuration is present in a surprisingly high percentage of these teeth.

apex well filled (see Figure 4-13, *C*), the result will be satisfactory (see Figure 4-13, *D*).

Mandibular Cuspid

Mandibular cuspids usually have only one root but in rare cases may have two separate roots. Teeth with one root may have Type I, II, or III configuration, as do the mandibular incisors. These teeth are usually the longest of the mandibular teeth but have greater length variation than do maxillary cuspids, as indicated in Table 4-1.

The root canal is thin mesiodistally but wide labiolingually. The cervical cross section is oval, as is the

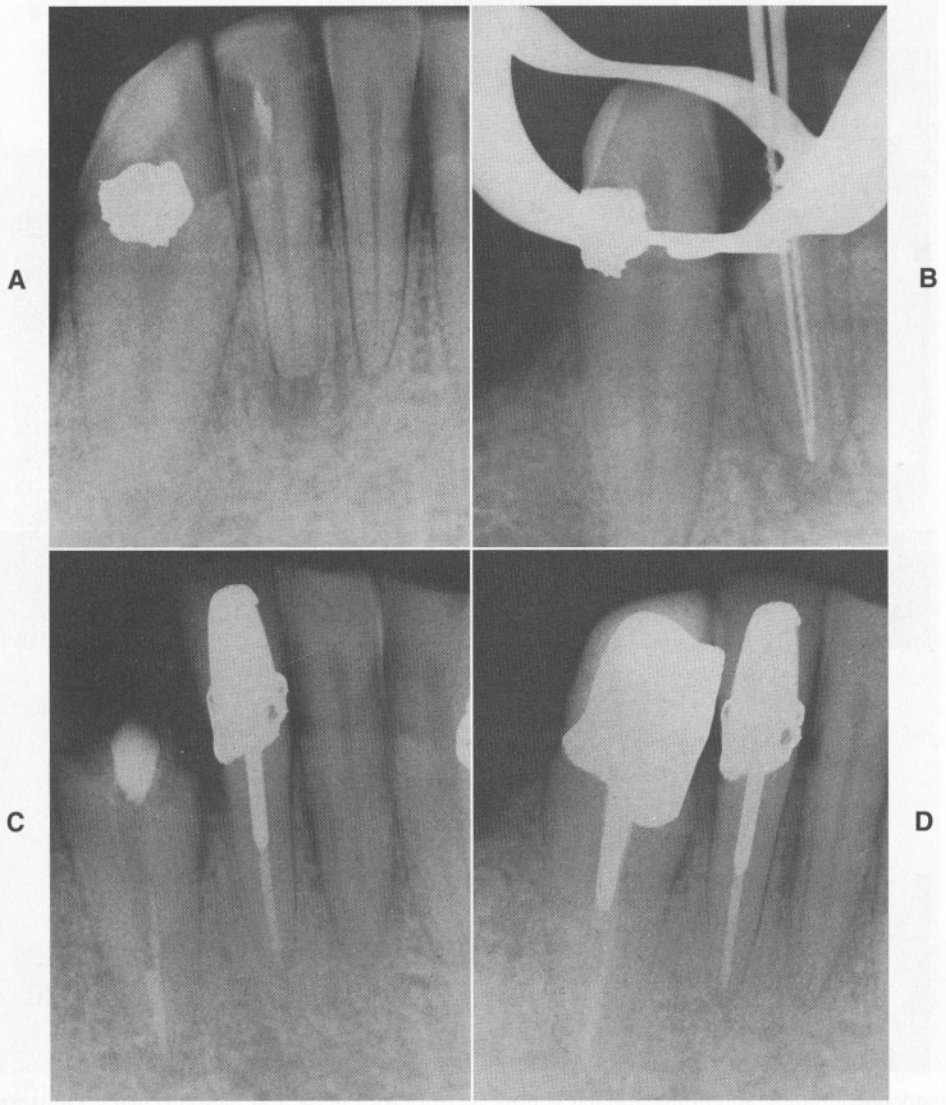


FIGURE 4-12 **Treatment of two canals in mandibular incisor. A,** Mandibular lateral incisor with periapical radiolucency and large distal carious lesion. Chronic draining sinus tract was present. **B,** Routine lingual access was prepared so one canal could be located and enlarged. The sinus tract persisted. Tooth was decoronalized and a second canal located. Note files in both canals. It was virtually impossible to angle film sufficiently to see that the canals were separate and distinct; but both went to their lengths independently, which does not happen in Type II canal configuration. **C,** Two canals were filled with laterally condensed gutta-percha. This film, taken 6 years later, indicates advanced apical healing. **D,** Nine years after treatment, perfect healing. (Restorations by Dr. Morton Schreiber, Highland Park, Ill.)

suggested entry (Figure 4-14). This tooth usually has a slightly labial axial inclination of the crown. Therefore the access is directed mildly toward the lingual surface.

A bifurcated canal is possible in this tooth, and generally there will be at least a hint in the preoperative or file-in-place radiograph (see Figure 4-15, *A* and *F*). If this is the case, an access preparation buccolingually wider than usual should be used. Should only one canal be present, it will be quite wide buccolingually in any case (see Figure 4-14, *B*), so that the extra width, even when unnecessary, will not be a problem. However, if two canals are present, only the extra buccolingual width of the access will permit proper location, preparation, and filling (Figure 4-15).

Maxillary First Bicuspid

Maxillary first bicuspids have a number of variations in root and canal configuration. Approximately 60% have two roots, one buccal and the other palatal, each with a single canal. The two roots may be completely separate or merely twin projections rising from the middle third of the root to the apex, with the latter slightly more common. The two roots are usually equal in length from apex to cusp.

