The ProTaper Technique
Shaping the Future of Endodontics

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There have been significant advancements in the development of NiTi rotary instruments in recent years. This evolution is driven by market demand and the continuous improvement in the manufacturing process. Dentists have increasingly identified the features they deem essential on the endless journey towards a more perfect file. These features include flexibility, efficiency, safety, and simplicity. The ProTaper system has been designed to provide these features; consequently, its entrance into the marketplace has had a profound effect.

The ProTaper NiTi files (Dentsply Maillefer; Ballaigues, Switzerland) represent a revolutionary generation of instruments for shaping root canals (Fig. 19.1). This chapter will review the ProTaper geometries, then describe the ProTaper concepts, techniques and finishing criteria that may be utilized to fulfill the mechanical and biological objectives for shaping canals. Learning the ProTaper concept will lead to discovery then appreciation for this six instrument set, comprised of just three Shaping and three Finishing files (Fig. 19.2).

PROTAPER GEOMETRIES

The following will describe the ProTaper geometries and specific features that make these Shaping and Finishing files remarkably unique.

The shaping files

Shaping File # 1 and Shaping File # 2, termed S1 and S2, have purple and white identification rings on their handles, respectively. The S1 and S2 files have D₀ diameters of 0.17 mm and 0.20 mm, respectively, and their D₁₄ maximal flute diameters approach 1.20 mm (Fig. 19.3). The Auxiliary Shaping File, termed SX, has no identification ring on its gold-colored handle and, with a shorter overall length of 19 mm, provides excellent access when space is restrictive. Because SX has a much quicker rate of taper between D₁ and D₉ as compared to the other ProTaper Shaping files, it is primarily used, after S1 and S2, to optimally shape canals in coronally broken down or anatomically shorter teeth. The SX file has a D₀ diameter of 0.19 mm and a D₁₄ diameter approaching 1.20 mm (Fig. 19.4).
Progressively tapered design

A unique feature of the ProTaper Shaping files is each instrument has multiple “increasing” percentage tapers over the length of its cutting blades. This progressively tapered design serves to significantly improve flexibility, cutting efficiency, and safety. Fortuitously, a progressively tapered design typically reduces the number of recapitulations needed to achieve length, especially in small diameter or more curved canals. As an example, the SX file exhibits nine increasingly larger tapers ranging from .035 to .19 between D1 and D9, and a fixed .02 taper between D10 and D14. The S1 file exhibits twelve increasingly larger tapers ranging from .02 to .11 between D1 and D14. The S2 file exhibits nine increasingly larger tapers ranging from .04 to .115 between D1 and D14. This design feature allows each shaping file to perform its own “crown down” work. One of the benefits of a progressively tapered shaping file is that each instrument engages a smaller zone of dentin which reduces torsional loads, file fatigue and the potential for breakage.

The finishing files

Three Finishing files named F1, F2 and F3 have yellow, red and blue identification rings on their handles corresponding to D0 diameters of 0.20 mm, 0.25 mm, and 0.30 mm, respectively. Additionally, F1, F2, and F3 have fixed tapers between D1 and D3 of .07, .08, and .09, respectively (Fig. 19.5). However, unlike
the Shaping files, the Finishing files have “decreasing” tapers from D₄-D₁₄. This design feature serves to improve flexibility, reduce the potential for dangerous taper-lock, and prevent the needless over-enlargement of the coronal two-thirds of a root canal.

**Convex triangular cross-section**

Another feature of the ProTaper instruments relates to their convex triangular cross-section (Figs. 19.6 A, B). This feature decreases the rotational friction between the blade of the file and dentin, enhances the cutting action, and improves safety, as compared to radial-landed instruments. As is true with any instrument, increasing both its D₀ diameter and taper correspondingly increases its stiffness. To improve flexibility, ProTaper Finishing files F₂ and F₃ have recently been machined with a reduced core, as compared to the other instruments in the series. The core is reduced by machining a small concavity within each of the three convex sides of the triangular cross-section.

**Helical angle & pitch**

ProTaper files have a continuously changing helical angle and pitch over the length of their cutting blades (Figs. 19.7 A, B). Changing the pitch and helical angles over the active length of blades optimizes its cutting action and more effectively augers debris out of the canal. Importantly, changing the pitch and helical angles of a file, in conjunction with a progressively tapered design, prevents each instrument from inadvertently screwing into the canal.

