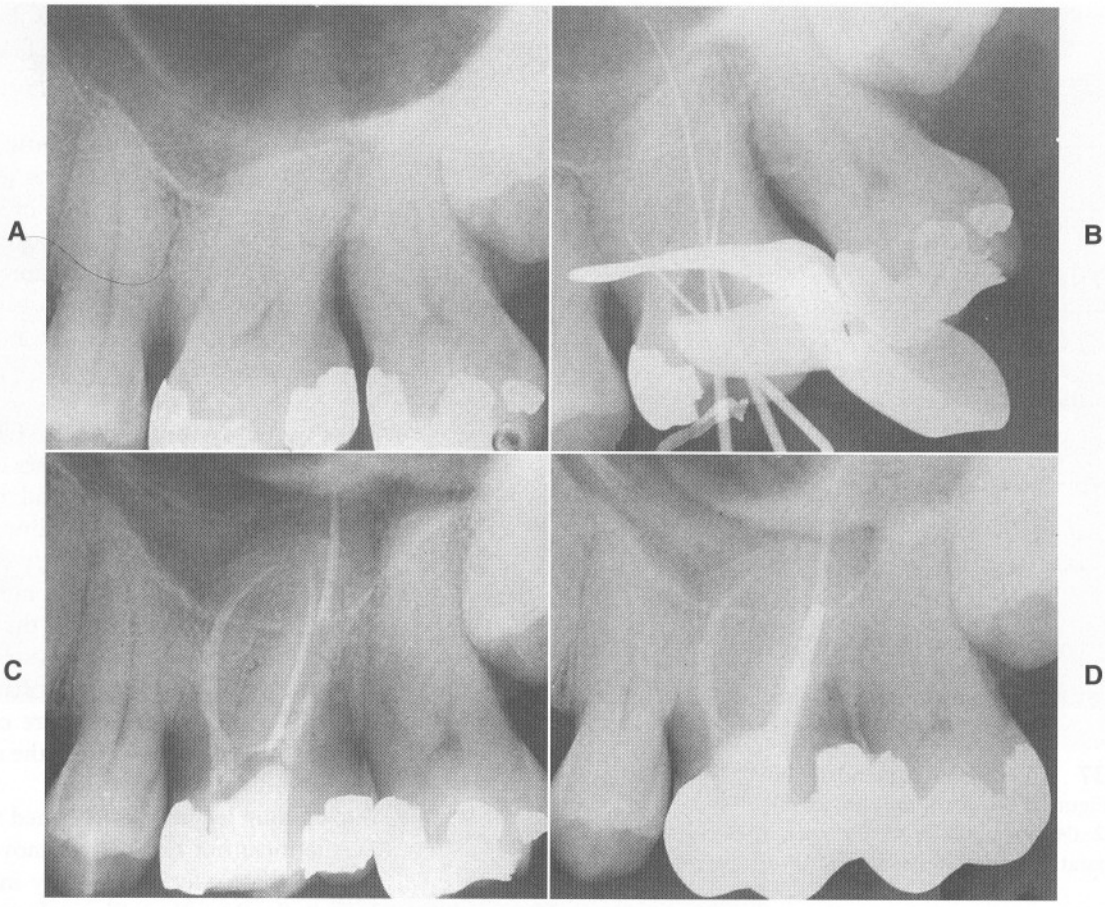


FIGURE 5-38 **A,** Preoperative radiograph of maxillary first molar; canals obviously are quite curved. **B,** Files in place indicate a curvature in the mesiobuccal of approximately 55° and an elbow at 7 to 8 mm. The curvature in the distobuccal is approximately 30°. The curvature in the palatal appears much less because the root is curving directly toward the x-ray cone (see Table 5-3), but it is probably greater than 30°. To prepare the mesiobuccal canal, early flaring was used followed by customized files in sizes 12, 14, 17, 19, 22, and 24 (this was before the introduction of .04 tapers). **C,** The canals were filled with laterally condensed gutta-percha and Wach's paste. **D,** Three years later. (Restorations by Dr. Richard Lammermayer, formerly of Kenilworth, Ill.)

However, I have attempted to treat many other similar teeth, and often the results are not nearly as excellent.

NEW FILE SYSTEMS FOR PREPARATION OF CURVED CANALS

In the past 15 years a plethora of new file system designs have been introduced for preparation of curved canals. As usual with most new products, several of these have been very useful and efficacious, but others have been worthless, and some have been potentially detrimental. Table 5-4 provides a listing of older and newer file systems and their usefulness for various aspects of canal preparation.

There have been three major areas of development for these systems: (1) increase in flexibility by changes in file designs, (2) increase in flexibility by changes in file metals, and (3) files that do not zip because of flute removal or modified tips.

Effects of Increased Flexibility on Final Canal Shape

One of the major reasons why larger files alter canal shape so quickly as opposed to the smaller sizes is that the instruments decrease in flexibility as the sizes increase. In this context, I am defining the word *flexibility* to mean the ability to stay bent in a curved canal and not attempt to straighten. The degree of flexibility may differ from manufacturer to manufacturer and even among batches of instruments by the same manufacturer.