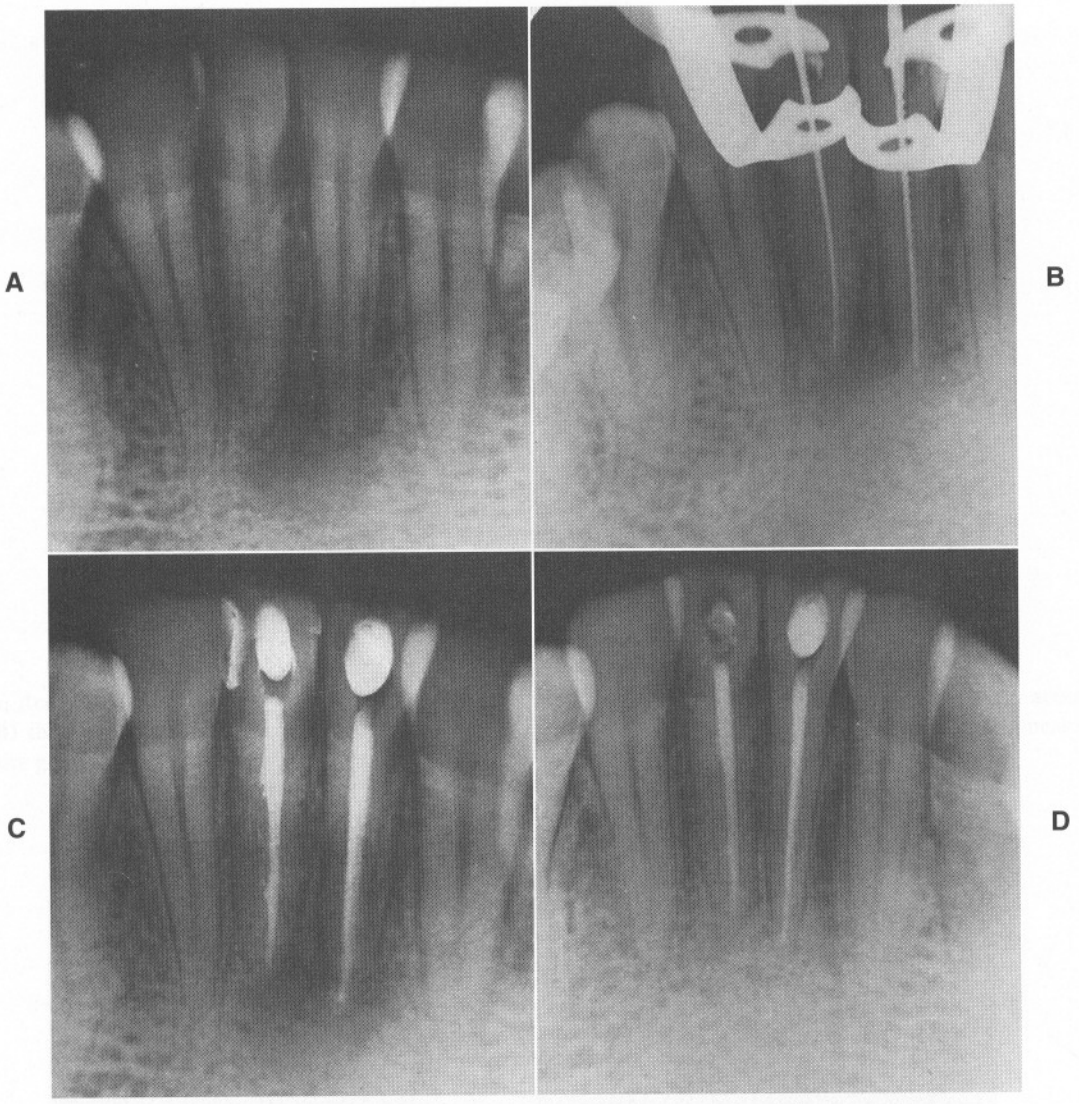


FIGURE 4-13 **A,** Preoperative radiograph of mandibular central incisors with periapical radiolucencies. Pulps were nonresponsive to pulp testing. There was a history of trauma. **B,** Files in place give a hint of two canals. **C,** Despite making a large labiolingual extension of the access, I could not locate the second canal in either tooth. However, at the time of filling, I could see that Type II canal configurations were present, with sealer backing up in central incisor to the right. Canals were filled with laterally condensed gutta-percha and Wach's paste. **D,** Excellent healing 2 years later.

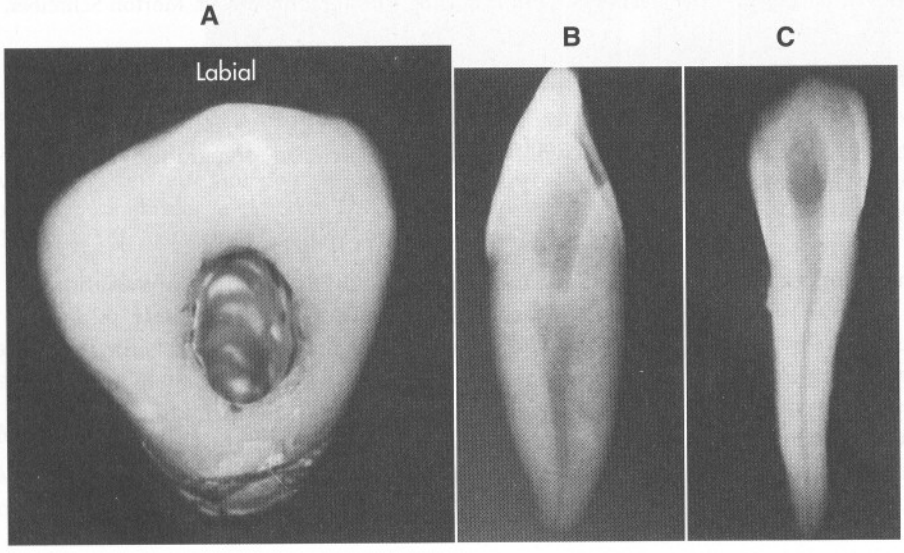


FIGURE 4-14 **A,** Entry for mandibular cuspid is oval with greatest width incisogingivally. Labial and proximal radiographs (**B** and **C**) demonstrate direct access to apex afforded by such a preparation. Similar to the maxillary cuspid, canal is much wider buccolingually than mesiodistally.

