SHAPING COMPLEX CANALS
CLINICAL STRATEGY AND TECHNIQUE

by Clifford J. Ruddle, DDS

Many times over several decades I have described various concepts, strategies, and techniques for shaping root canals. Although the concepts and strategies have essentially remained the same, the techniques have evolved based on the technology available in any given era. As an endodontic educator, I am continuously reminded of the criteria dentists deem most important when selecting a brand line of files for preparing canals; namely, a file or short sequence of files that will optimize safety, efficiency, and simplicity at an affordable price.

As important as the actual mechanical attributes of any given brand line is to fully understand the final shape a file, or series of files, can produce. It is imperative to appreciate that well-shaped canals promote 3D cleaning and filling root canal systems ***(Figure 1)***.[1] This article will focus on the concepts, strategies, and techniques that may be utilized to prepare longer, narrower, and more curved canals. The method I will describe for preparing canals will fulfill the criteria mentioned above and is proven, easy-to-learn, and readily transferable.

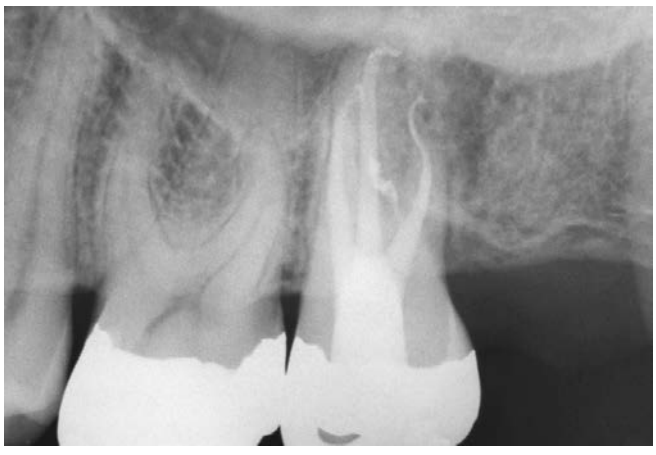

Figure 1. *This image demonstrates straightline access, abrupt apical curvature and recurvature of the P and DB systems, respectively, and a treated furcal canal.*

CONCEPTS FOR CORONAL AND RADICULAR ACCESS

The concept of coronal access is to remove the entire pulpal roof, including all unsupported dentin. In furcated teeth, the size of the access cavity is dictated by the position of the orifices on the pulpal floor. The axial walls are extended laterally such that the orifice(s) is just within this outline form. Coronal access objectives should focus on flaring and flattening the internal axial walls, yet recognize that access to the underlying root canal system is oftentimes limited. In furcated teeth, leaving a residual shelf of dentin overlying any aspect of the pulpal floor compromises identifying hidden orifices and negotiating canals.

The concept of radicular access is to pre-enlarge the body of a canal, which will serve to provide excellent access to the typically more anatomically difficult apical one-third of the same canal ***(Figure 2)***.[2] Radicular access frequently requires eliminating internal triangles of dentin. Further, in multi-rooted teeth, radicular access should focus on intentionally relocating the coronal-most aspect of a canal away from furcal danger. As will be discussed later, radicular access is an extension of coronal access and may be immediately performed whenever there is sufficient working width to passively accommodate the tip of a mechanical shaping file.

Figure 2. *This graphic illustrates endodontic anatomy and a strategy for pre-enlarging the coronal two-thirds before shaping the apical one-third of the same canal.*

Strategies for Glide Path Management

Following coronal and radicular access, two possibilities exist when initiating glide path management (GPM) procedures. In roots that hold shorter, wider, and straighter canals, a gentle reciprocating handle motion, followed by a few engaging and outward cutting cycles, will typically pull a size 10 hand file through the canal and to length. When the apical one-third of a canal is negotiated, then working length is established, patency is confirmed, and a smooth, reproducible glide path is verified. When necessary, the terminus of any canal should be expanded to 0.15 mm to confirm sufficient space is available to safely initiate mechanical shaping procedures.[3]

The second clinical possibility that exists when performing GPM procedures is encountered in roots that hold longer, narrower, and more curved canals. In more coronally calcified canals, the inward movement of the size 10 file is oftentimes limited because the rate of taper of this file initially exceeds the rate of taper of the canal. Rather than using smaller size stainless steel (SS) hand files to reach length, a strategy may be utilized that focuses first on pre-enlarging the coronal two-thirds of a canal before attempting to negotiate the typically more open apical one-third of the same canal. The secret to pre-enlargement is to use a sequential glide path strategy.