In general, when a difference in flexibility is present in the same size of files by different companies, the more flexible files will alter canal shape less than will the less flexible files of the same sizes (Figure 5-43). By the same

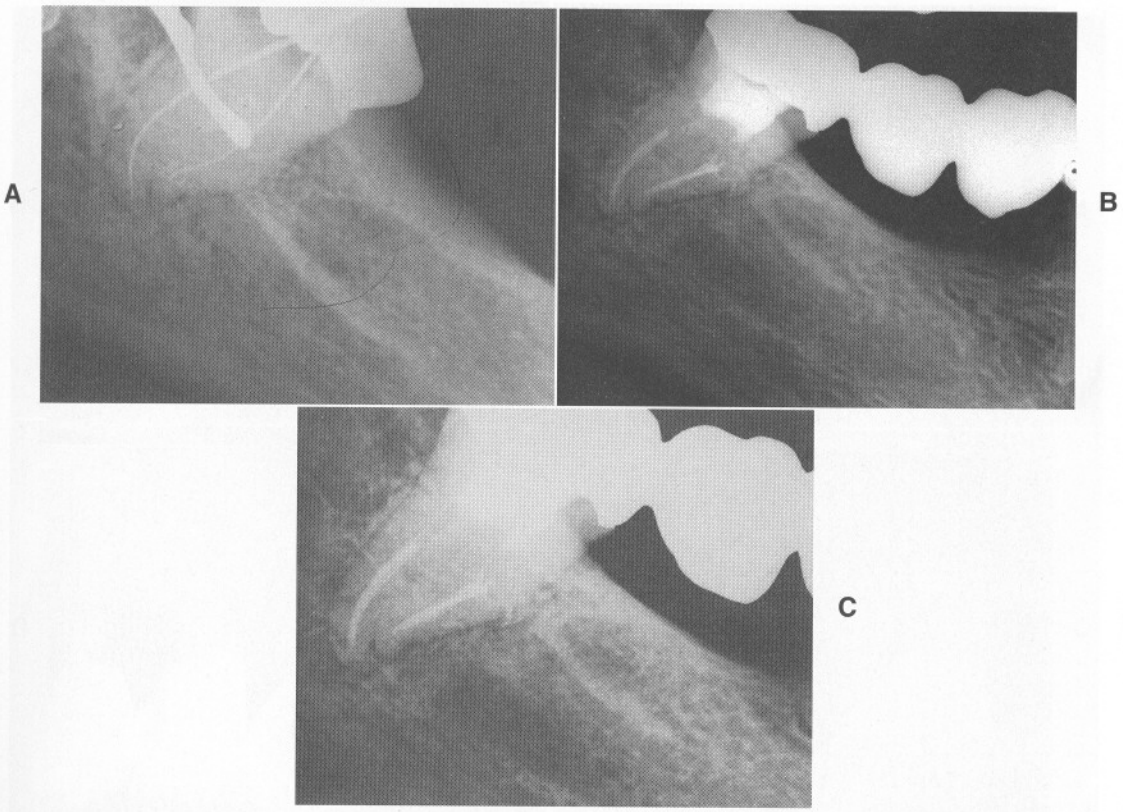


FIGURE 5-39 **A,** Files in place in mandibular second molar, extremely curved distal canal with elbow approximately 2 mm from apex. Compare to Figure 5-38 in which elbow was approximately 7 mm from the apex. **B,** Canals filled with laterally condensed gutta-percha and Wach's paste. Note how the curvature in the distal canal was maintained by careful use of customized files. **C,** Two years after completion of treatment, normal periapical areas maintained. (Restoration by Dr. Steve Labkon, Kenilworth, Ill.)