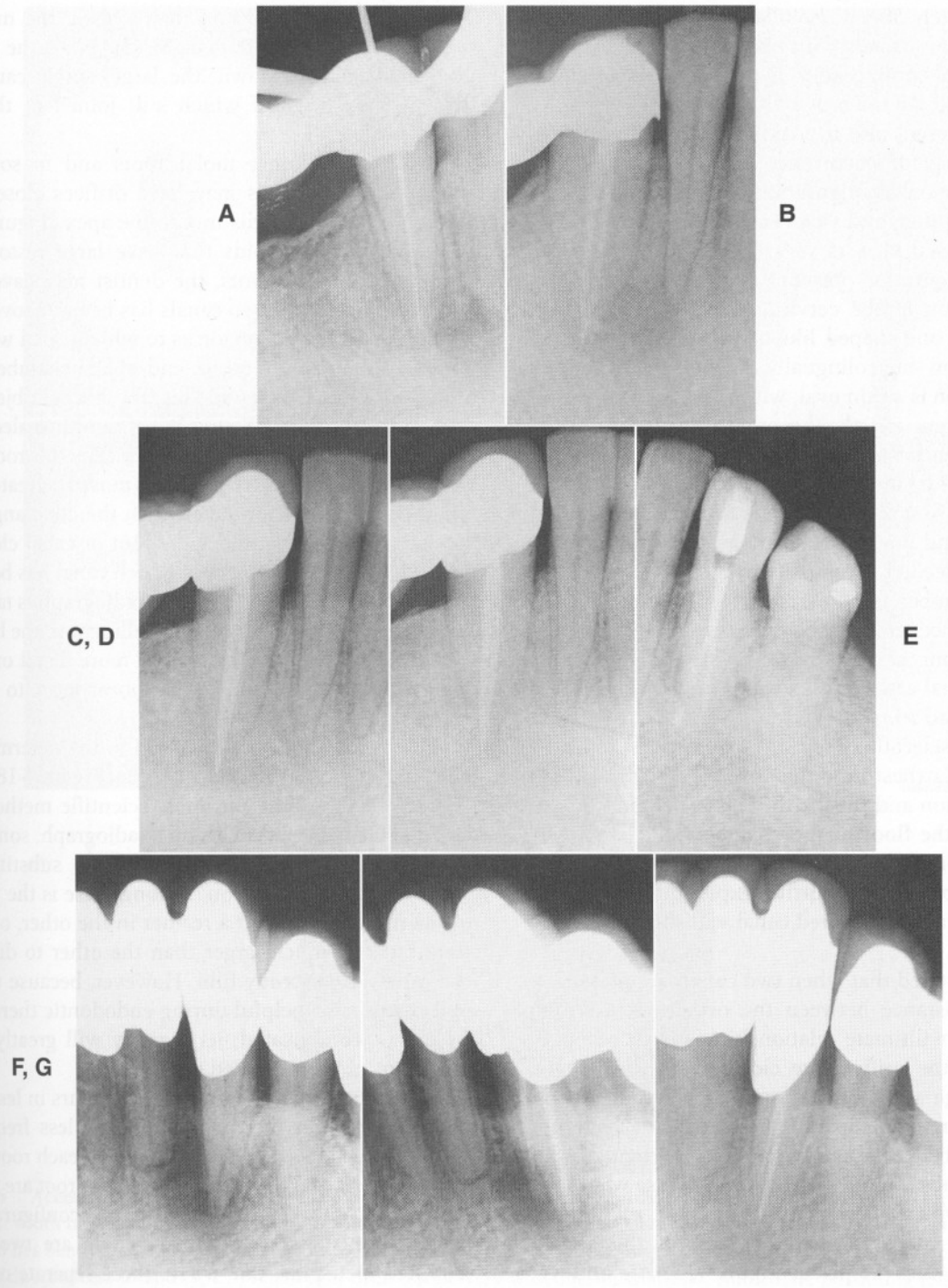


FIGURE 4-15 **Treatment of mandibular cuspids with two canals. A,** Radiograph of mandibular cuspid with initial file in place indicates periapical lesion to the mesial and short placement of file. There is also an extreme fluting of the root on both the mesial and the distal, indicating the possibility for an additional canal. Accordingly the access was widened considerably to the buccal and lingual. **B,** A second canal, the lingual was located through this wider access preparation. Both canals were prepared and filled with laterally condensed gutta-percha and Wach's paste. On this angled radiograph it appears that the canals merge at the apex. However, each canal was prepared separately, and there probably was a small distance between the two, but not wide enough to be seen at this angulation. **C,** One year later. **D,** Three years later, excellent healing. **E,** Another two-canaled mandibular cuspid, with site of separation much further apically, a more difficult position. Canals were filled with chloropercha technique. **F,** Preoperative radiograph of mandibular cuspid with two roots and a large periapical lesion. **G,** Canals filled with laterally condensed gutta-percha and Wach's paste. **H,** Seven years later, perfect healing. (Restorations by Dr. Robert Wheeler, Chicago.)

In approximately 38% of maxillary first bicuspids, only one root is present, usually with two separate canals (Type III). Type II canal configuration is present less frequently. Type I is very rare. All the root and canal configurations of this tooth are present also in maxillary second bicuspids, but the frequency of occurrence changes considerably. The most common configuration in one is the least common in the other, and vice versa (see Table 4-2). The preoperative angled view is very helpful in determining the type of configuration present.

A cross section at the cervical line shows a ribbon-shaped canal or one shaped like a figure eight, with the widest dimension buccolingually. Therefore the access cavity preparation is a thin oval, with the greatest width in the same direction, exactly the opposite of the occlusal cavity preparation for maxillary bicuspids (Figure 4-16).