**Modified guiding tip**

Another feature of the ProTaper files is each instrument has a modified guiding tip. A modified guiding tip is created by machining off 25% of the most apical extent of each file’s rounded, non-cutting, and parabolic-shaped tip. This design feature allows each instrument to accurately follow a smooth reproducible glide path, and importantly, enhances its ability to load soft tissue and loose debris into the intrabrade flutes, where it can be efficiently augured out of the canal (Fig. 19.8).
There are a few basic concepts that, when followed, will promote efficient performance and excellent safety when using NiTi rotary instruments (Fig. 19.9). Rotary instruments should only be placed in portions of the canal that have a confirmed, smooth and reproducible glide path. Further, rotary NiTi instruments should only be used in the apical one-third of a canal that has a known, accurate working length and is patent. Finally, when incorporating the ProTaper instruments, clinicians should follow the specific directions for use, observe the recommended sequencing of files, and adhere to the correct range of speed and prescribed torque.

The following summarizes the ProTaper rotary shaping file concepts and guidelines:

**Straightline access**

The access preparation is an essential element for successful endodontics. Preparing the endodontic access cavity is a critical step in a series of procedures that potentially leads to the three-dimensional obturation of the root canal system. Access cavities should be cut so the pulpal roof, including all overlying dentin, is removed. The size of the access cavity is dictated by the position of the orifice(s). The axial walls are extended laterally such that the orifice(s) is just within this outline form. The internal walls are flared and smoothed to provide easy, straightline access into the orifice and the root canal system (Fig. 19.10).

Access preparations are expanded to eliminate any coronal interference during subsequent instrumentation. Access objectives are confirmed when all the orifices can be visualized without moving the mouth mirror. Ideally, endodontic access cavities should parallel the principle of restorative dentistry where the axial walls of a “finished” preparation taper and provide draw for a wax pattern. Cleaning and shaping potentials are dramatically improved when instruments conveniently pass through the occlusal opening, effortlessly slide down smooth axial walls and are easily inserted into a preflared orifice (Fig. 19.11).

Spacious access cavities are an opening for canal preparation.

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**PROTAPER CONCEPTS & GUIDELINES**

Fig. 19.8. ProTaper files have a modified guiding tip which enables the tip of the file to safely follow the glide path and better auger soft tissue and loose debris out of the canal (Courtesy of Prof. Elio Berutti; Torino, Italy).

Fig. 19.9. ProTaper files were utilized in the endodontic treatment of this mandibular first molar. Note four optimally prepared systems exhibiting multiplanar curvatures (Courtesy of Dr. Pierre Machtou; Paris, France).

Fig. 19.10. A photograph at 15x shows straightline access, divergent axial walls and the orifices just within this outline form.
Irrigation & lubrication

No instrument should be introduced into the root canal space until the appropriate irrigant is introduced into the pulp chamber. The importance of irrigants, their methods of use and their role in negotiating and shaping canals and in cleaning the root canal system has been described in several clinical articles.5-13

Reproducible glide path

Cleaning and shaping outcomes are significantly improved initially utilizing stainless steel 0.02 tapered sizes 10 and 15 hand files (Dentsply Maillefer; Ballaigues, Switzerland). Small-sized hand files are optimally utilized, in the presence of a viscous chelator, to scout any portion of the overall length of a canal.13-15

Hand files create or confirm a smooth, reproducible glide path before introducing any rotary NiTi instruments into this secured length of the canal.6,7 With the onset of NiTi rotary instrumentation, the role of hand instruments has diminished and been redefined. For many rotary file users, small hand instruments are primarily used to gather reconnaissance information, to confirm available space, or when necessary, to create sufficient space prior to using more efficient rotary NiTi instruments. The 10 and 15 “scouter files” should not be thought of as just measuring wires, rather they can additionally provide feedback regarding.15

1) Cross-Sectional Diameter

Scouter files immediately reveal the cross-sectional diameter of a canal and provide information as to whether the canal is open, restricted, or significantly calcified. Before a ProTaper rotary instrument can be safely introduced into the canal, sufficient space must exist to passively accommodate and guide their tips. In other words, there must be a pilot hole of circumferential dentin and a smooth glide path for a NiTi rotary instrument to follow. As an example, if a canal has been scouted to within 3-4 mm of anticipated working length with 10 and 15 hand files, then more space exists than the files’ numerical names suggest. Recall the 10 and 15 hand files taper 0.02 mm/mm, have 16 mm of cutting flutes and their $D_{16}$ diameters are 0.42 and 0.47 mm, respectively. Generally, these small-sized instruments will provide a sufficient “opening” for the implementation of rotary instruments.