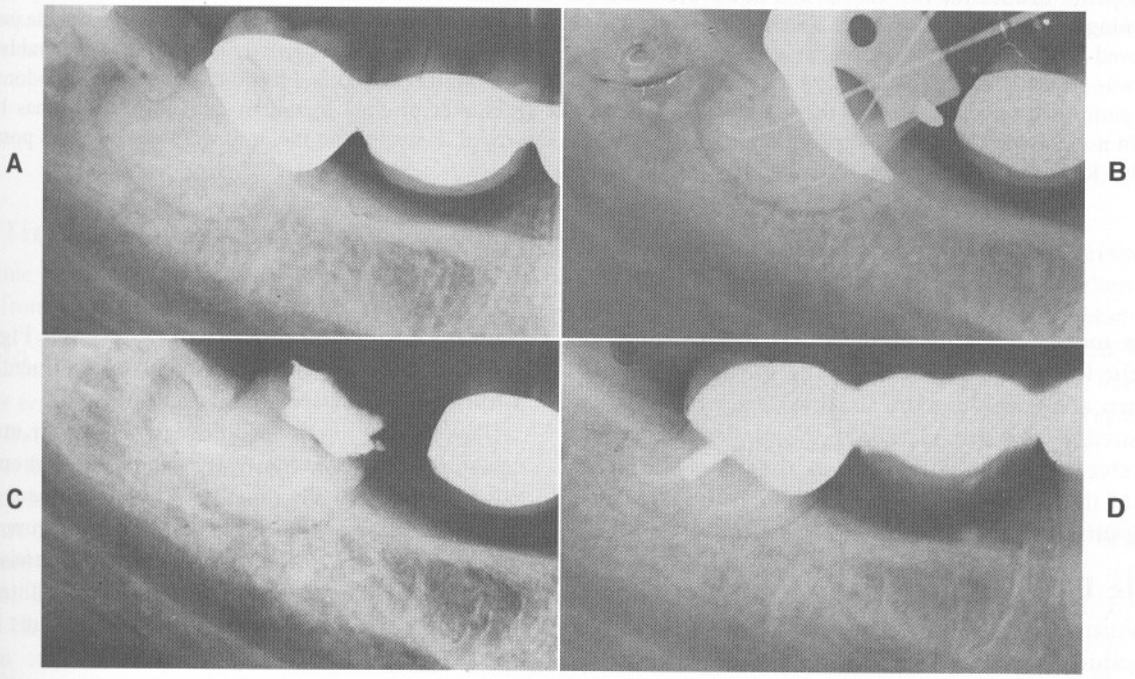


FIGURE 5-40 **A,** Mandibular third molar with extreme curvature of both roots, distal apical radiolucency, and distal bridge abutment. **B,** Files in place, indicating curve on mesial of 85° and on distal of 120°. Both canals were prepared with clips of 0.5 mm and enlarged apically to size 25 with flaring to size 40. **C,** Canals filled with laterally condensed gutta-percha and Wach's paste; post room in distal. **D,** Excellent healing 1 year later. (Restorations by Dr. Steve Mele, formerly of Oakbrook, Ill.)

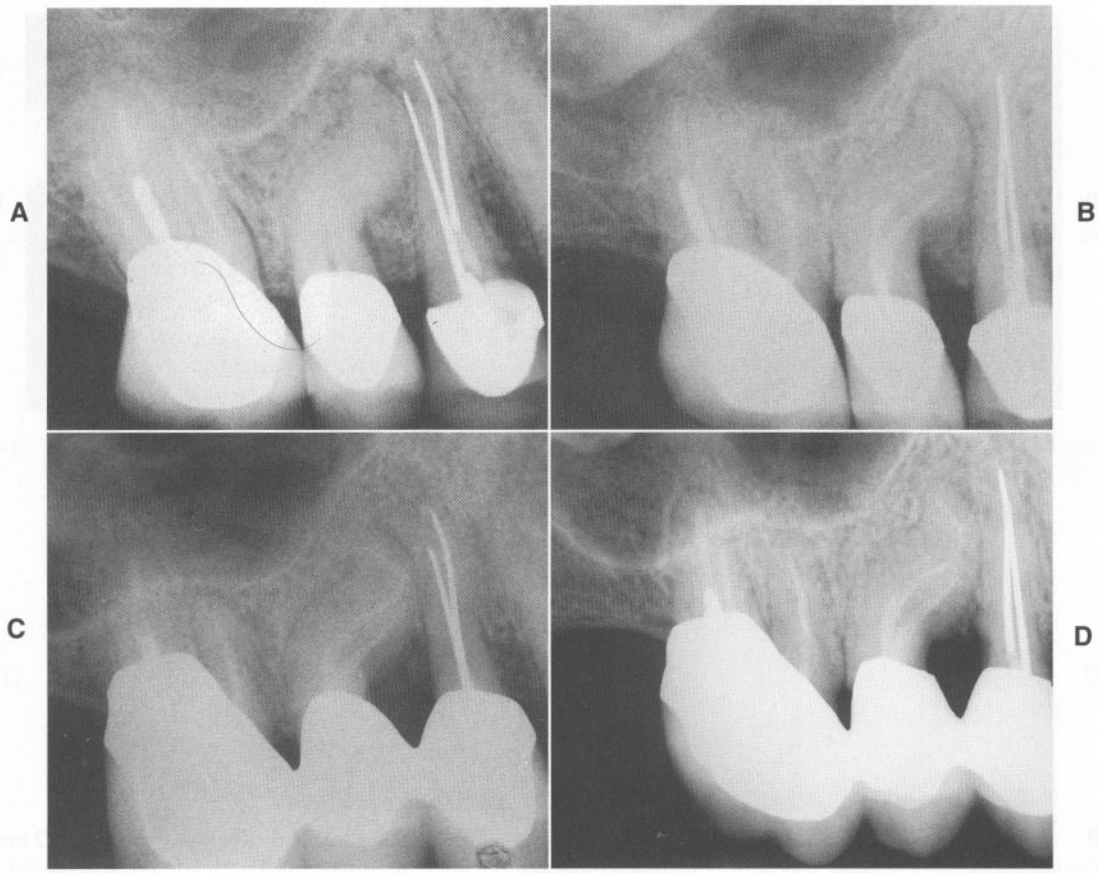


FIGURE 5-41 Double-curve successfully treated with customized files prior to introduction of .04 tapers. A, Preoperative radiograph of maxillary posterior area. Treatment had been performed on the first bicuspid 12 years earlier and on the first molar 7 years earlier. A periapical lesion is seen associated with the second bicuspid, and a double curvature is present in that root. **B,** Maximal reverse flaring was performed for the two canals, and flutes were removed for 4 mm on the mesial side of customized files to protect against mesial opening of the file at the tip. Canals were filled with vertical condensation using a modified chloropercha technique (see Chapter 7). I removed the crown during treatment and did not cement it correctly. Periapical lesion has decreased considerably since the treatment was started 1 month earlier. **C,** Nine months later, periapical lesion has healed and a splint is in place. Periodontal surgery had been performed on the mesial of the second bicuspid. **D,** Six years after original treatment, periapical lesion has healed and remained in normal condition. Area of periodontal surgery also has improved. Bicuspid and molar now 18 and 13 years postoperative, respectively. (Restorations by Morton Schreiber, Highland Park, Ill.)

token, the more flexible files remove less tooth structure than do the less flexible files, assuming the same unit of time. When one uses the more flexible files, which seem more desired in the curved canals, the aspect of flaring must receive particular attention so the more coronal portions of the canal are made wide enough to allow for the filling procedures.