For all bicuspids, initial access preparation is begun by using a tapered fissure bur in the middle of the central groove. Buccal and lingual movement of the bur develops the oval shape needed for most bicuspids. Once the roof of the pulp chamber is penetrated, a safe-tipped fissure bur is used to uncover the orifices to give direct access to the apices. The buccal canal lies beneath the buccal cusp, whereas the palatal canal lies beneath the palatal cusp (see Figure 4-16, *A* and *E*).

In teeth with sclerotic canals, it is usually best to locate the canal that is farthest from the deep portion of decay or existing restoration and thus is the least calcified. Careful examination of the floor of the chamber, aided by fiber-optic illumination, will show the ribbon-shaped outline of the presclerotic pulp canal. Further exploration at the end opposite the already discovered canal will soon reveal the missing channel.

Vertucci has stated that when two canals are present in one root, the distance between the orifices is a strong indicator of their ultimate relationship to each other. In other words, if the orifices are close to each other, the canals will merge short of the apex, and if they are far apart, they will remain separate and distinct. I have not found this to be consistently correct, particularly in maxillary bicuspids. Figure 4-3 illustrates a case where the orifices of the two canals were quite far apart, each under their respective cusps (as can be seen in the angled radiograph with files in place, Figure 4-3, *A*), and yet merged short of the apex into a single site of exiting. Similarly, I have treated many bicuspids where the orifices were more centered, away from the buccal and palatal extents of their teeth, and yet these canals remained separate and distinct all the way to their apical exiting sites, often being very parallel to each other.

Vertucci's comments referred to molar teeth as well as bicuspids. In the mesial root of mandibular molars, his views are accurate. If the mesial canals in these roots are close together, the chances of them being merged are much higher than if they are far apart. The reason for this is that developmentally in many cases, the mesial canal had a single, large, figure-eight shape. As the isthmus in the middle closed down, the large, single canal became two canals, many of which still joined at the apex in these cases.

However, in other molar roots and in some single-rooted molars, canals may have orifices close, but they remain separate and distinct to the apex (Figure 4-17).

In treating bicuspids that have large restorations, as under bridges or splints, the dentist may have difficulty telling which of the two canals has been uncovered. If the wrong assumption is made as to which canal was located, preparation at the opposite end of the chamber will lead to a perforation. To avoid this, the buccal object rule, so important in the radiography of multicanaled teeth, is extremely useful. This rule states that the root or canal farther from the film (the buccal) moves a greater distance on an x-ray projection taken with the cone angled in the horizontal plane than does the root or canal closer to the film. To solve the problem of which canal has been found, a file is placed in the canal and a radiograph is taken. If the cone is pointed toward the distal direction, the buccal root will move more and therefore be more distal on the film, whereas the palatial canal will appear more to the mesial area (Figure 4-18).

The buccal object rule is used in the determination of working lengths for posterior teeth (Figure 4-18, *A*). Even though it is the best and most scientific method for distinguishing between canals on a radiograph, some dentists fail to understand the concept and substitute other methods for identification. Among these is the placement of file in one canal and a reamer in the other, or two files used but one much larger than the other to differentiate the canals on an x-ray film. However, because the buccal object rule is so helpful during endodontic therapy and is really not complicated, its mastery will greatly facilitate treatment of multicanaled teeth.

A rare combination of roots that occurs in less than 2% of maxillary first bicuspids and even less frequently in second bicuspids is the trirooted tooth, each root with one canal. Two buccal roots and one palatal root are present in these cases and closely resemble the configuration of a small maxillary second molar. There are two types of trirooted bicuspids, one where three separate orifices are present (Figure 4-19), and the other where the two buccal canals come off a single orifice, whereas the palatal canal has its own orifice (Figure 4-20). The latter is more difficult to treat.

Preoperative diagnosis is very important because once the condition is recognized, then further treatment is facilitated. The roots are not always easily recognizable, and the angled views in particular (see Figures 4-19, *A* and 4-20, *A*) seem to give a confusing perspective of the tooth. The three orifices present reveal the underlying condition when that configuration exists and the operator is