Sequential Glide Path for Shaping Canals

Pre-enlargement procedures use a sequential glide path strategy where the clinician scouts, secures, and shapes the coronal two-thirds of longer, narrower, and more curved canals, prior to scouting, securing and shaping the apical one-third of the same canal. The concept of *pre-enlargement* is the antithesis of the so-called *crown-down* technique. Whereas either method serves to initially open the body of a canal, pre-enlargement safely progresses from small-to-large size files, whereas crown-down plows away dentin by progressing from large-to-small size files.

ARMAMENTARIUM FOR PREPARING CANALS

In the article published in the July issue of *Dentistry Today*, entitled "Endodontic Canal Preparation: Innovations in Glide Path Management and Shaping Canals," a description was made of the features, benefits, and clinical advantages of ProGlider and ProTaper Gold (PTG) rotary files (*Dentsply Tulsa Dental Specialties* or *DTDS* and *Dentsply Maillefer*) for preparing canals.[4] Let's briefly review this armamentarium for preparing canals.

ProGlider is a new dedicated rotary glide path file designed to replace a traditional, considerably stiffer, and more dangerous SS size 15 hand file ***(Figure 3)***. ProGlider utilizes M-Wire technology, which has been shown to improve the resistance to cyclic fatigue by a staggering 400%.[5] ProGlider has a D0 diameter of 0.16 mm and a D16 diameter of 0.82 mm. Strategically, this file has 12 increasing percentage tapers from 2%-8% over the length of its active portion. One ProGlider can cut a considerably wider canal pathway than any other market version dedicated glide path multi-file sequence.[4] Mechanical glide path procedures have been shown to improve safety and efficiency, while reducing chairtime by up to 40%.[6]

ProTaper NiTi rotary files (*DTDS* and *Dentsply Maillefer*) came to market in 2001 and was the first system to offer active cutting edges, a progressively tapered design on a single file, and both Shaping and Finishing files.[7] Over the past 13 years, these design features have catapulted this system to become the #1 selling file in the world, the #1 file choice of endodontists, and the #1 system taught in international dental schools to undergraduate students.[4] ProTaper's dominant success is primarily linked to reproducible final shapes that promote 3D disinfection and filling root canal systems. PTG has the exact geometries as ProTaper Universal (PTU), but fortuitously has been metallurgically enhanced through heat treatment technology ***(Figure 4a)***.

The PTG Shaping and Finishing files set a new standard in safety and canal centering by significantly improving flexibili-

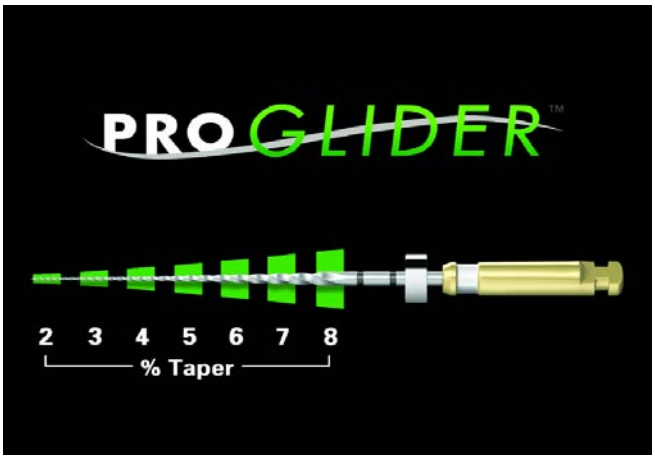

Figure 3. *ProGlider has a progressively tapered design and utilizes M-Wire technology. These features make GPM safer, faster, and easier.*

