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The K3 rotary nickel–titanium file system

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The K3 rotary nickel–titanium file system (SybronEndo, Orange, California) was introduced initially in North America in January 2002 (Fig. 1). The K3 system was designed by Dr. John McSpadden (Lookout Mountain, Georgia). The K3 has universal applicability across a wide range of clinical indications and includes the following features:

1. K3 canal shaping files with a fixed taper of 0.02, 0.04, or 0.06. (The 0.02 tapered K3 files are available in tip sizes 15 to 45 and in 21-, 25-, and 30-mm lengths; the 0.04 and 0.06 tapered K3 files are available in tip sizes 15 to 60 and in 21-, 25-, and 30-mm lengths) (Fig. 2).
2. A slightly positive "rake" angle (Fig. 3). A positive rake (cutting) angle provides a more effective cutting surface than a negative one. U-shaped rotary instruments possess a negative rake angle.
3. A variable core diameter (Fig. 4). This feature enhances flexibility over the entire cutting length.
4. A series of three radial lands with a relief behind two of the three lands (Fig. 5). This feature reduces friction on the canal wall.
5. Asymmetrically placed radial lands and unequal land widths, flute widths, and flute depths (Fig. 6). Asymmetrical flutes allow the K3 to provide superior canal tracking, virtually eliminate transportation, aid in preventing the file from screwing into the canal, and add peripheral strength. The proportion of the core diameter to the outside diameter is greatest at the tip where strength is most needed. The proportion then decreases uniformly as the fluting moves up the taper, resulting in greater flute depth and increased flexibility while maintaining strength.
6. An "Axxess" handle design, which shortens the file handle by approximately 5 mm without affecting the working length of the file (Fig. 7).

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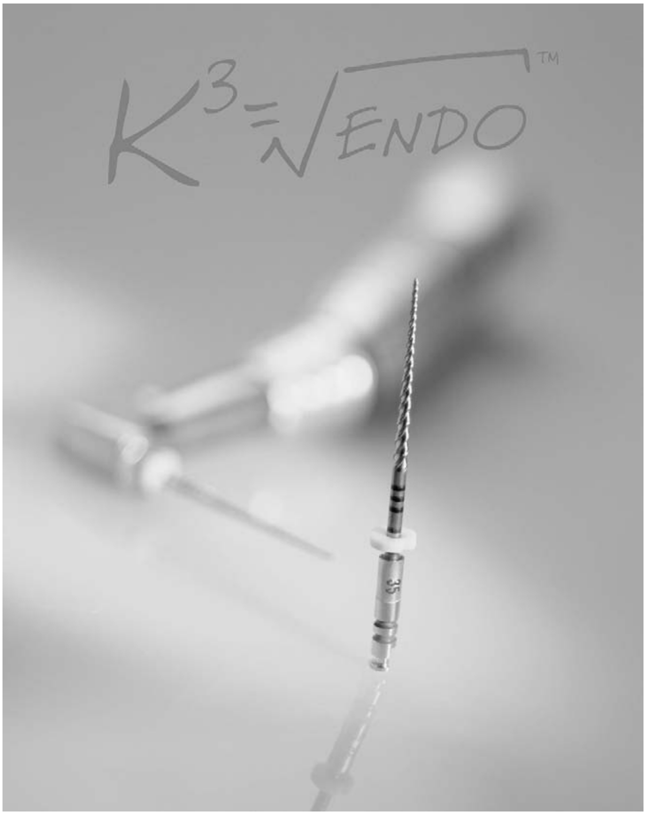

Fig. 1. The K3 rotary nickel–titanium file system (SybronEndo, Orange, California) was introduced initially in North America in January 2002.

7. A variable flute pitch (Fig. 8). This feature also helps prevent the screwing-in effect common with some brands of files and promotes debris removal.
8. Color coding to distinguish between different tip sizes and tapers (Fig. 9).
9. A safe-ended cutting tip (Fig. 10).
10. K3 "body shaper" files with an enhanced taper of 0.08, 0.10, and 0.12 that can act as both canal shaping files, orifice openers, and "deep body"

Taper	Tip Size	17mm	21mm	25mm	30mm
02	#15-#40		YES	YES	YES
04	#15-#60		YES	YES	YES
06	#15-#60		YES	YES	YES
08	#25	YES	YES	YES	
10	#25	YES	YES	YES	
12	#25	YES	YES	YES	

Fig. 2. The availability of K3 canal shaping files with regard to taper, tip size, and length.

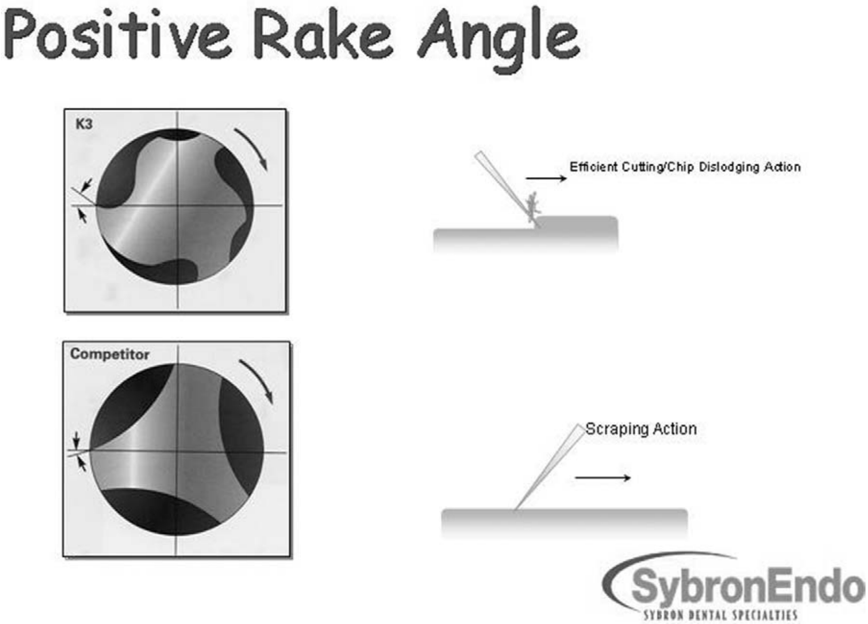

Fig. 3. The K3 has a positive rake angle, providing a more effective cutting edge (SybronEndo).