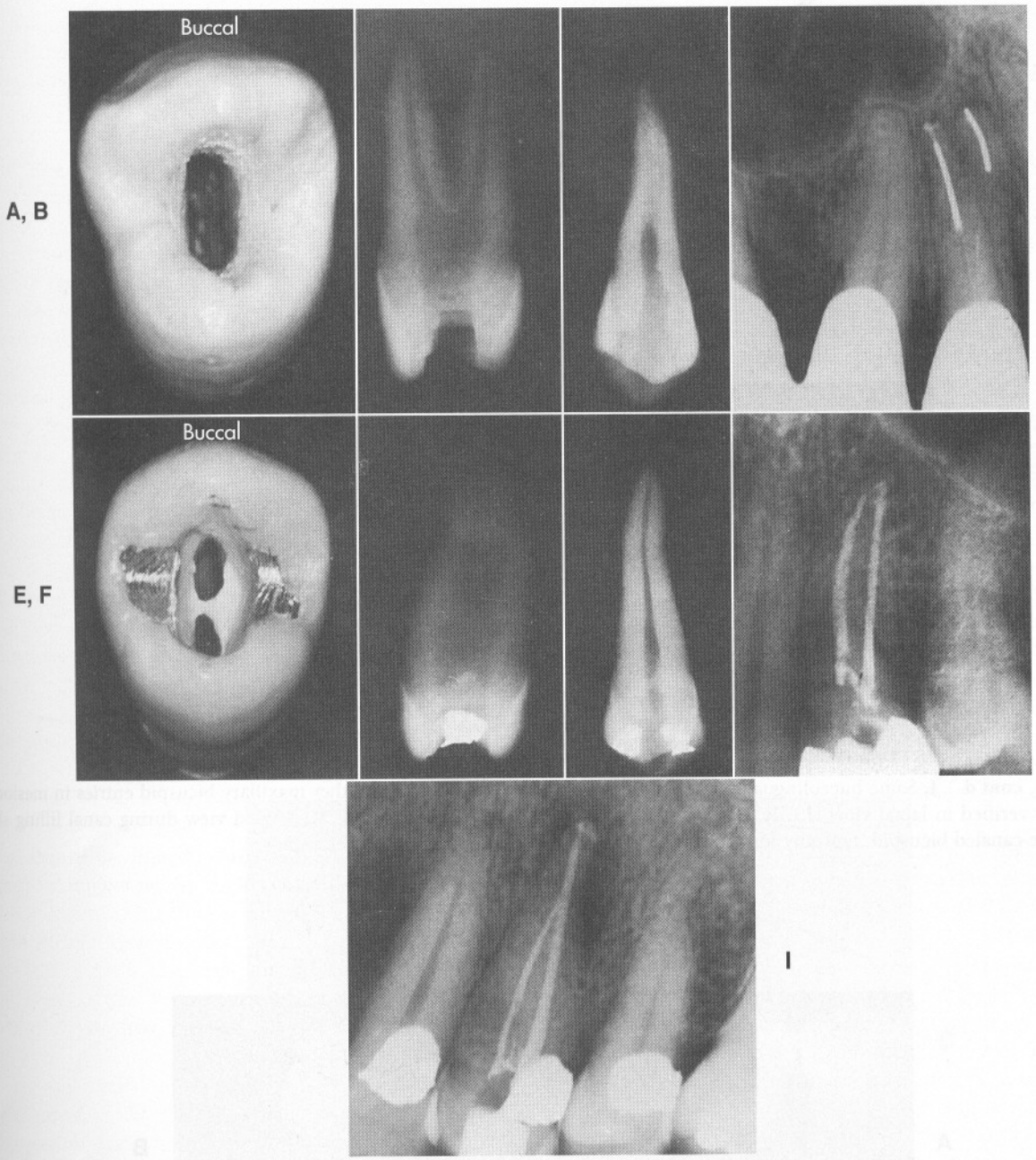


FIGURE 4-16 **Access preparations for three typical types of maxillary bicuspids. A,** Entry for tooth with two separate roots is oval with greatest width in buccolingual direction. Preparation must reach height of cusps because buccal canal lies beneath buccal cusp and palatal canal lies beneath palatal cusp, as seen in proximal radiograph. **B,** Attempting to narrow preparation by not extending to cusps will prevent direct access to apices. **C,** Preparation need not be very wide mesiodistally. **D,** Immediate postfilling radiograph of typical tooth with this configuration, in this case filled with sectioned silver points. **E,** Entry for single-rooted maxillary bicuspid with two canals leaving floor of chamber. Orifices are closer together than in birooted tooth, and extension to cusp height is not required for direct access to apices. **F** and **G,** Buccolingual and mesiodistal views of bicuspid with one root and two canals. **H** and **I,** Immediate postfilling radiographs show two types of teeth in which this access was used: two separate canals all the way to apex *(H)* or canals merging to form a single apical foramen *(I)*.

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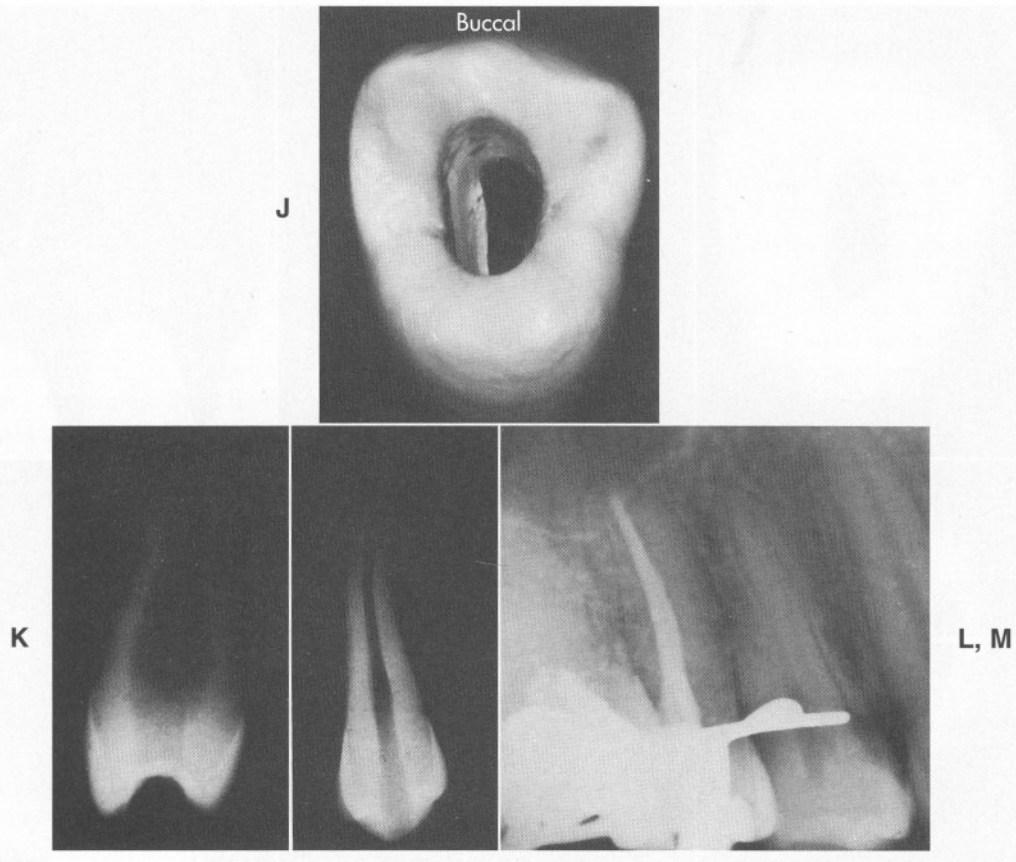


FIGURE 4-16, cont'd **J,** Same buccolingual extension as in *E,* but slightly wider than other maxillary bicuspid entries in mesiodistal direction, as verified in labial view **(L). K,** Very wide canal, as seen from proximal view. **M,** Angled view during canal filling shows typical single-canaled bicuspid, typically found in second bicuspids but very rare in first bicuspids.