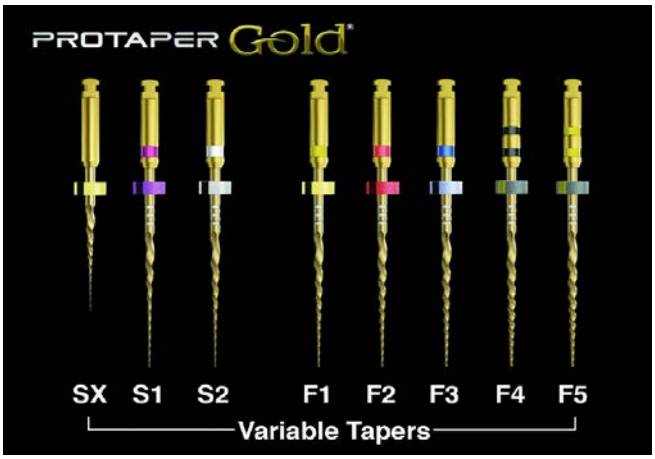

Figure 4a. *PTG increases flexibility and provides more than twice the resistance to cyclic fatigue compared to PTU (Internal Dentsply testing, data on file).*

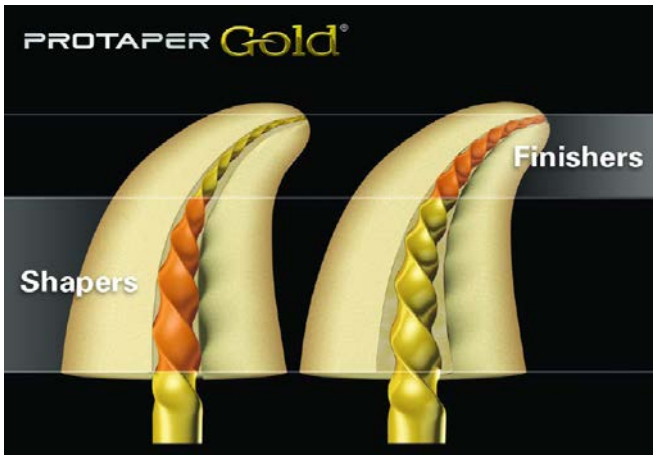

Figure 4b. *The Shapers advantageously prepare the coronal two-thirds of a canal; whereas, the Finishers prepare the apical one-third of the same canal.*

ty and the resistance to cyclic fatigue, when comparing PTG against PTU or any other brand-line of files of like sizes. Like PTU, the PTG Shaping files dominantly prepare the coronal two-thirds of a canal, whereas the Finishing files serve to increase the terminal diameter and apical one-third taper of a canal without needlessly further enlarging the body of the same canal ***(Figure 4b)***. Both ProGlider and PTG Shaping and Finishing files have been validated at 300 rpm and a torque of 4.0-5.2 Ncm. The following will describe a technique to endodontically prepare longer, narrower, and more curved canals.

SCOUT AND SECURE THE CORONAL TWO-THIRDS

In coronally restrictive canals, after locating any given orifice, the pulp chamber may be filled brimful with a viscous chelator. It is virtually always possible to insert a size 10 file into the coronal aspect of most canals. Gently reciprocating the handle of a size 10 file will generally pull this file into the canal several millimeters ***(Figure 5)***. In longer and narrower canals, the size 10 file will generally not reach length because the rate of taper of this file exceeds the rate of taper of the canal. In these instances, any portion of the overall length of a canal that can be readily negotiated can typically be secured. The secret to securing canals is to gently work the size 10 file, utilizing 0.5-1.0 mm ultrashort vertical strokes, until it is super loose.[8]

The loose depth of the size 10 file is measured and this length is transferred to either a SS size 15 hand file or, preferably, a safer, faster, and easier to use dedicated mechanical glide path file, such as ProGlider. The viscous chelator is flushed out and the pulp chamber is filled with NaOCl. ProGlider's variably tapered design enables this file to passively run inward and progressively advance along the secured portion of a canal. If the file ceases to easily advance inward, remove the file and irrigate, recapitulate with the size 10 file, then re-irrigate to liberate this debris. Typically, in 1 or 2 passes, the ProGlider will rapidly expand or pre-shape the secured portion of any given canal ***(Figure 6)***.