shaping files (these are available in a fixed tip size of 25 and in 17-, 21-, and 25-mm lengths) (Fig. 11). These body shapers have a modified design relative to the 0.02, 0.04, and 0.06 tapered K3 files. The body shapers have a shorter taper length (the apical 8 mm, which provides the cutting function to the file), allowing for a smaller maximum diameter at the shank and creating a more flexible instrument. The fluting on the straight (nontapered) shank is not designed to cut effectively and the straight

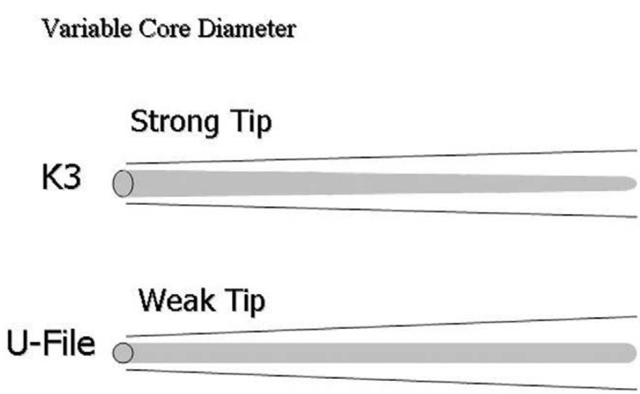

Fig. 4. The K3 has a variable core diameter, which increases flexibility over the entire cutting length.

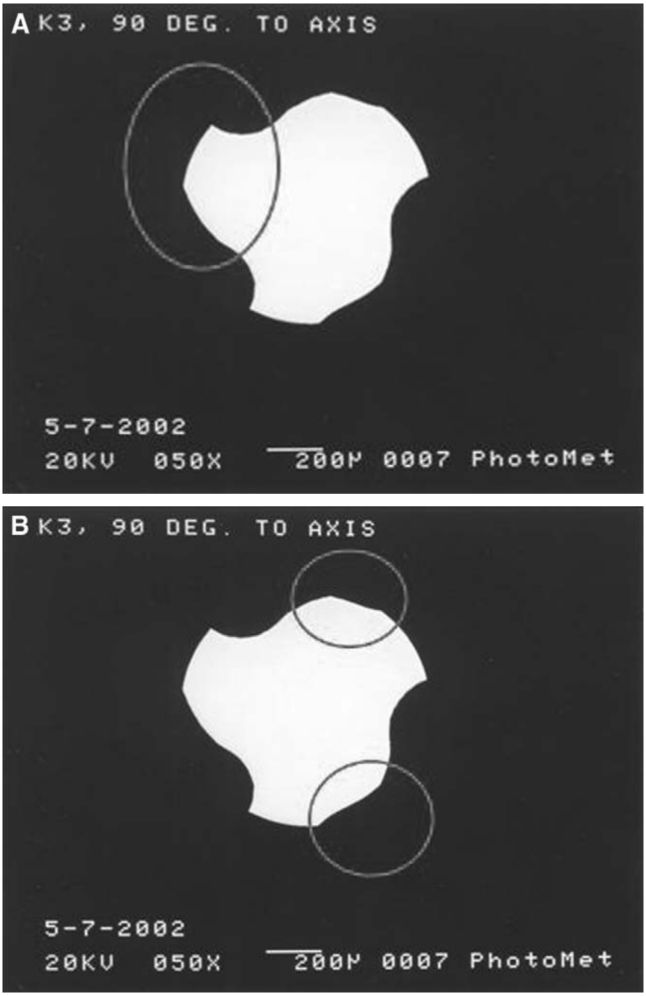

Fig. 5. (*A–C*) In cross-section, the K3 has a series of three wide radial lands to keep the file centered, with a relief behind two of the lands. The feature reduces friction on the canal wall and prevents the file from overengagement.

shank section does not have relieved radial lands. The remaining flutes are parallel so as to increase file flexibility and optimize the rate at which the file can be introduced into the canal. By design, the K3 body shapers channel debris away from their tips, which can mean somewhat less required recapitulation, less cutting time, and decreased fracture rates. Like the original K3 files, the tapered region of the body shapers' flutes are relieved at the distal of their radial lands to reduce peripheral surface contact, enhancing performance. Generally, these files are rotated at 350 rpm. The K3 body shapers have a slightly different helix angle relative to the other K3 sizes and tapers to make them cut more smoothly.

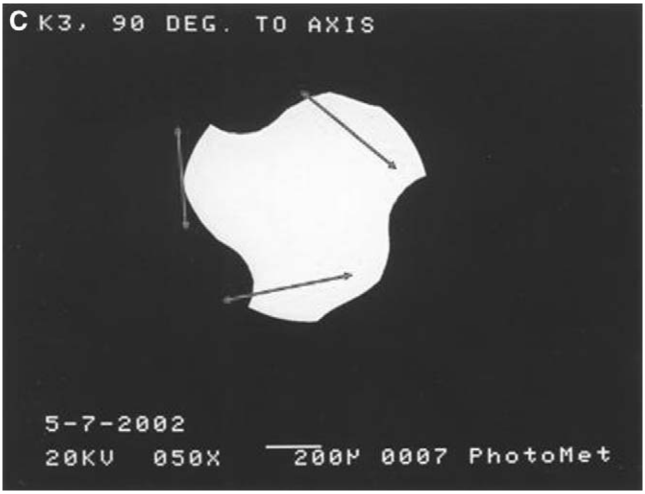

Fig. 5 (*continued*)

The author's experience with the K3

In the author's hands, the K3 feels stable and solid. It does not feel as though the file will fracture at any moment. In essence, the K3 moves smoothly down the canal with a robust sense of tactile control. The K3 negotiates canals with ease and without undue force.

The K3 has excellent fracture resistance, far better than other commercially available brands, especially those of variable taper (Fig. 12).

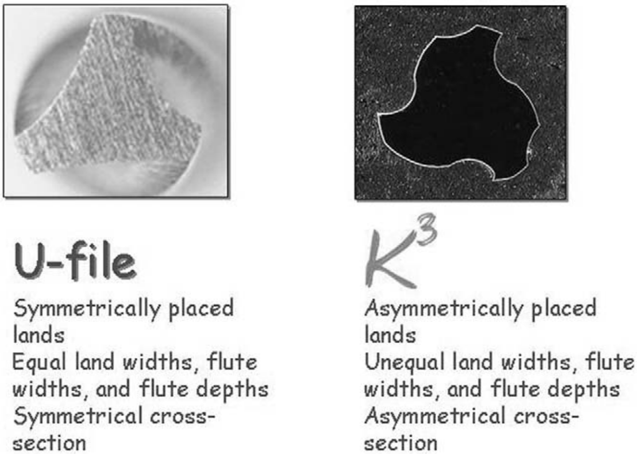

Fig. 6. The K3 (*right panel*) has asymmetrically placed radial lands of unequal width and unequal flute widths and depths that aid in preventing the file from ''screwing into'' the canal. In contrast, U-shaped files (*left panel*) have symmetrical attributes that promote ''screwing in,'' increasing the risk of separation.