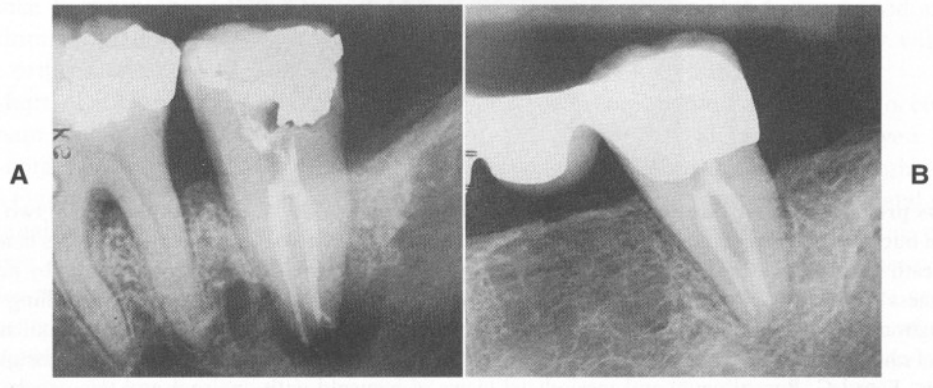


FIGURE 4-17 **A,** Mandibular second molar with two canals close to each other at floor of the chamber, remaining separate and distinct to the apex. Film taken after canal filling. Note large periapical lesion. **B,** Area 18 years after treatment, indicating perfect healing. The first molar had been extracted several years earlier for periodontal reasons.