SHAPE THE CORONAL TWO-THIRDS

The coronal two-thirds of virtually any canal can be mechanically shaped when sufficient working width is available to passively accommodate the tip of the PTG Auxiliary Shaping

Figure 5 *In the presence of a viscous chelating agent, a size 10 file may be utilized to scout and secure a glide path over any length of a canal.*

Figure 6. *In the presence of NaOCl, ProGlider may be used to safely and rapidly pre-shape the secured portion of a canal.*

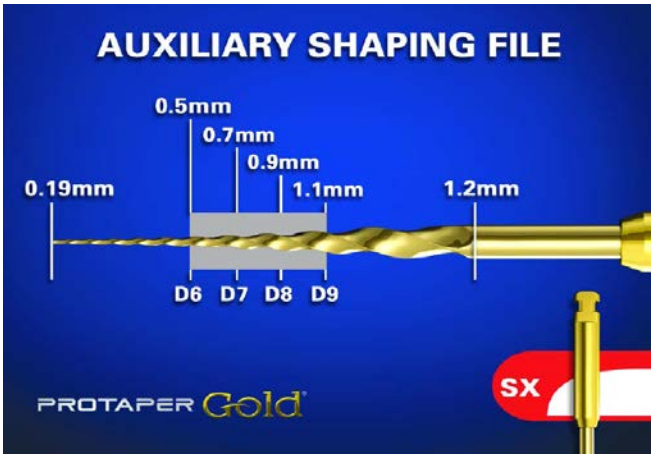

Figure 7. *SX is for radicular access and is utilized in a brushing manner, on the outstroke, to cut dentin between D6 and D9.*

file, termed SX. This file has an overall length of 19 mm, which facilitates its use when space is restrictive. Further, because SX has 9 increasing tapers up to 19%, it is the industry leader for pre-enlarging the coronal two-thirds of virtually any canal ***(Figure 7)***. SX is designed so its apical extent passively follows the glide path while the body of this file is utilized to cut dentin.

Specifically, SX is designed to cut between D6, D7 D8, and D9, where the cross-sectional dimensions are equivalent to 0.5 mm, 0.7 mm, 0.9 mm, and 1.1 mm, respectively. In the presence of NaOCl, SX is used like a brush to laterally and selectively cut dentin on the outstroke. Without pressure, and in one or more passes, SX is used to eliminate triangles of dentin, intentionally relocate the coronal aspect of a canal away from external root concavities, and to shape the coronal two-thirds of virtually any canal ***(Figure 8)***.[9] In general, only about one-half to two-thirds of the overall length of the active portion is carried below any given orifice.

SCOUT THE APICAL ONE-THIRD

With the pulp chamber filled brimful with a viscous chelator, a size 10 file is generally used to scout, negotiate, and secure the apical one-third of a canal. Fortuitously, a pre-enlarged canal will more easily enable dentists to direct a precurved size 10 file to length ***(Figure 9)***. However, infrequently but on occasion, it may be necessary to drop to a smaller size hand file to safely achieve length. Once a size 10 file has reached length, it is gently, deliberately, and repeatedly worked, again using 0.5-1.0 mm ultrashort vertical strokes, until it is completely loose.

Establish Working Length

Working length is established using radiographic images and/or an electronic apex locator. With experience, apex locators can provide an accurate working length determination, even in canals that contain exudates or electrolytes. However, it is appreciated that apex locators are more reliable when used with a viscous chelator in a pre-enlarged canal. When the apical one-third of a canal has been fully negotiated, working length is established ***(Figure 10)***. To promote the biological and mechanical objectives for preparing canals, working length corresponds to the radiographic terminus (RT), as the canal, by definition, will be open and patent, apically.