Flexible File Systems

As mentioned earlier in this chapter, the first flexible file to be introduced as an aid for preparation of curved canals was the K-Flex (see Figures 5-4, *C*, and 5-45, *bottom*). These files quickly increased in popularity because it was clearly seen that they minimized drastic change in the shape of canals with moderate curves (approximately 30 degrees). Examination of plastic blocks (see Figure 5-43) and cases treated with these new instruments (Figure 5-45) clearly indicated their usefulness.

The success of the K-Flex led to further attempts to design more flexible file systems, and the next entrant into this field was the Flex-o-file.* This instrument utilized a triangular blank, as used for the reamer (Figure 5-45, *top*; see also Figure 5-4, *A*), with the flutes twisted more tightly to give more cutting edges but maintaining the same narrow cross-sectional diameter for increased flexibility.

*Caulk/Dentsply, Milford, DE 19963.

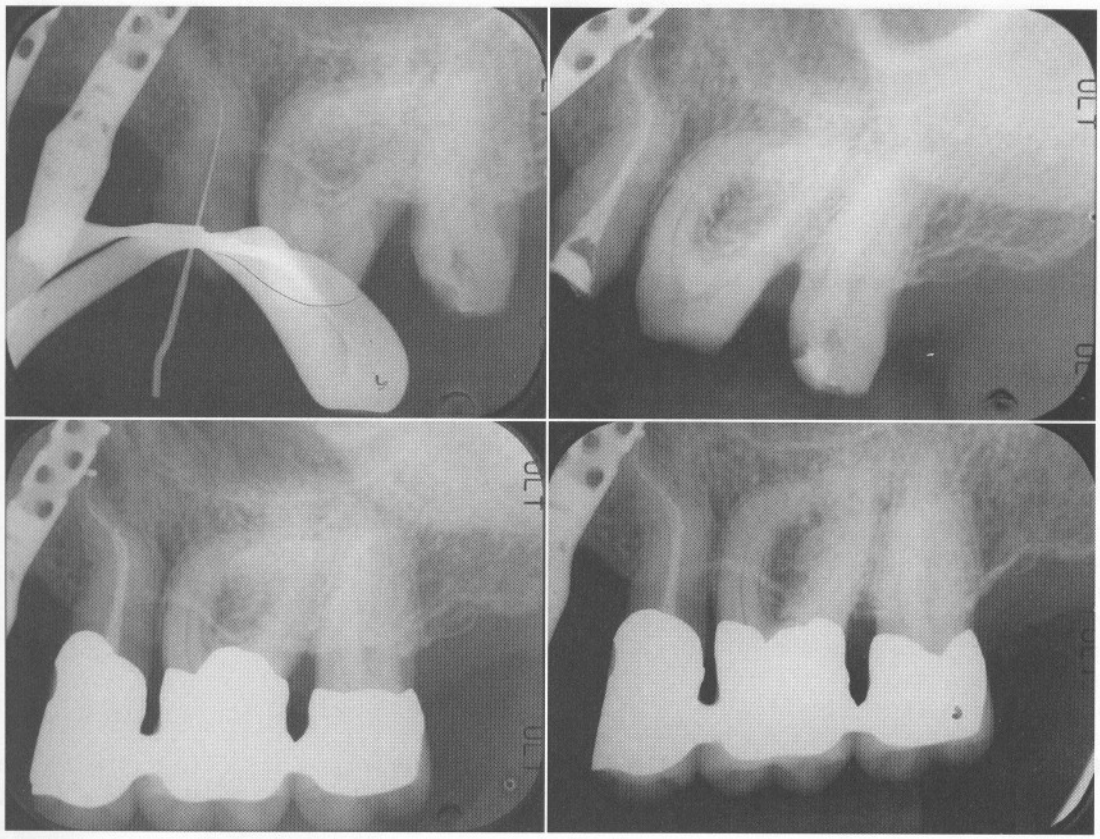


FIGURE 5-42 Double curve treated with customized files and .04 tapers. A, File is placed in maxillary second bicuspid with double curves of approximately 45° each and a periapical lesion. **B,** The size no. 10 file was worked up and down several mm to the working length for approximately 10 minutes to establish a clear path through the canal system. This was followed by using #2, #3, and #4 .04 tapers to the first curve, always followed by the IAF to the apex. Customized files were used from no. 10 through 25, including a number of intermediate sizes. At the third appointment the canal was filled with gutta-percha and Wach's paste. **C,** Six months later, the lesion has decreased in size. **D,** One year after treatment, the lesion continues to decrease, although it is difficult to see behind the implant. (Restorations by Dr. Kerry Voit, Chicago.)

Nickel-Titanium Files

More flexible systems were also developed by changes in the metal from which the files were made. Instead of the carbon steel (used for the old 1 to 12 designations and in a few of the more modern systems) or stainless steel (used in most file systems presently), nickel-titanium was introduced for endodontic use. Called *NiTi files,* these instruments have the ability to return to their original shape, even if bent severely and held in this position for a long time (Figure 5-46, *A*). They have minimal resistance to pressure, and thus have been considered to be "flexible." Whether or not they are truly flexible is a matter of semantics. I believe they have great memory and usually will return to their original (straight) shape. If this happens at the tip or through the apex of the tooth, over-instrumenting the canal, the result may be undesirable. Files that straighten at the apex or through the tip of the canal will produce zipping (see Figure 5-20, *A*).