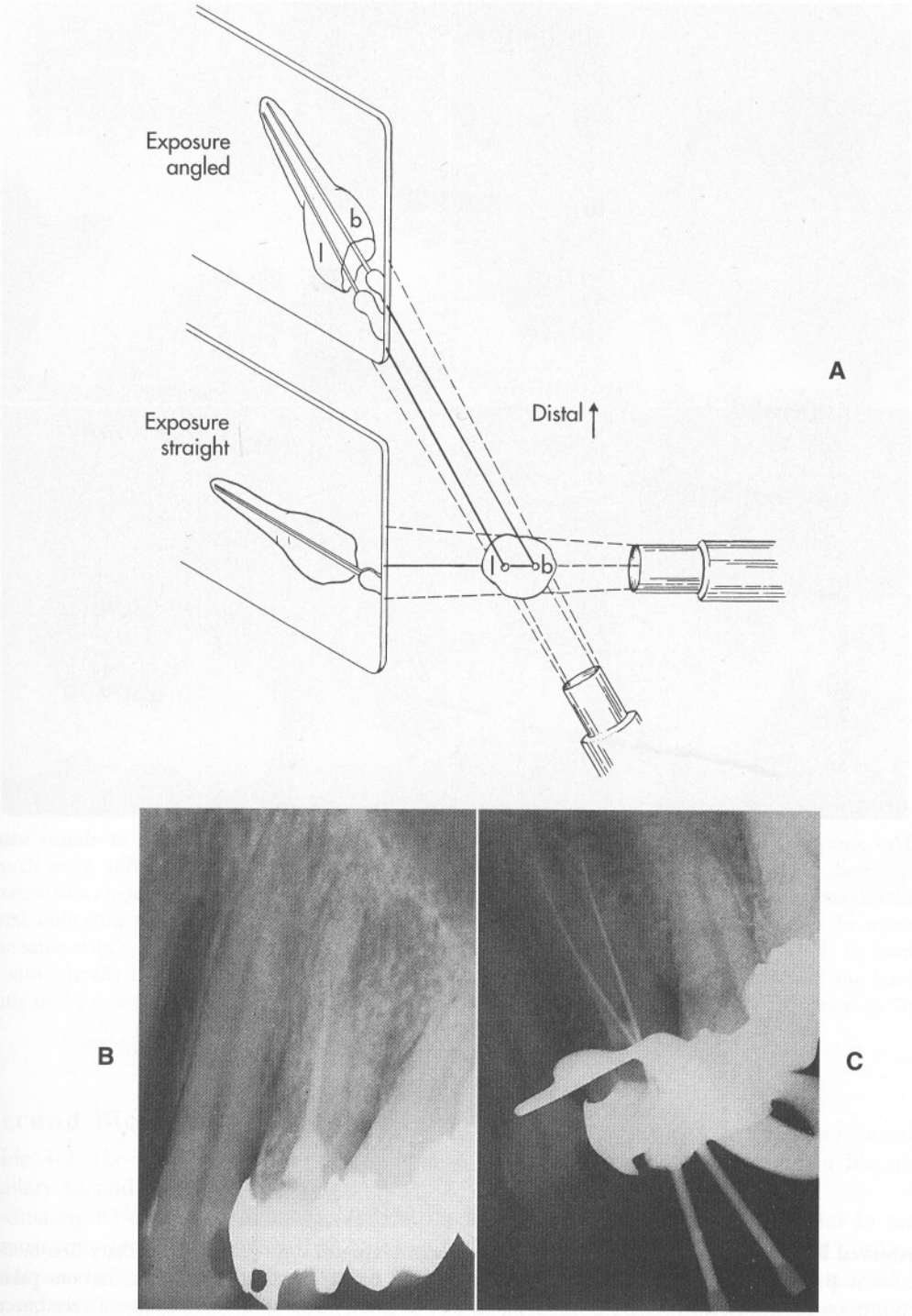


FIGURE 4-18 Buccal object rule, very useful when treating posterior teeth. A, When straight-on exposure is given a bicanaled tooth, canals become superimposed on film, and no individual visualization is possible. If cone is turned to give an angled exposure, film will separate the roots. According to the buccal object rule, the root or canal farther from the film will move a greater distance on the radiograph than will the root or canal closer to the film. Therefore, when the cone is aimed to the distal, the buccal canal, *b,* moves more and appears distal to the lingual or palatal canal, *l.* This rule is used in radiographic evaluation and determination of canal length for maxillary bicuspids, bicanaled mandibular bicuspids, and both maxillary and mandibular molars. **B,** Typical case involving use of buccal object rule during access cavity preparation. Entry into a maxillary first bicuspid indicated a gutta-percha filling approximately in center of chamber floor, but no exact indication as to which of the two canals had been filled. Rather than chance a perforation by searching incorrectly, I consulted the angled preoperative radiograph. Film was taken with cone pointing to distal. Because buccal root moves more than palatal, it appears as distal on the film and is the unfilled canal. **C,** With this information, location of the other canal and establishment of working lengths became a simple matter.

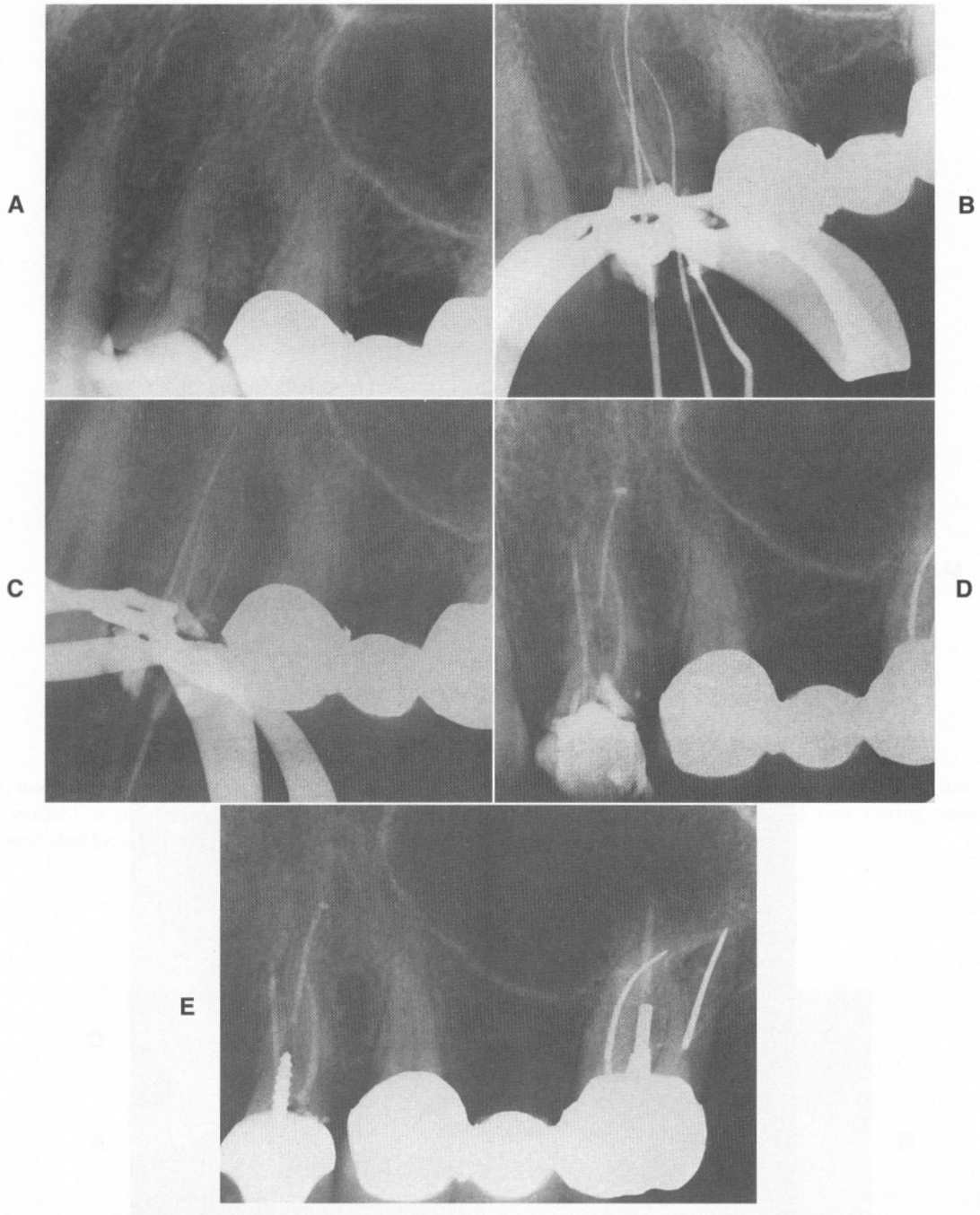


FIGURE 4-19 Trirooted first bicuspid with three separate orifices. A, Angled radiograph of maxillary first bicuspid gives strange perspective of the tooth. **B,** Problem is that it is a trirooted bicuspid. Files in place indicate two buccal and one palatal root. Note that files in buccal roots cross within orifice. **C,** Master cones in place. Due to flared preparation (see Chapter 5), the buccal cones no longer cross. **D,** Final canal filling with laterally condensed gutta-percha and Wach's paste, indicating separate orifices for the buccal canals. **E,** One year later, area looks excellent. I had treated second molar 11 years earlier. (Restorations by Dr. Gary Meyers, Highland Park, Ill.)

observant. Another hint of three roots occurs when the canals are entered and a moderate-sized file (no. 15, 20, or 25) fits in the palatal canal, whereas it is difficult to gain proper depth in the buccal even with a size 10 instrument.