Confirm Patency

Patency is confirmed by gently sliding a precurved SS size 10 file to and minutely through the terminus of a canal ***(Figure 11)***. At this depth, ultrashort vertical strokes are continued until this file is completely loose. The RT is anatomically recognized to be a point minutely beyond the cementodentinal junction (CDJ). Working a flexible, small-sized file to the RT serves to encourage the elimination of pulpal tissue, bacteria when present, and dentinal mud. Keeping the terminus of a canal patent discourages blocks, ledges and perfo-

Figure 8. *SX is used to remove triangles of dentin, relocate canals away from external root concavities, and produce more root-centered preparations.*

Figure 9. *In the presence of a viscous chelator, a precurved size 10 file is passed through a pre-enlarged canal and utilized to negotiate the rest of the canal.*

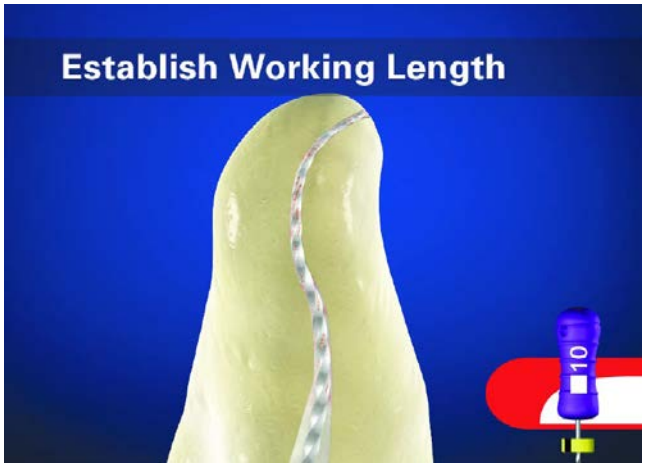

Figure 10. *Working length is more accurately established in a pre-enlarged canal.*

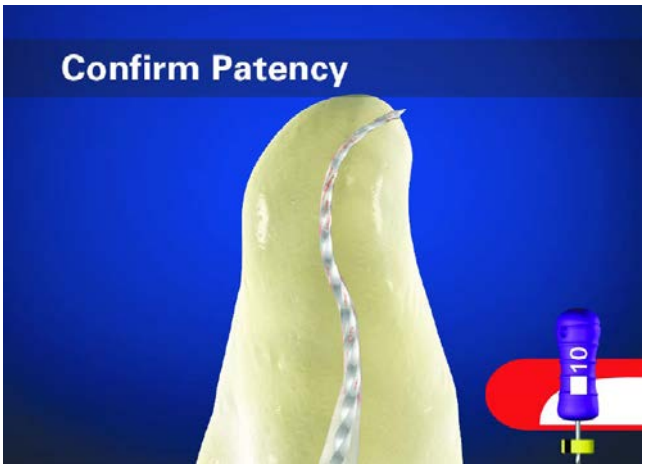

Figure 11. *Patency is confirmed when the size 10 file can gently and reproducibly slide to and minutely through the terminus of a canal.*

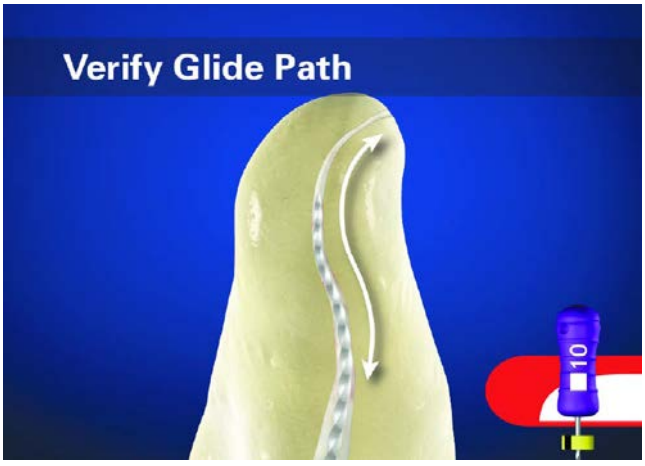

Figure 12. *A canal is termed secured when a size 10 file can reproducibly slip, slide, and glide over the apical one-third of a canal.*

rations. It is illogical to assume that passing a small-sized file passively and minutely through the CDJ will predispose to any irreversible harm, when one reflects on the healing capacity of the supporting structures.