Because they have so little resistance to pressures, the NiTi files cause little change in canal shape when they are used by hand. However, by the same token, when used by hand, these files do very minimal preparation for given time periods. Therefore, it has been suggested that they be used in mechanical handpieces to complete preparation in a reasonable amount of time (Figure 5-46, *B*).

Minimizing Zipping by Flute Removal and Modification of Tips

The first article dealing with flute removal, by Weine, Kelly and Lio, was published in 1975. Although the paper indicated that the technique was effective in reducing alteration of canal shape in curved canals of both plastic blocks and clinical cases, only a small number of dentists were moved sufficiently to utilize the method in their own endodontic treatments.

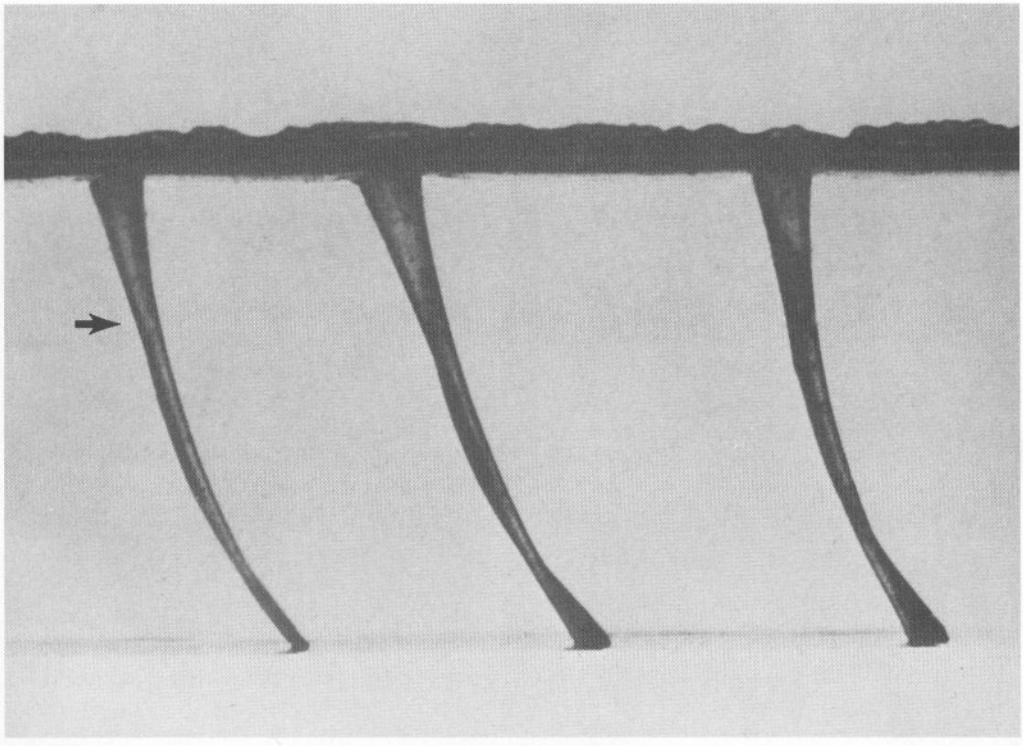


FIGURE 5-43 Plastic block canals prepared with files of various flexibilities. Canal at left *(arrow)* was prepared with Kerr K-Flex files to size 30 and no removal of flutes. Minimal elbow and virtually no zip. Center canal was prepared with files to size 30 from a company that manufactures very inflexible files. Narrow elbow and wide zip. Right canal was prepared to size 30 by the most inflexible files I could find, regardless of the manufacturer. Considerable zipping and constricted elbow.

This original paper did spark a number of investigations, virtually all of which endorsed its conclusions. Gradually, more techniques and modifications were introduced that attempted to alter the shape, position, or presence of file-cutting ability to maintain canal shape.

In 1985 and 1986, papers were written by Roane, Sabala, Powell et al and others from the group at the University of Oklahoma, suggesting a new preparation technique, called "balanced forces." Among other aspects of therapy, this method recommended use of file rotation, filing to the radiographic apex, and the use of only three preparation regimens to cover every type of canal width, length, or degree of curvature. These theories are all completely contrary to my own. In these reports, however, a new type of file was suggested for use with this technique, the Flex-R-File.* This file had its tip modified so that there were no cutting edges or surfaces present (Figure 5-47). Studies indicated that this new shape reduced ledging and root perforation because the nonworking tip acted merely as a guide for the instrument to pass through the curved portion of a canal without removing dentin. Since that time, many companies have changed their file tips to this new shape.

In theory, tip modification is the next evolutionary change after removal of flutes because the cutting ability in the apical area is restricted and therefore zipping is reduced. I believe that it is the Flex-R-File, not the theory of balanced forces, that has enabled cases treated with that technique to be successful. Benenati et al addressed iatrogenic strip perforations treated successfully at the University of Oklahoma. To obtain the sample size necessary to report on this procedure, a huge number of molar teeth had to be available with strip perforations, a common problem with the file rotation recommended in balanced forces but uncommon in a rasping-only method. Sabala et al also reported that in a technique course using balanced forces at that school, instrument breakage was 17%. This number is incredibly high, but again, typical of a rotation technique, although very rare of when using rasping only.

A similar modification recently introduced is the pilot tip, used for the Canalmaster,* where a noncutting tip of 1.5 mm is present, followed by several millimeters of cutting flutes and then a more narrow smooth shaft. Several other instruments have pilot tips.

*Union Broach Co., New York, NY 10010.