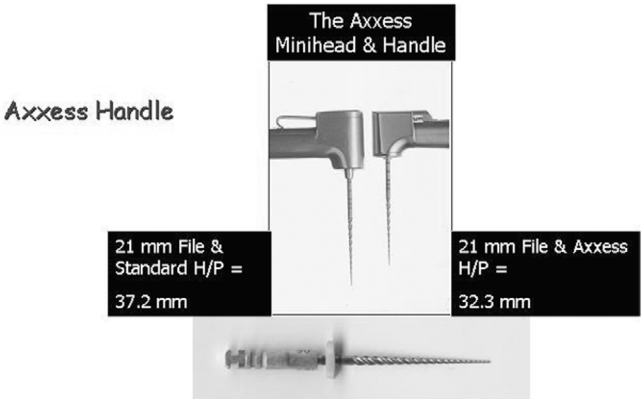

Fig. 7. An "Axxess" handle design, which shortens the file handle by approximately 5 mm without affecting the working length of the file.

It also has excellent cutting ability. The file cuts dentin effectively, yet does not pull itself into the canal apically.

The K3 can be used more than once in all tapers, especially above a tip size of 25. How many times a file can be used before it is discarded is a matter of clinical judgment (see the later section on "Assumptions for K3 clinical technique"). The K3 will bend out of straight alignment when used beyond its elastic limit and should be discarded with this occurrence and with the presence of wear marks. This ability to bend is a unique feature not possessed by other commercially available brands.

The 17-mm body shapers have the greatest universal applicability. The 25-mm K3 canal shaping instruments are easier to visualize under the surgical operating microscope due to the Axxess handle. The 25-mm K3 files are easy to use and visualize even with patients of limited opening and access.

The K3 instruments are more than adequately flexible. Their tactile sense of rigidity or "stiffness" in hand has no clinical correlation. The 0.02 and

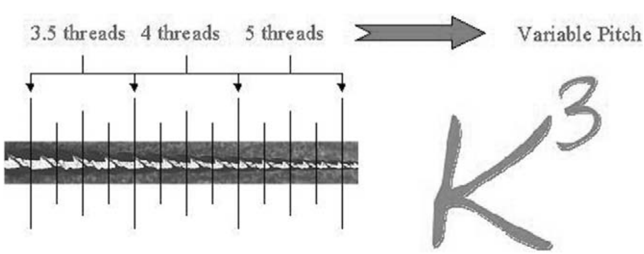

Fig. 8. The K3 has a variable flute pitch to reduce the "screwing in" effect common with some brands of rotary nickel titanium files.

Fig. 9. The K3 has simple color-coding to distinguish between different tip sizes and tapers.

0.04 tapered K3 files in the smallest tip sizes (15–20) make excellent tracking files as an aid to helping create and/or accentuate a glide path. Specifically, after a glide path has been established to a size 10 K file, for example, the 0.02 and 0.04 size 15 file will generally slide close to true working length and create efficiencies with regard to insertion of subsequent files. Because the K3 tracks the canal easily, it moves smoothly down the root to accentuate the initial shapes created by hand in the preparation of the glide path.

Literature

Because of the relatively recent introduction of the K3 into the marketplace and despite its widespread popularity, there is limited literature available.

Bergmans and colleagues [1], using microfocus CT, concluded that in extracted teeth, the ProTaper (Dentsply Tulsa Dental, Tulsa, Oklahoma) and the K3 "were capable of preparing canals with optimum morphological characteristics in curved canals." In addition, "the amount of dentin removal at all separate horizontal regions was comparable for both groups." There was no significant difference in transportation between the two groups and with regard to their tendency to straighten the canal.

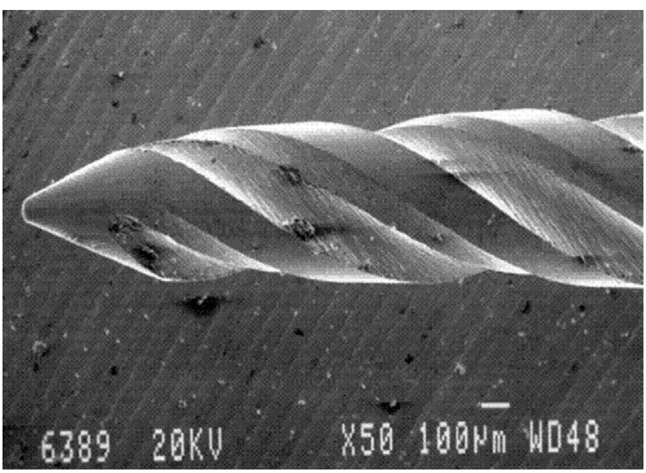

Fig. 10. A safe-ended cutting tip.