2) Coronal & radicular access

Scouter files confirm the presence or absence of straightline coronal and radicular access. Clinicians can observe the handle position of the smaller sized instruments to see if they are upright and parallelizing the long axis of the tooth or skewed off-axis. In the instance where the roots are under the circumferential dimensions of the clinical crown and the file handle is upright, or “ON” the long axis of the tooth, then the clinician is able to confirm both coronal and radicular straightline access. In instances where the handle of the initial scouting instrument is “OFF” the long axis of the tooth, then pre-enlargement procedures should be directed towards uprighting the file handle (Fig. 19.12).16-21

Fig. 19.11. The canals of this endodontically treated mandibular first molar were gauged and tuned, and the pack demonstrates the uniform and fully tapered shapes.

Fig. 19.12. The handles of small hand files are frequently “OFF” axis in furcated teeth due to internal triangles of dentin.
To upright the handle of the small scouter files oftentimes requires refining and expanding the access preparation and selectively removing the triangle of dentin from the coronal one-third of the canal. This procedural distinction is critical and simplifies all subsequent instrumentation procedures while virtually eliminating many cleaning and shaping frustrations (Fig. 19.13). 16,18

3) Root canal system anatomy
Scouter files can provide information regarding root canal system anatomy. Clinicians need to appreciate the five commonly encountered anatomical forms which include canals that merge, curve, recurve, dilacerate or divide. Scouter files provide information regarding the anatomy and give important feedback regarding the canal’s degree of curvature, recurvature, or if there is a dilaceration (Fig. 19.14). Further, before introducing rotary instruments, clinicians need to know if a single canal coronally subsequently divides or if two or more systems within a root merge along their length. It must be recognized that certain root canals exhibit anatomical configurations which preclude the safe use of NiTi rotary files. In these instances, precurved manual ProTaper files afford a safe alternative, as compared to the risk associated with using rotary instruments (Fig. 19.15).

Working length & patency
The breakthrough to predictable shaping procedures is to have both an accurate working length and a patent canal. Patency is performed by gently directing small, highly flexible files to the radiographic terminus (RT) 20.

To ensure patency, the file tip is intentionally inserted minutely through the foramen to discourage the accumulation of debris (Fig. 19.16). Importantly, working a small, flexible file to the RT will encoura-
ge the elimination of dental pulp, related irritants, and dentinal mud. Keeping the canal terminus patent discourages blocks, ledges and perforations. It is illogical to assume that passing a small file passively and minutely through the apical foramen is going to prejudice the result or predispose to any irreversible conditions when one reflects on the rich collateral circulation and healing capacity available in the attachment apparatus. Clinicians should stop fretting over the use of patency files and recall the well-known, often used, and more invasive disciplines, such as endodontic surgery and dental implants.

Researchers, academicians and clinicians are well aware that when a file is passed through the entire length of a canal and its most apical extent is observed to be at the radiographic terminus, then, in actuality, the instrument is minutely long. Traditional wisdom advocates that since the apical extent of a canal terminates at the cementodentinal junction (CDJ) then working length should extend to this anatomical landmark. Although the CDJ exists in a non-pulparly involved tooth, its position can never be precisely located clinically as this histological landmark varies significantly from tooth to tooth, from root to root, and from wall to wall within each canal. Working arbitrarily short of the radiographic terminus based on statistical averages encourages the accumulation and retention of debris, which frequently results in apical blocks that predispose to ledges and perforations. Working short has led to many frustrations, interappointment flare-ups, “unexplained” failures, surgical procedures and extractions.

Electronic apex locators represent an improvement over radiographs for more accurately identifying the position of the foramen. Technological advancements in specific apex locators provide greater accuracy in length determination even in canals that contain exudates or electrolytes. It should be understood that apex locators do not replace films but are used intelligently in conjunction with radiographs. When a predictable and smooth glide path is established to the RT and working length is confirmed, then the apical one-third of the canal can be shaped and finished in a variety of ways.