*Brasseler USA, Savannah, GA 31419.

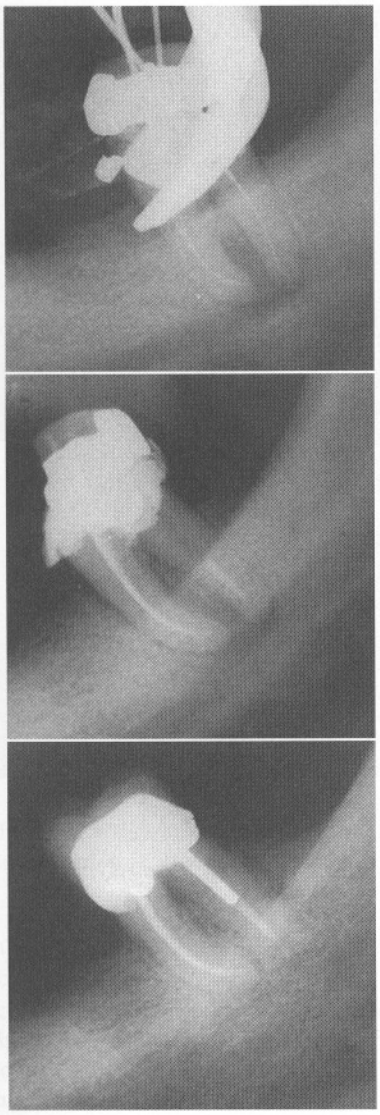


FIGURE 5-44 **A,** One of the first molar teeth to be treated with a flexible file system. Film of files in place of mandibular second molar, indicating curves of approximately 30° in the mesial canals and large periapical lesion. Canals were prepared with K-Flex files to the full working lengths and apical to the elbow, incremental instrumentation used to create intermediate sizes, and Hedstrom files for flaring coronal to the elbow. **B,** Film taken after canal filling with laterally condensed gutta-percha and Wach's paste, with post room prepared. Minimal zipping despite no flutes removed during preparation. **C,** Eight years after treatment, excellent healing. (Restoration by Dr. John Davis, Park Ridge, Ill.)

Disadvantages of Flexible Files

When the new flexible instruments were introduced for treatment, they became very popular almost immediately for use in small, curved canals because they performed the function of enlargement very well. However, some portions of this type of preparation were not clearly understood.

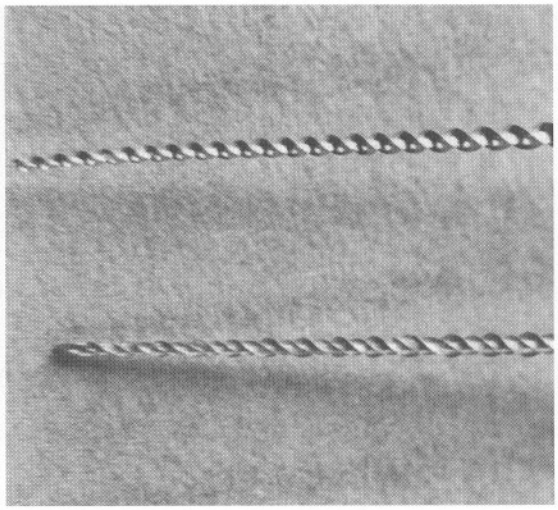


FIGURE 5-45 Flutes of two popular flexible file systems. The K-Flex file *(bottom)* is the result of twisting a diamond blank (see Figure 5-4, *C*) to give cutting edges. Close examination reveals that only every other edge is a true cutting edge. However, this skip of cutting edges helps to remove more dentin and debris from the canal. The Flex-o-file *(top)* uses a triangular blank (see Figure 5-4, *A*), as typically used for reamers, but it is twisted more tightly to give more cutting edges. The triangular shape yields the narrowest cross-sectional diameter among the variously shaped blanks for twisting.

Three different functions must be performed by instruments for treating curved canals, and a single file system rarely performs all of these. They are (1) penetration, the ability to gain access to the tip of a narrow canal; (2) need for flaring and early flaring; and (3) maintaining the shape of the curve. The flexible file systems, while being excellent for maintaining curves, are very poor in penetrating to the tip of these channels, often lined by sclerotic dentin deposits that make the walls very irregular. When flexible files were used in an attempt to traverse such canals, many would buckle, just like a wet noodle, particularly when the small sizes (nos. 08 and 10) were used. Clearly, for this function, the older, unmodified tipped instruments are superior. The files available with their primary functions are listed in Table 5-4.

Non-ISO Taper File for Penetration

To perform the function of reaching the apex of a curved, sclerotic canal, another type of file was needed. In the old 1 to 12 system, Kerr* had manufactured such an instrument as its no. 1.

The old Kerr no. 1, not having been manufactured with any thought of accordance with a standardized taper, in fact had a very narrow taper of approximately 0.015 per millimeter of width for every 1 mm of length. With a tip size of approximately 0.12, the D_{16} width was only

*Sybron Endo, Orange, CA 92687.