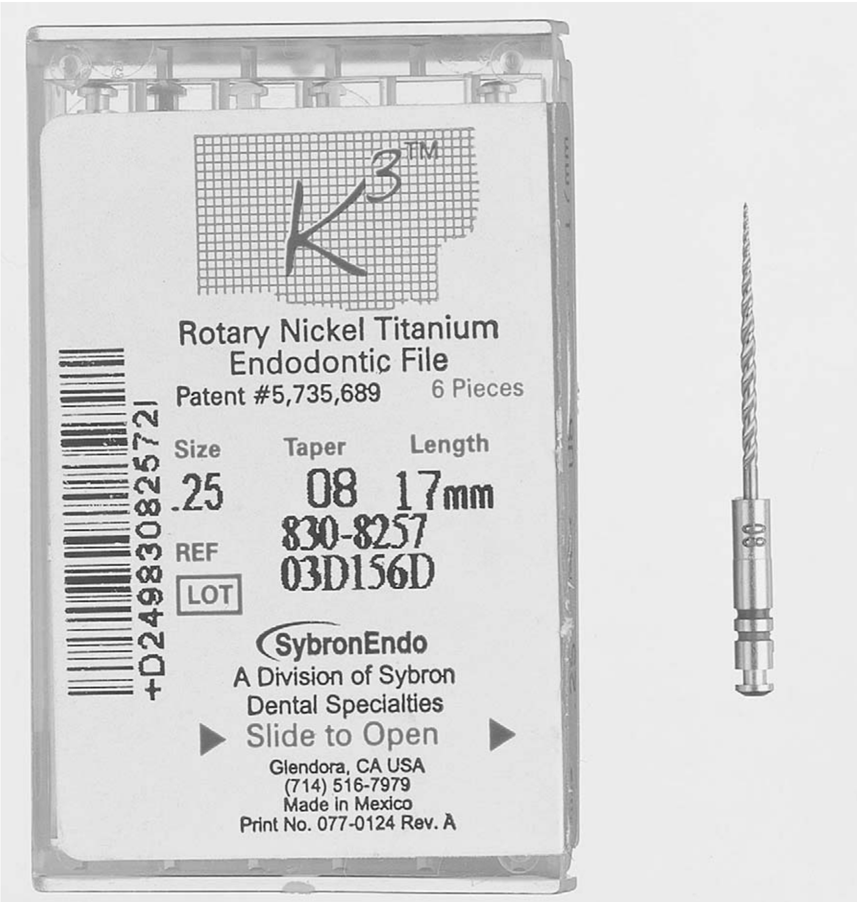

Fig. 11. K3 "body shaper" files with enhanced taper of 0.08, 0.10, 0.12 that can act as both canal shaping files, orifice openers, and deep body shaping files (these are available in a fixed tip size of 25 and in 17-, 21-, and 25-mm lengths (SybronEndo).

Shafer and Florek [2] compared K3 to stainless steel K-Flexofiles in simulated canals with 28° and 35° curves in resin blocks with a rotational speed of 250 rpm with a crown down technique to a size 35 at the endpoint of preparation. Pre- and postinstrumentation images were recorded and an assessment with regard to material removal was measured at 20 points beginning 1 mm from the apex. The authors concluded that the K3 instruments achieved better canal geometry and showed significantly less canal transportation than the hand-powered K-Flexofiles. During the preparation of 96 canals, 11 K3 instruments fractured.

This study's findings with regard to file fracture do not match clinical reality as experienced by the author. In the author's personal experience

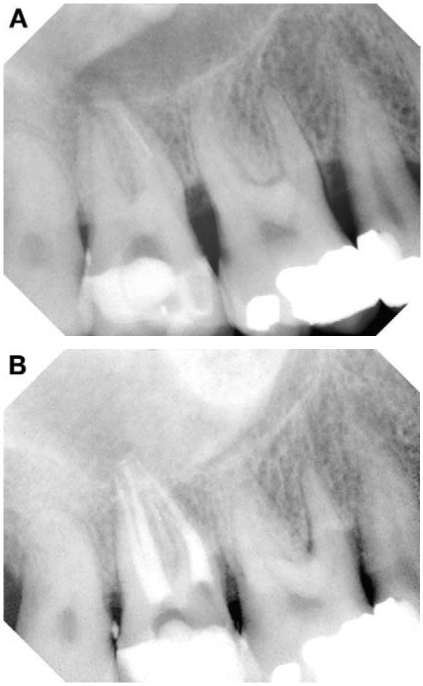

Fig. 12. (*A*, *B*) The K3 has excellent fracture resistance. Removal of separated rotary nickel–titanium files is an ultrasonic microscopic procedure as illustrated.

with the K3 in daily clinical practice, the K3, for the most part, is difficult to fracture and will do so only if used after it has acquired deformations (an indication for being discarded) or a significant amount of undue force is placed on it. It is possible that the performance characteristics of the K3 in resin bear no resemblance to those in human teeth and that the master apical rotary size used in the study (size 35) is larger than that most commonly employed in clinical practice. Also, rotating the files at 250 rpm may also have contributed to this finding instead of at the recommended 350 rpm.

Assumptions for K3 clinical technique

Use of the K3 embraces the following concepts for enhanced cleansing and shaping and prevention of file separation. Although many of these assumptions are also applicable to other rotary file systems, when employed with the K3, the operator can be assured of optimal K3 performance and more predictable long-term clinical results.

- Be gentle and deliberate in your motions with the K3. Never put more force on a K3 file than you would use on a soft lead pencil. Do not force a K3 apically that resists movement. Pull back at the first sign of undue resistance in the canal. The motion in entering the K3 into the canal should be slow, gentle, smooth, and deliberate and in approximately 1- to 2-mm deeper increments relative to the last instrument.

- Frequent irrigation with 5.25% sodium hypochlorite is desirable. An average molar tooth might optimally require 72 to 144 cc of irrigant delivered with a close-ended, side-venting needle. The longer the irrigant is in contact with the canal, the more effective its tissue dissolving capability, especially in the apical third. EDTA or sodium hypochlorite (or both) should be in the canal or canals at all times. Failure to do so (instrumenting dry) can create a plug of apical dentin mud and increase the risk of transportation or instrument fracture. EDTA should be used from the start in all vital cases and can emulsify and hold the pulp in suspension until its removal by way of irrigation. Failure to do so can create a collagenous mass of pulp that can be pumped irretrievably into the narrowing cross-sectional diameters of the root canal system, often with iatrogenic results.
- Removal of the smear layer present after instrumentation is desirable. Rinsing or soaking the canal with liquid EDTA (SmearClear, SybronEndo) after a final sodium hypochlorite irrigation is optimal. SmearClear includes surfactants that reduce surface tension and allow maximum wetting of the canal walls for greatest efficacy (Fig. 13).
- Patency is maintained. Patency refers to the deliberate attempt to keep the minor constriction of the apical foramen open during instrumentation procedures so as to block the apex with dentin mud, move the canal from its original position, or change the foramen's original size and shape. Dentin mud includes pulp and dentin debris from instrumentation that can plug the apical foramen and prevent negotiation to the constriction mentioned previously. Patency is important primarily because its loss causes significant debris to remain harbored in the canal's apical third (predisposing the case to failure), and blockage can be a major factor in causing iatrogenic events (most commonly ledging and separated instruments). Patency is most often obtained by using small K file sizes of 6 to 15 after every rotary file just slightly (usually 1 mm) out the apical foramen to make sure that the canal path is clear to its most apical extent. In some calcified and curved roots, it may be necessary to irrigate and recapitulate after every K3 insertion to keep the foramen open (Fig. 14).
- Crown down instrumentation is desirable. Crown down instrumentation implies that the coronal third is instrumented first, the middle third second, and apical third last (Fig. 15). Using the K3 from larger to smaller tips sizes (of the same or varying taper) incorporates crown down instrumentation as each successively smaller file progresses further down the canal passively. K3 files and the body shapers can be taken to the true working length and used as the master apical file,

Fig. 13. Removal of the smear layer with liquid EDTA (SmearClear, SybronEndo) after final irrigation with sodium hypochlorite is optimal.

but only where the file will progress smoothly to length. In delicate apical anatomy, K3 files (as with any rotary nickel–titanium system) are absolutely contraindicated unless preceded by creation of a glide path with small K files (sizes 6 and 8) up to approximately size 15 to true working length. In some canals, the apical third must be instrumented by hand because curvatures can exist in both a mesial-distal and a buccal-lingual plane, resembling a pigtail. Such canals are at risk for file separation and are best judiciously treated by hand.