**Directions for use**

Rotary instruments should be employed in strict accordance with their prescribed directions for use. If any NiTi rotary instrument ceases to advance deeper into a canal, withdraw it, and recognize the four factors that typically prevent the file from passively moving in an apical direction:

1) **Insufficient canal diameter.** Insufficient canal diameter will prevent a rotary NiTi instrument from passively moving deeper into the canal. Recognize that the working end of a rotary file may be too big or stiff to follow the anatomy or diameter of a canal. It is important to appreciate NiTi rotary instruments may not be able to follow a canal that abruptly curves, divides, or whose walls exhibit resorptive or iatrogenic defects. In smaller diameter or more curved canals, use the 10 and 15 hand files, in conjunction with a viscous chelator. If necessary, a few larger hand instruments may be required to create a smooth, reproducible glide path for manual or rotary NiTi instruments to predictably follow.

2) **Intracanal debris.** Intracanal debris may accumulate in a canal that previously exhibited a confirmed and reproducible glide path. To eliminate intracanal debris, after each rotary file, voluminously irrigate the root canal space, recapitulate with a # 10 file to break-up debris and move it into solution, then re-irrigate to flush-out this loosened debris. Use a 10 or 15 file to confirm a smooth, reproducible glide path before commencing with rotary shaping procedures.

3) **Intrablade debris.** Another possibility that limits the apical movement of an instrument is the accumulation of debris within the depth between the cutting blades. Intrablade debris tends to deactivate an instrument as it pushes the active part of the file off the wall of the canal. In this latter case, withdraw the instrument and clear its blades, irrigate the canal, recapitulate with a small hand file to confirm the existence of the previously established glide path, then re-irrigate to flush out debris.

4) **Root canal anatomy.** Certain systems exhibit difficult anatomical configurations that discourage or prevent the tip of a rotary instrument to passively and safely follow the canal (Figs. 19.17 A-D). In these instances, irrigate and recapitulate with small hand files to improve the diameter of the glide path of the canal or precurve a ProTaper hand file to bypass the anatomical impediment. It should be recognized that certain anatomical configurations, pathological defects, or iatrogenic ledges are best shaped with hand files. The ProTaper files can be precurved and used manually to follow any part of a canal that has been negotiated and enlarged to at
least a size 15 hand file. However, ProTaper rotary files should not be used until there is a confirmed, smooth, and reproducible glide path.

**Multiple vs. single use**

The two most important causes that contribute to NiTi rotary instrument breakage are “method of use” and “multiple use” of files. During use, any given ProTaper file should be inspected for wear and its cutting blades frequently cleaned to optimize efficiency and reduce the potential for breakage. In the author’s opinion, all NiTi rotary instruments should be discarded after each case due to metal fatigue, loss of cutting efficiency, and the great variation in length, diameter and curvature of any given canal. When the guidelines for use are carefully followed then the ProTaper files’ unique geometries afford unsurpassed safety, flexibility and efficiency.

**Motors**

All the ProTaper instruments should be utilized in a gear reduction handpiece in conjunction with a torque controlled electric motor. The motor should be set to provide a torque of 520 g.cm and speeds ranging from 250-300 RPM. Advancements in electric motors in the years immediately ahead hold the promise to improve clinical performance and safety when using NiTi rotary files.
THE PROTAPER TECHNIQUE

Preparing a root canal can commence after completing straightline access to the orifice(s). In teeth exhibiting calcification, dentin can be precisely sanded away and orifices more readily identified by utilizing contra-angled, parallel-walled and abradively coated ultrasonic instruments (Fig. 19.18) (ProUltra Endo Tips, Dentsply Maillefer; Ballaigues, Switzerland). In combination, microscopes and ultrasonics have driven “microsonic” techniques that have improved successfully locating receded orifices. Once any orifice has been located, it can be advantageously flared with one or more gates glidden drills (Dentsply Maillefer; Ballaigues, Switzerland). Attention to detail when finishing the access cavity facilitates the subsequent shaping of a root canal (Fig. 19.19).

Scout the coronal two-thirds

The potential to consistently shape canals and clean root canal systems is significantly enhanced when the coronal two-thirds of the canal is first pre-enlarged followed by preparing its apical one-third (Figure 19.20). The concept of first pre-enlarging a canal followed by finishing its apical one-third is analogous to a crown preparation procedure in which the tooth is first reduced prior to finishing the margins.