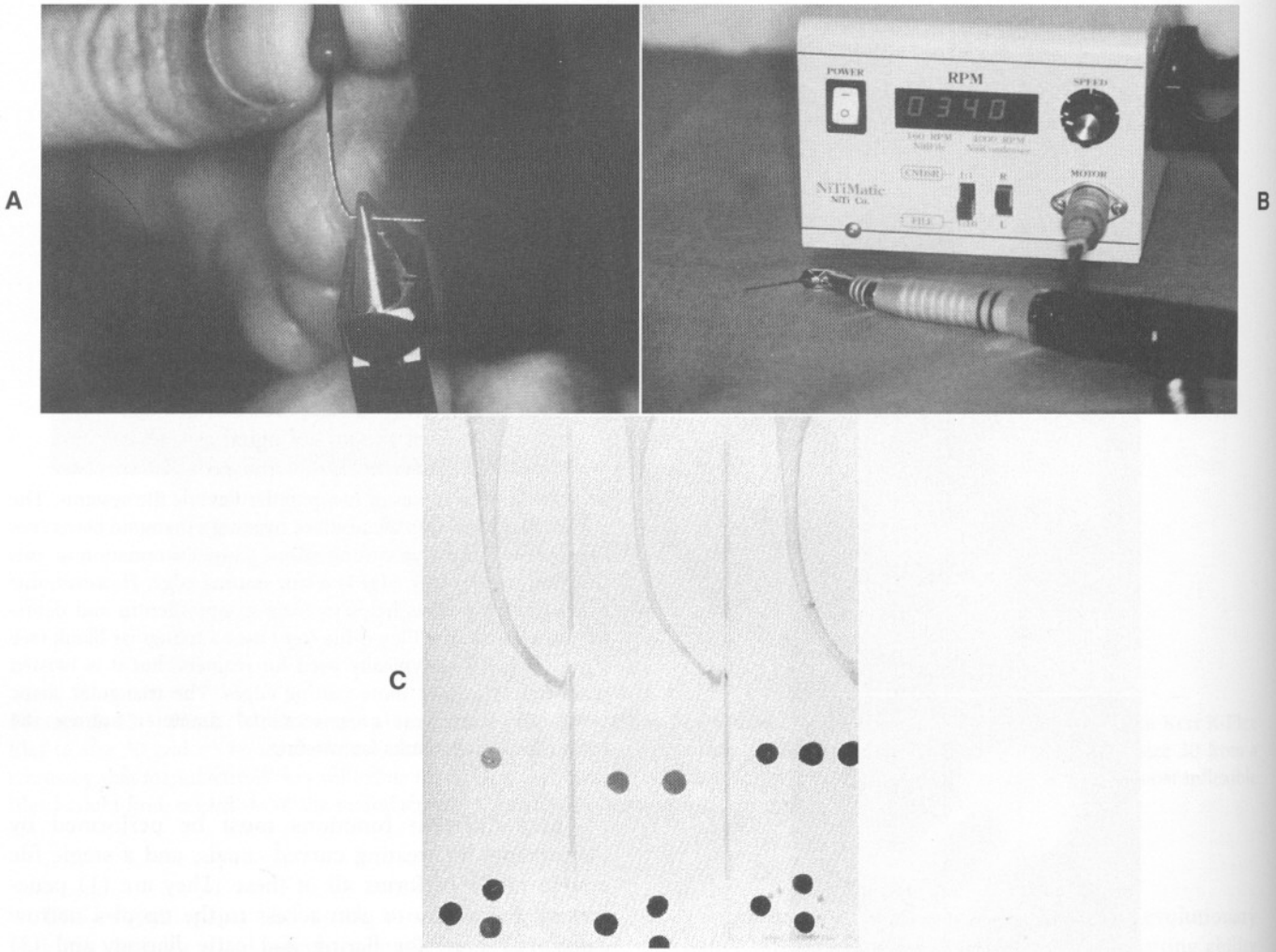


FIGURE 5-46 Use of NiTi files. A, Files made of nickel-titanium have been described as "superelastic" because of their ability to return to their original shape. This NiTi was bent with a pliers at 90° for 1 hour, but when released, it returned to being straight. **B,** Because the NiTi instruments are slow cutters, canal preparation is very slow and removes minimal amounts of tooth structure unless the instrument is used with a mechanical handpiece. **C,** Three plastic blocks, all prepared for the same length of time, all with early flaring. *Left,* NiTi with mechanical handpiece; *center,* NiTi by hand; *right,* customized files with flutes removed (similar to Figure 5-28). *Center,* NiTi by hand indicates a minimally prepared canal. The two side blocks are fairly similar, with the mechanical NiTi canal *(left)* having a smoother taper than the hand-prepared canal *(right),* with a more irregular taper. (Courtesy Dr. Mary Campbell, LaCrosse, Wis.)

0.40 mm. However, this non-ISO taper gave it better ability to be twisted and forced into a small, tortuous canal than the flexible instruments, particularly because the metal used was carbon steel.

PREPARATION OF TYPE II CANAL SYSTEMS

As shown in Figure 4-2, four common canal configurations are possible. The Type II system consists of two canal orifices exiting the chamber, then merging within the body of the root into a single canal to the site of exiting. This system is most frequently found in the mesial roots of mandibular molars and maxillary second bicuspids, but it also may occur in any bicuspid, the distal root of mandibular molars, and mesiobuccal root of maxillary molars.

The most difficult root with a Type II system is the mesial of the mandibular molar, where curvatures complicate the relationship of the two canals. However, a Type II system still is easier to prepare and fill than a Type III system of similar canal width and curvature.