- Wipe the flutes of the K3 after every use. Do not allow debris to build up on the flutes of the files.
- Do not force a K3 apically that resists advancement, especially in the apical third. Employ an instrument that is smaller or larger at the point of resistance (to either create more shape above the resistance or bypass it) but never force the instrument to a preconceived length. Do not allow the K3 to spin in place without apical movement for more than a second at any level of the canal.
- Check the flutes of these files after every use. If the K3 is bent or stretched, has a shiny spot, or has other defects, discard it immediately.

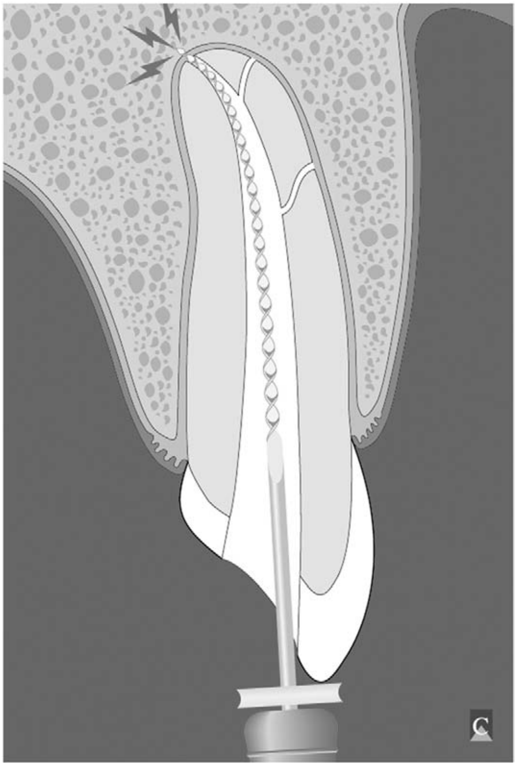

Fig. 14. Patency is important primarily because its loss causes significant debris to remain harbored in the canal's apical third (predisposing the case to failure), and blockage can be a major factor in causing iatrogenic events (most commonly, ledging and separated instruments). (Courtesy of Arnaldo Castelucci, DDS, Florence, Italy.)

- Although the K3 can be used in more than one clinical case, as mentioned previously, the files should not be employed a second time after use in a canal of severe or abrupt curvature.
- Use an electric torque control motor with auto reverse to power the files at the correct rpm. The TCM Endo III motor (SybronEndo) is such a device. Clinically, most manufacturers have endorsed a rotational speed of approximately 300 to 350 rpm for maximum efficiency (Fig. 16).

K3 clinical technique

Coronal-third and middle-third management

Before making access, it is essential to radiograph the tooth from multiple angles including mesial, straight buccal, and distal. Preoperatively, an assessment of the number of roots, canal curvature, length of tooth,

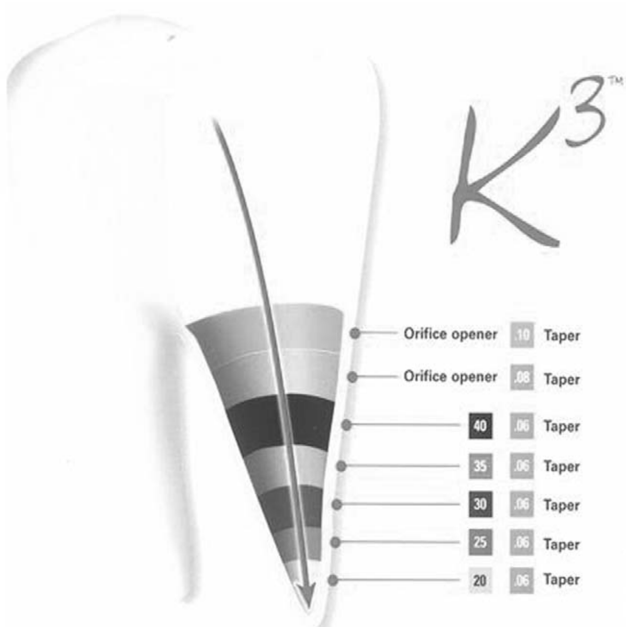

Fig. 15. Crown down instrumentation is desirable. Crown down instrumentation implies that the coronal third is instrumented first, the middle third second, and apical third last. The diagramed instrumentation sequence ensures a crown down technique.

canal calcification, strategic tooth value, restorability, periodontal status, access difficulties, and so forth must be made. Such an evaluation will allow the operator to anticipate difficulties that might be encountered in subsequent treatment, to preoperatively visualize the final result, or to determine whether treatment should be contemplated (Fig. 17).

After achieving excellent local aesthesia, access to the canal orifice is always straight line, with the common lateral dentinal triangle removed at the cervical level in molars. Files never should deflect off access walls as they make their way into canals. The pulp chamber must be completely unroofed.

After all the canal orifices have been located, the orifice is initially enlarged with the K3 enhanced-tapered body shapers. Coronal-third enlargement in larger canals (distal roots of lower molars, palatal canals of upper molars, and so forth) will be accomplished with the 0.12; medium canals (upper second bicuspids, upper central incisors, and so forth) will be accomplished with the 0.10; and smaller canals accessed coronally with the 0.08 tapered files. For these smaller canals, after the 0.08 gains a “toehold” in the canal, the operator can go back with a larger 0.12 and 0.10 body shaper, enhancing access and coronal shape. The K3 body shaper is used to light resistance, which is usually about 3 to 4 mm down the canal. Such