When straightline access is completed, the pulp chamber may be filled brimful with a viscous chelator. Based on the pre-operative radiographs, ISO 0.02 tapered sizes 10 and 15 hand files are measured and precurved to match the anticipated full length and curvature of the root canal. However, in this method of canal preparation, these instruments are initially limited to the coronal two-thirds of a root canal. The 10 and 15 hand files are utilized within any portion of the canal until they are loose and a smooth reproducible glide path is confirmed (Figs. 19.21 A, B). The loose depth of the 15 file is measured and this length transferred to the ProTaper S1 and S2 files.

Shape the coronal two-thirds

The secured portion of the canal can be optimally pre-enlarged by first utilizing S1 then S2. Prior to ini-
A full strength solution of NaOCl is applied to the pulp chamber. Without pressure, and in one or more passes, the ProTaper Shaping files are allowed to passively "float" into the canal and "follow" the glide path. To optimize safety and efficiency, the Shaping files are used, like a "brush", to literally and selectively cut dentin on the outstroke. A brush-cutting action creates lateral space which will facilitate the shaping file's larger, stronger and more active cutting blades to safely and progressively move deeper into the canal. If any ProTaper file ceases to easily advance within the secured portion of a canal, withdraw it, and recognize that intrablade debris has deactivated and pushed the instrument off the wall of the canal. Upon removing each Shaping file, visualize where the debris is located along its cutting blades to better appreciate the region within the canal that is being prepared.

Following the use of each Shaping file, irrigate, recapitulate with a 10 file to break up debris and move it into solution, then re-irrigate. Without pressure, and in one or more passes, S1, then S2, is used in this manner until the depth of the 15 hand file is reached (Figs. 19.22 A, B, C).
Scout the apical one-third

When the coronal two-thirds of the canal is shaped, then attention can focus on apical one-third procedures. With the pulp chamber filled brimful with a viscous chelator, the apical one-third of the canal is fully negotiated, working length established and patency confirmed (Fig. 19.23). When the apical one-third of the canal has been enlarged to at least the size of a 15 hand file, then a decision must be made between whether to finish the apical one-third with rotary or hand instruments. If a new and straight 15 file can gently “slide” and passively “glide” to length, then rotary instruments will follow this confirmed and reproducible glide path. However, certain canals exhibit anatomical challenges that necessitate a reciprocating handle motion in order to move precurved 10 and 15 files to length. When there is an irregular glide path then the apical one-third of a canal may be advantageously finished with precurved manual ProTaper instruments (Figs. 19.24 A, B and 19.25 A, B).

Shape the apical one-third

When the apical one-third of the canal has been secured, then the pulp chamber is filled brimful with NaOCl. The ProTaper sequence is to carry the S1, then the S2, to the full working length. As previously described, float, follow and brush as previously described.
bed until the terminus of the canal is reached. S1, then S2, will typically move to length in one or more passes depending on the length, diameter and curvature of the canal (Figs. 19.26 A, B). Following each ProTaper file, irrigate, recapitulate with a 10 file, then re-irrigate. After using the Shaping files, particularly in more curved canals, working length should be reconfirmed, as a more direct path to the terminus has been established. At this stage of treatment, the preparation can be finished using one or more of the ProTaper Finishing files in a “non-brushing” manner. The F1 is selected and passively allowed to move deeper into the canal, in one or more passes, until the terminus is reached (Fig. 19.27). When the F1 achieves length, the instrument is removed, its apical flutes are inspected and if they are loaded with dentin, then visual evidence confirms this instrument has carved its shape in the apical one-third of the canal. Following the use of F1, flood the canal with irrigant, recapitulate and confirm patency, then re-irrigate to liberate debris from the canal.

**ProTaper finishing criteria**

Following the use of the 20/.07 F1, the “ProTaper Finishing Criteria” is to gauge the size of the foramen with a 20/.02 tapered hand file to determine if this instrument is snug or loose at length (Fig. 19.28). If the 20 hand file is snug at length then the canal is fully shaped and, if irrigation protocols have been followed, ready to pack. Following the use of F1, if the 20 hand file is loose at length, then gauge the size of the foramen with a 25/.02 tapered hand file. If the 25...
file is snug at length, then the canal is fully shaped and ready to pack. If the 25 file is short of length, proceed to the 25/.08 F2 and, when necessary, the 30/.09 F3, gauging after each Finisher with the appropriately sized hand files (Figs. 19.29 A, B). If the 30 file is loose at length, then an alternative NiTi rotary file line or manual files may be utilized to finish the apical extent of these larger, easier and more straightforward canals.