When treating trirooted bicuspids with only a single buccal orifice, it is important to consider the buccal root to be a Type IV (see Figure 4-20, *C*) canal system. The mesiobuccal canal must be widened to the mesial and the distobuccal canal to the distal so that separate sites for instrument and filling cone placement are developed. Remember that the buccal segment with this configuration is much wider mesiodistally when two roots are present than when only a single root is present, and plenty of room for this widening is available.

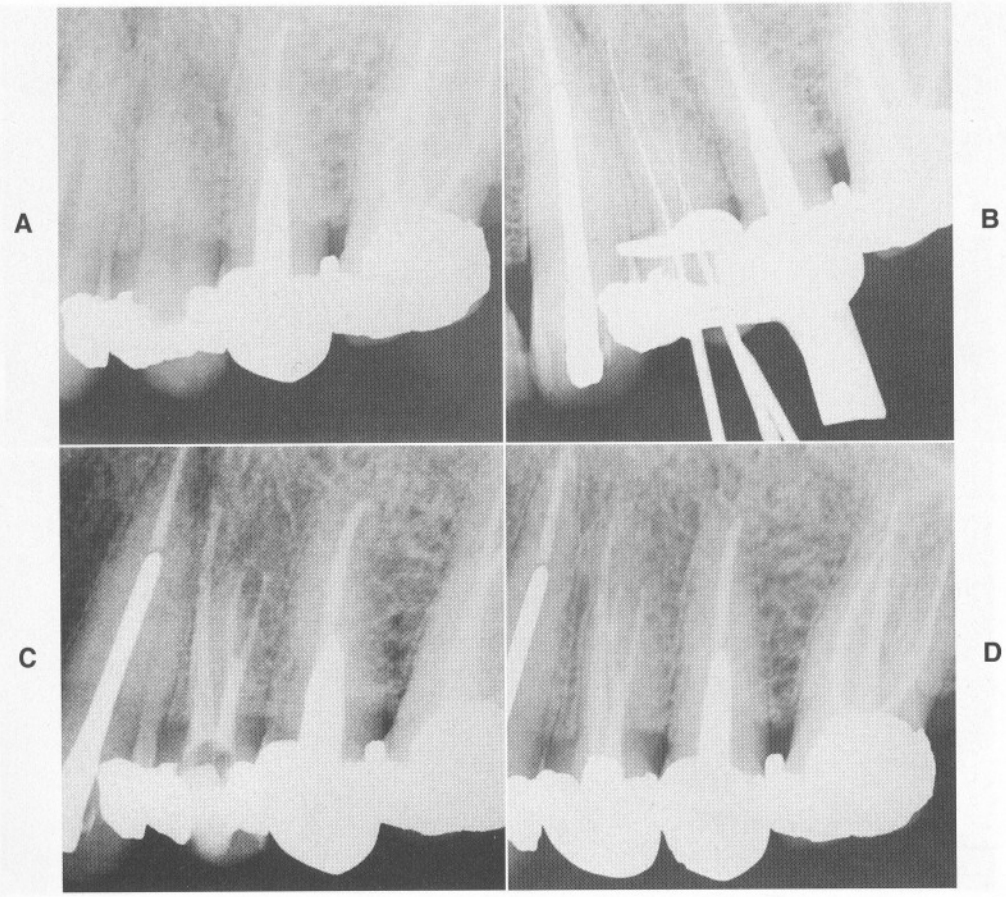


FIGURE 4-20 **Three canals in a maxillary first bicuspid, with both buccal canals coming off the same orifice.** This type of configuration is much more difficult to diagnose and treat than that demonstrated in Figure 4-19, where three separate orifices are present. **A,** Preoperative film angled view with appearance similar to Figure 4-19, *A*. The adjacent cuspid also needs treatment. **B,** Angled view from the mesial, indicating that a size 15 Hedstrom file in the distobuccal canal and a size 10 K file in the mesiobuccal canal are coming through the same orifice. Note the difference between this film and the files in place in Figure 4-19, *B*. **C,** Immediate postfilling film, canals filled with laterally condensed gutta-percha and Wach's paste. Note that the orifice portion of the buccal root has been widened significantly to the point of division of the two buccal canals. **D,** Radiograph 1 year later. (Restorations by Dr. George Morfas, Munster, Ind.)

Maxillary Second Bicuspid

As stated in Table 4-2, the most common root configuration in maxillary second bicuspids is a single root, occurring approximately 85% of the time. Type I canal configuration is most common, but Type II, III, or IV may be present, with decreasing frequency. Approximately 15% of the time, two separate roots are present, each with a single canal. An extremely rare variant has three separate roots (Figure 4-21).

There is variation in the cervical cross section of maxillary second bicuspids, depending on the canal configuration. If only one canal is present, the canal shape is slightly oval and well centered. If two canals are present, the canal shape resembles a ribbon or figure eight, as in the first bicuspid. The access preparation is exactly the same as that for maxillary first bicuspids.

If only one canal is found, but it is not in the center of the tooth, it is probable that another canal is present; one should be searched for on the opposite side. Radiographs from various angles, some with a file in place, may be helpful.

The finding of a Type IV canal in maxillary second bicuspids went virtually unnoticed until papers by Pineda and Kuttler and by Vertucci et al reported that it did occur in a small percentage of teeth. I have found it as frequently as 8% of the time, which is a much higher percentage than in either of those reports. Type IV canals are the most difficult to prepare and fill. It becomes almost impossible to cleanse both apical segments adequately (see Chapter 5). Although it is possible to express sealer into the segment that does not receive the direct placement of the master cone, a true sealing of the canal is problematic.

In many cases the finding of a Type IV is discovered when the canal filling is completed (Figure 4-22, *B*), and for many years I thought that this was merely a large apical auxiliary canal. As with many other instances when