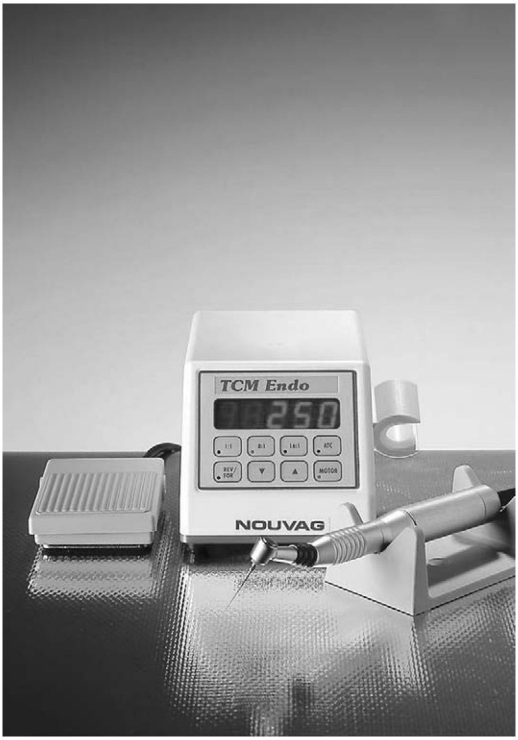

Fig. 16. It is recommended to use an electric torque control motor with auto reverse to power the files at the correct rpm. The TCM Endo III motor (SybronEndo) is such a device. Clinically, most manufacturers have endorsed a rotational speed of approximately 300 to 350 rpm for maximum efficiency.

initial exploration should occur in the presence of an EDTA gel (especially at the start of a vital case), and debris should be flushed away with sodium hypochlorite (5.25%) and EDTA reapplied. Body shapers can be used as the master apical file if they slide easily down a canal or if used in a root in which a previous glide path has been created after apical scouting with K files. The initial chosen body shaper (canal size dependent) is followed by successively smaller tapered body shapers (ie, as each smaller tapered file is used, it will advance further apically, ensuring a crown down sequence). Used in succession, these three body shaping files alone may take the operator to the junction of the middle and apical third or further, from which the operator can then perform the final apical preparation. These files are ideal for achieving deep body shape (described later) because they are highly fracture resistant, allow subsequent 0.02, 0.04, and 0.06 tapered K3 files greater penetration into the apical third than they could achieve alone, enhance irrigation, enhance tactile control over the apical third, remove coronal restrictive dentin, and create ideal canal preparation shapes.

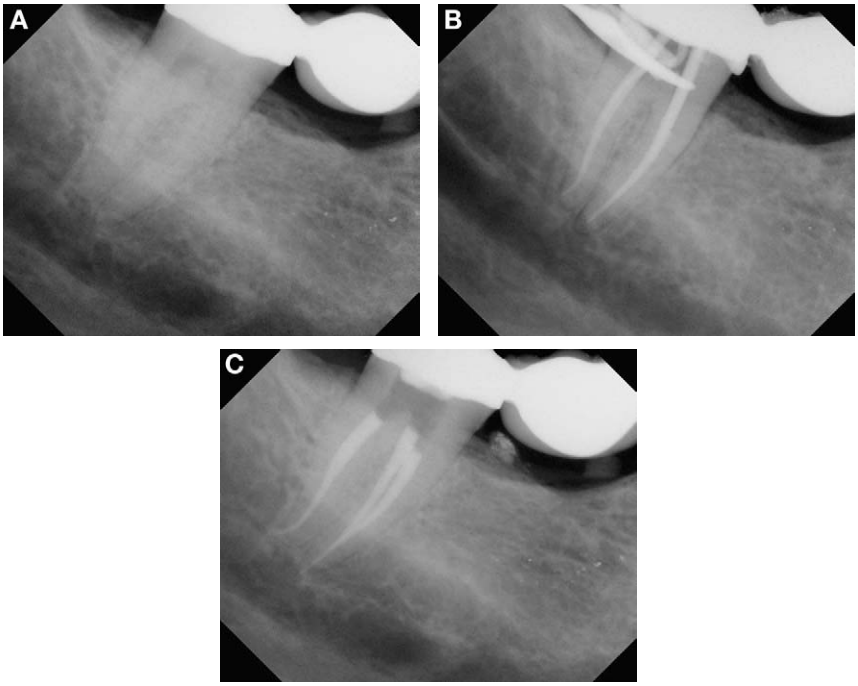

Fig. 17. (*A*) Before making access, it is essential to radiograph the tooth from multiple angles (only the straight buccal is shown). (*B*, *C*) Subsequent treatment with the K3 system.

Clinical experience will dictate how much hand instrumentation will be needed in the form of a glide path before using body shapers and K3 files of all tapers. When the K3 body shapers fall easily into a canal, depending on the clinical case, the glide path may not always be needed; however, in the vast majority of teeth, it will. Conversely, in some narrow, severely curved and calcified canals, it may be advisable in the middle third to first scout with size 6 to 10 K files to ensure canal patency before using body shapers, even at this level. When a glide path is indicated, after canal location and opening of the orifice, the glide path is created by instrumenting canals by hand with small K files in the middle third to a size 10 to15 K file before proceeding with K3 files of all types at this level. After middle-third scouting with K files, in general, a 0.06 K3 with a tip size of 35 (or the appropriate body shaper) can be placed to at least midroot and, oftentimes, slightly beyond. Despite the temptation to enter the apical third in these cases, it is advised to take the K3 file only as far as it will advance without placing excessive pressure on the file and not take it into the apical third yet. Taking rotary files into the apical third without prior exploration with K files as described later will increase the chance that the canal will become blocked with dentin mud, a ledge will be created, or worse, the file will separate. After middle-third scouting with K files, if the 0.06 K3 with a tip size of 35

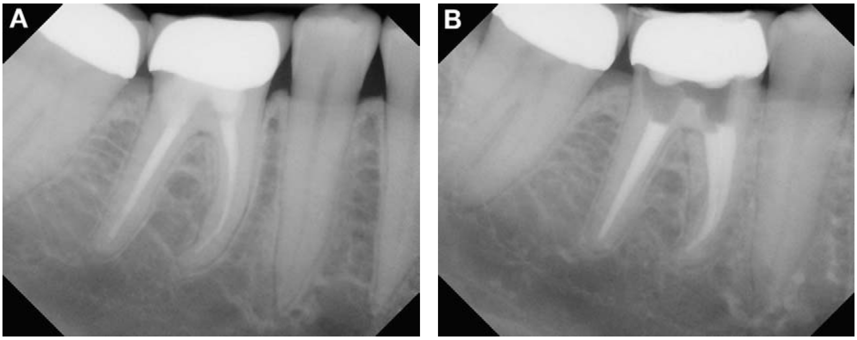

Fig. 18. Deep body shape is a key component of achieving control over subsequent apical-third instrumentation and obturation. (*A*) A lack of deep body shape. (*B*) Subsequent retreatment and its attainment.