In the instance of a longer, smaller diameter, and a more curved canal, generally only three ProTaper instruments are required to produce a cleaned, tapered canal that exhibits shape over length. Regrettably, there are ongoing debates regarding the extent of apical enlargement. It is needless to over-prepare the foramen if we understand and fully appreciate the relationship between apical file size and apical one-third taper. In fact, it has been shown that irrigating with EDTA, followed by NaOCl, can produce clean dentinal surfaces that are free of debris on uninstrumented surfaces of root canals. ProTaper shapes are easy to fill utilizing a ProTaper matching gutta percha obturator or master cone in conjunction with a warm vertical condensation technique (Figs. 19.30 A, B).

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Fig. 19.29. A. Following the use of the 25/.08 F2 rotary file to length, the foramen is gauged using a 25/.02 hand file. B. Following the use of the 30/.09 F3 rotary file, the foramen is gauged using a 30/.02 hand file.

Fig. 19.30. A. A three-dimensionally packed maxillary second molar demonstrates the smooth flowing, uniformly tapered shapes that ProTaper files consistently create (Courtesy of Prof. Elio Berutti; Torino, Italy). B. The canals of this mandibular molar were shaped with ProTaper files. The three-dimensional pack demonstrates flowing shapes, apical one-third curvatures and multiple portals of exit (Courtesy of Dr. Jason West; Tacoma, Washington).
Finishing larger systems

In instances where the foramen is gauged and determined to be greater than 0.30 mm, and a smooth glide path has been verified, then an alternative NiTi rotary file line may be used. The decision as to which specific line of instruments to select should be based on cutting efficiency, flexibility and safety. Importantly the instruments chosen and the techniques employed must create deep shape and the resistance form to hold filling materials during three-dimensional obturation (Fig. 19.31).

Research evaluating canal cleanliness compared to apical one-third shape has clearly shown that preparations need to taper greater than 0.06 mm/mm to ensure that a sufficient volume of irrigant over an adequate interval of time can efficaciously circulate, penetrate, and promote deep lateral cleaning.14,15,19 Except in larger and straighter canals, rotary files that have \( D_0 \) diameters greater than 0.30 mm and tapers greater than 6% are frequently too stiff to safely place to the apical one-third of a more curved root canal. As such, NiTi 0.04 or 0.06 tapered rotary files, like ProFiles (Dentsply Maillefer; Ballaigues, Switzerland) will provide the flexibility to safely shape the apical extent of these larger, more open canals. As noted with hand files, NiTi rotary files can be employed in a step-back technique to create virtually any tapered shape that is desired.

Expanding the deep shape

There are cases when a ProTaper 20/.07 Finishing file is snug at length, the foramen is confirmed to be 0.20 mm after gauging with a 20/.02 hand file, yet the clinician may find it advantageous to expand the deep shape of the canal. In the instance where the \( F_1 \) was at length, then a fuller shape can be easily and safely accomplished by carrying the \( F_2 \) 1.0 mm short and the \( F_3 \), 2.0 mm short of the working length.

This clinical method of carrying each larger ProTaper Finishing file progressively shorter than the previous one will maintain the size of the foramen while expanding the overall shape in the middle and apical one-thirds of the canal. This step-back method is not done routinely and is only appropriate when different, well-angulated radiographs confirm that the dimensions of a root can safely accommodate a fuller shape.

Evidence for clinical success

A clinical investigation of the ProTaper technique, emphasizing method of use, was conducted on mesial canals of extracted mandibular molar teeth using \( \mu \)CT-Analysis.19 In this particular study, horizontal sections from different radicular levels were analyzed using \( \mu \)CT slices and volume renderings. The green color represented the anatomical contours before instrumentation whereas the red color indicated the shape after instrumentation.

The results from this investigation are clinically relevant and a portion of the data is available for review in Figs. 19.32 A-D.

The advantages of the Shaping files to brush laterally and selectively cut dentin on the outstroke are summarized below:

1) The Shaping files were essentially loose within a canal during the majority of their work.
2) The coronal aspects of the canals were safely relocated away from an external root concavity.
3) A brush-cutting action achieved a centered preparation and maximized remaining dentin.
4) The Shaping files physically contacted over 90% of the internal walls of the canals.

Fig. 19.31. An endodontically treated maxillary central incisor demonstrates that a shaped canal provides resistance form to achieve three-dimensional obturation.