The standard method for preparation of a Type II system is to select one of the branches to be the master canal, prepare that completely, and then file the other, dependent, canal merging into it. Although that is not difficult in most bicuspids, the mesial root of the mandibular molar may cause problems (Figure 5-48). In the mandibular first molar the mesiolingual should always be selected as the master canal. In the mandibular second molar, the mesiolingual usually is preferable as the master

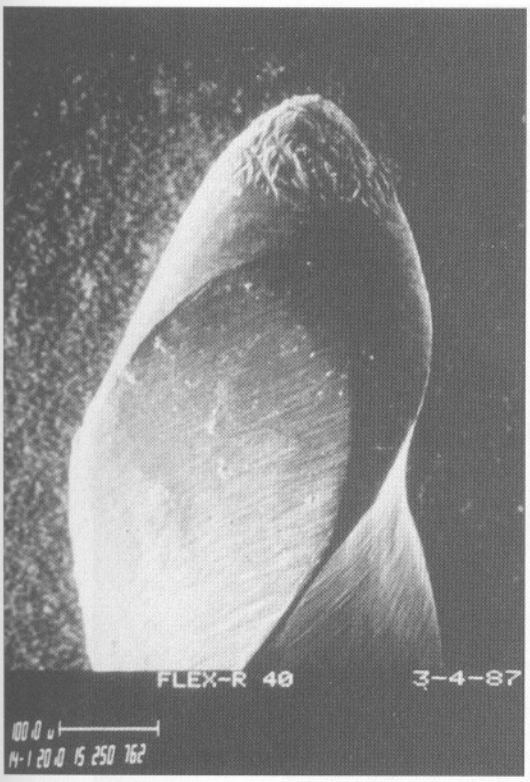


FIGURE 5-47 Tip of the Flex-R-File, indicating total absence of cutting ability, which should eliminate ledging and greatly diminish zipping. (Courtesy Union Broach Co., New York.)

canal, but in some cases the mesiobuccal is the better choice. In bicuspids the choice varies between the buccal and palatal canals. The master canal is chosen on the basis of being the canal most consistent with the root curvature.

It may seem logical to file the master canal to its entirety, then file the dependent canal to the site of merging. Doing that, however, may cause dentin shavings from the dependent canal to block off the master canal at the point of confluence and prevent filling to the desired end point.

The correct method involves alternating preparation between the two canals, starting and ending in the master canal but also enlarging the dependent canal between work on the master. A typical case of this type is shown in Figure 5-49; the working length of the mesiolingual (master canal) was verified at 19 mm, and the site of confluence (working length of the dependent mesiobuccal canal) was 17 mm. The mesiolingual was enlarged with a size 10 file to 19 mm, then the mesiobuccal with a size 10 to 17 mm, and then the mesiolingual again to 19 mm to prevent dentin from packing at the point of confluence. When a size 15 could be used, it was passed down the mesiolingual to 19 mm, then into the mesiobuccal to 17 mm, and back into the mesiolingual at 19 mm. This system was continued until the MAF was reached and until flaring was performed similarly. Reverse flaring, removal of flutes, or customized files might be used as necessary.

The key step in these preparations is to pass the file the full working length in the master canal following every file used in the dependent canal to ensure patency to the apex. Type IV canal systems (see Figure 4-2), one main canal that branches into two separate and distinct canals at the apex, are very complicated to prepare. Once each branch (buccal and lingual) has been located and measured, preparation will be easier if the main segment is widened buccolingually so that the files will find the apical branches more readily. This may be accomplished by early flaring.

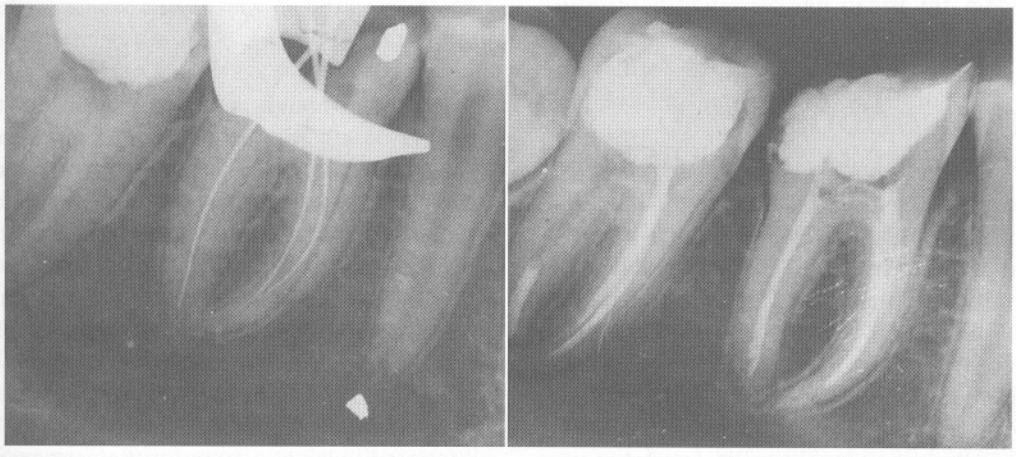


FIGURE 5-48 **Incorrect method for preparation of Type II canal system. A,** Radiograph of files in place for treatment of mandibular first molar. The file in the mesiolingual went 20 mm, and the file in the mesiobuccal canal joined it at 18 mm (this view was slightly from the distal). The mesiolingual was made the master canal and was enlarged to size 30 at that length and flared to size 45. Then the mesiobuccal canal was enlarged apically to size 30 at 18 mm and flared to size 40. Unfortunately the filing from the mesiobuccal canal packed off the mesiolingual canal at the point of confluence. **B,** When the canals were filled, a ledge was created at 18 mm, and no filling material could be packed past that site. The case was jeopardized by the error in preparation.