(or the appropriate body shaper) will not progress to the desired level (the junction of the middle and apical third), then a 0.06 K3 with a tip size of 30, 25, 20, or 15 can be employed instead. Recapitulation and irrigation should be frequent as described earlier, ideally after every file.

Apical-third management and deep body shape

The apical third is the most challenging root canal anatomy to cleanse, shape, and pack properly. Instrumenting the apical third first, without removing restrictive dentin in the more coronal two thirds, risks apical blockage, underpreparation, and iatrogenic misadventure, among other less than satisfactory outcomes. Coincident to the importance of crown down

Fig. 19. A recently introduced state-of-the-art fourth-generation apex locator (Elements Diagnostic System, SybronEndo).

instrumentation is the importance of creating deep body shape. Deep body shape refers to the final and ideal shape of a prepared canal at the junction of the middle and apical thirds. This space might be considered the "gate keeper" to the apical third. Deep body shape is a key component of achieving control over subsequent apical-third instrumentation and obturation. The body shapers described previously are ideal for the creation of this deep body shape to allow ideal irrigation, tactile control, recapitulation, and attainment of hydraulic forces in the apical third during the vertical compaction of warm gutta percha (Fig. 18).

Instrumentation in the apical third can only be done well using time, patience, and a gentle touch as the watchwords. After the apical third is opened (with deep body shape created), it often must be carefully explored first with hand instruments to determine (like the middle third before it) the apical canal diameter, curvature, calcification, patency, and ease of negotiation. Beginning with size 6 to 10 K files, the operator should slowly and gently attempt to reach the estimated working length as determined by tactile sense and the radiographic preoperative estimate of root length done initially. These K files should be entered passively and never forced to reach a preconceived or estimated length. Using minimal apical pressure, the files should be allowed to progress apically just as far as they want to go. Maintaining canal patency and leaving the foramen in its initial position and size is critical. After a size 10 or 15 K file reaches the estimated working length, an apex locator reading should be taken and a radiograph exposed to verify the correct length and make any necessary adjustments. Recently, a state-of-the-art fourth-generation apex locator was introduced (Elements Diagnostic System, SybronEndo) that is ideal for this purpose (Fig. 19). This length can later be verified by a second apex locator reading after instrumentation is complete (before obturation), a bleeding/moisture point measured by way of paper points (as popularized by Dr. David Rosenberg, Vero Beach, Florida) at the true working length, and a gutta percha master cone-fit radiograph. After true working length is established, a glide path for subsequent K3 files is established to approximately a size 15 to 20 K file at this length. Irrigation and recapitulation should be frequent.

After true working length is reliably established and the aforementioned glide path is created, K3 files are then introduced in a crown down fashion with a sequence that either varies the tip size (with subsequently smaller K3 tip sizes of the same taper) or varies the taper (mixing the tapers of the instruments as the tip size diminishes) (Fig. 20). With either of these methods, K3 files are introduced with larger to smaller tip sizes used in a coronal to apical direction until true working length is reached. In the method that varies tip size, for example, the 0.06 K3 files are generally inserted from a size 35 (or larger) to a size 20 or 15 (canal size, curvature, initial diameter of the apical foramen, and apical curvature dependent) and the sequence repeated until the desired apical diameter is achieved (see the following section, "Gauging the apex"). For smaller canals, the 0.04 K3 series could be used in a similar fashion. It is noteworthy that 0.02 K3 files of varying tip sizes can be introduced into the sequence as needed, especially in small canals and to aid in creation of a glide path.

Gauging the apex

Before a master apical file can be selected, it is important to ‘‘gauge the apex,’’ that is, to determine to what size the apex is patent. This technique is best described by an illustration: if a size 25 K file slides to the true working

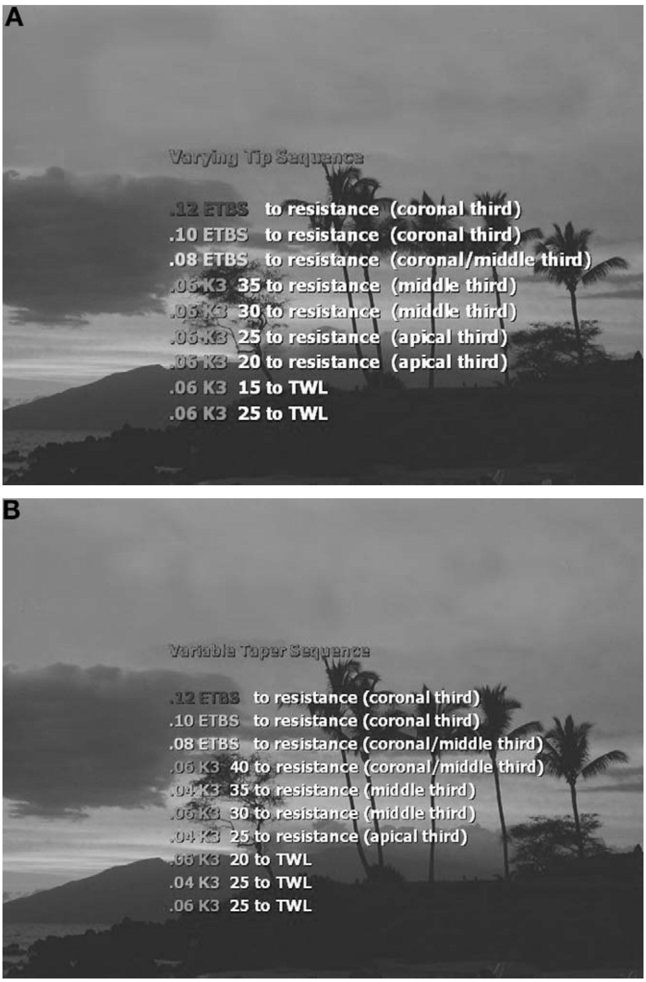

Fig. 20. K3 files are introduced in a crown down fashion with a sequence that either (*A*) varies the tip size (with subsequently smaller K3 tip sizes) or (*B*) varies the taper (mixing the tapers of the instruments as the tip size diminishes). ETBS, enhanced tapered body shapers.

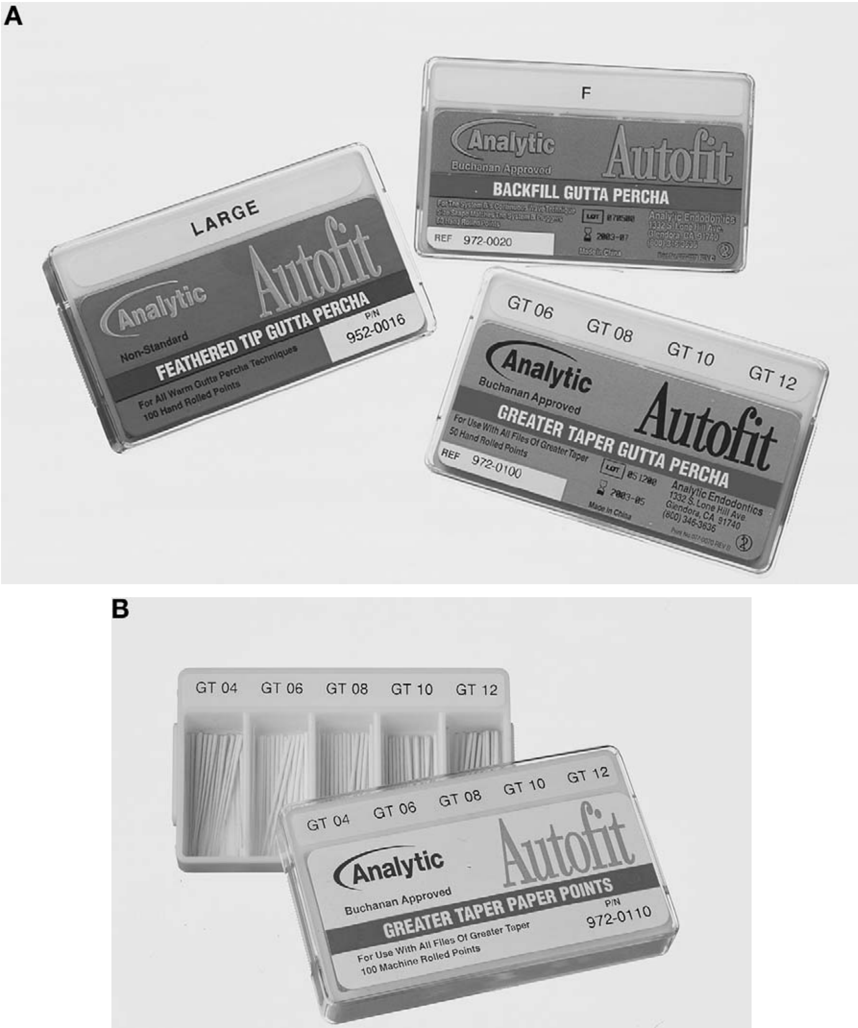

Fig. 21. The final shape imparted to the canal by a given K3 file can be matched by a gutta percha point (*A*) and a paper point (*B*) of the same taper (Autofit gutta percha and paper points, SybronEndo).

length and gives a resistance to apical displacement through the foramen, then a K3 with a tip size of 30 or 35 with an appropriate taper (if it will advance passively) can be used to true working length to create shape above the foramen to give an acceptable cone fit. Gauging the apex allows shape to be created above the foramen while maintaining its size, location, and patency.

The final shape imparted to the canal by a given K3 file can be matched by a paper point and gutta percha point of the same taper (Autofit gutta percha and paper points, SybronEndo) (Fig. 21). A paper point of the appropriate taper, if it will slide to length without deformation (after the canal is dry), informs the operator of the actual taper of the prepared canal and simplifies cone fit. A cone-fit radiograph with the gutta percha point in place before obturation confirms working length and appropriate preparation shape and is strongly recommended to assure the best results, even with the information gained by way of the paper points used as detailed earlier. These steps also facilitate subsequent obturation with the continuous wave of condensation obturation technique (System B obturation with the System B heat source, SybronEndo). After a cone-fit radiograph and usually minor adjustments, excellent obturation is possible for a multirooted molar in a matter of minutes without the necessity of leaving a carrier as required in carrier-based obturation techniques.

Variations on the standard K3 technique

K3/LightSpeed hybrid technique

One method using the crown down philosophy and gaining popularity is the hybrid technique whereby the K3 rotary nickel–titanium file system is used for coronal-third and middle-third shaping and the initial exploration of the apical third, and LightSpeed rotary files (LightSpeed Technology, San Antonio, Texas) are used for the final apical preparation. Although K3 files can be used to shape the entire canal including the apical third, some practitioners prefer using the LightSpeed to create a larger final apical diameter (eg, the buccal roots of upper first molars can be instrumented to a size 50), giving rise to the K3/LightSpeed hybrid technique, blending the two instruments. Intuitively, larger apical sizes, created judiciously, are desirable. Such larger apical diameters can be associated with enhanced

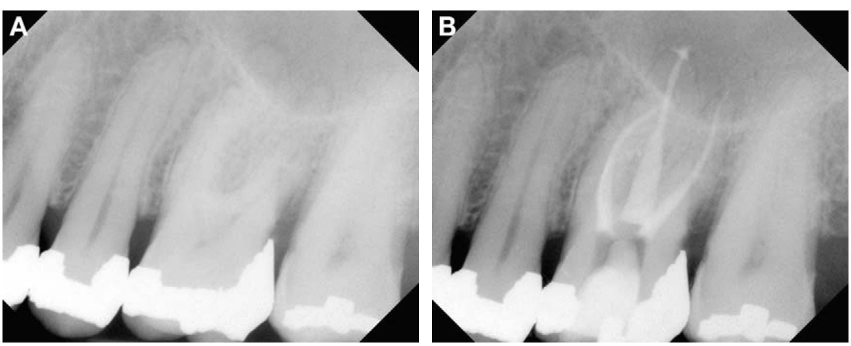

Fig. 22. The hybrid technique. The K3 rotary nickel–titanium file system is used for coronal-third and middle-third shaping and the initial exploration of the apical third (*A*), whereas LightSpeed rotary files are used for the final apical preparation (*B*).

irrigation, ease of cone fit, and cleaner canals in the apical third by virtue of the dentin and pulp removed at that level. The smooth shaft of the LightSpeed files facilitates their use deep in canals with greater ease than many other brands of rotary nickel–titanium files. Although the use of LightSpeed files is detailed elsewhere in this issue, it is noteworthy that before the employment of LightSpeed files to create a larger final apical diameter, the K3 should be taken to true working length, generally in a tip size of 25 and taper of 0.06 (Fig. 22).

Summary

The K3 rotary nickel–titanium file system by SybronEndo is a state-of-the-art rotary nickel–titanium endodontic instrumentation method that combines excellent cutting characteristics with a robust sense of tactile control and excellent fracture resistance. Although it is a complete instrumentation system, future possibilities for hybrid instrumentation techniques that combine the best features of K3 with other rotary systems (most notably the LightSpeed) hold promise.

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