Verify the Glide Path

An apical glide path is verified and the canal termed secure when a size 10 file can reproducibly slip, slide, and glide along the length of the apical one-third of any given canal ***(Figure 12)***. On the contrary, there is no reproducible glide path if the handle of a small-sized file must be manually reciprocated in order to carry a precurved size 10 file to length. In these instances, the reader is invited to visit my website for information on how to prepare canals when there is no reproducible glide path. When a size 10 file can reproducibly slide along the glide path and to length, then when necessary, this pathway is further expanded to a minimum of 0.15 mm to more readily accommodate the tips of mechanical shaping files.

PRE-SHAPE THE APICAL ONE-THIRD

Traditionally, a rather stiff SS size 15 hand file has been used to expand the terminal diameter of the glide path. Beyond stiffness, the other clinical problem associated with a size 15 file is the fact that its D0 diameter is 50% bigger than the D0 diameter of the size 10 file. As such, a considerably stiffer and larger size 15 hand file has long been associated with iatrogenic problems, especially when expanding the apical one-third portion of the glide path in longer, narrower, and more curved canals. Fortuitously, a metallurgically enhanced ProGlider offers a safer, faster, and easier method to pre-shape the apical one-third glide path.

Clinically, it is easy to move from a loose size 10 file to a ProGlider, even though this represents a theoretical transition from 0.10 mm to 0.16 mm. Recall the size 10 file has a taper of 0.02 mm/mm, which means this file is 0.12 mm in diameter at D1. If the size 10 file is carried minutely beyond the CDJ and to the RT, and gently worked until it is loose, then the canal, by definition, is a little larger than the file itself. If a size 10 file is used as described, then the CDJ would be transitioned from 0.12 mm to at least 0.13 mm in diameter. As such, the actual percentage change between the size 10 file at D1 and the ProGlider at D0 is a negligible 23%.

With the pulp chamber filled with NaOCl, ProGlider is inserted into a pre-enlarged and apically secured canal and allowed to passively and progressively advance toward length. In longer, narrower, and more curved canals, the ProGlider file may bog down and resist advancement along the glide path. In these instances, remove the file, irrigate, recapitulate with a size 10 file, then re-irrigate to flush out debris. In this manner, continue with the ProGlider and pre-shape the apical one-third of virtually any previously secured canal ***(Figure 13)***.

Figure 13. *In a bath of NaOCl, ProGlider is utilized, in one or more passes, to expand or pre-shape the glide path.*

SHAPE THE APICAL ONE-THIRD

When the apical one-third of the canal has been secured and expanded to at least 0.15 mm, then the pulp chamber is filled brimful with NaOCl. The PTG sequence is to first carry the Shaping File No. 1, termed S1 to the full working length in one or more passes. Specifically, S1 is allowed to float into the canal and, before resistance, is used with a brushing action on the outstroke. A brush-cutting action creates lateral space and allows the bigger, stronger, and more efficient blades to passively run deeper into the canal.[9] If S1 bogs down and ceases to passively advance, remove the file, then irrigate, recapitulate with a size 10 file, and re-irrigate. In this manner, continue with S1 until the terminus of the canal is reached ***(Figure 14)***.

Following S1, irrigate, recapitulate with a size 10 file, and re-irrigate. Proceed to Shaping File No. 2, termed S2, and use this file in the exact same manner as just described for S1. Importantly, a brushing action facilitates shaping canals that exhibit irregular shaped cross-sections. S2 will typically move to length in one or more passes depending on the length, diameter, and curvature of the canal ***(Figure 14)***. After removing any given rotary file, irrigate, recapitulate with a size 10 file, then re-irrigate. After sequentially using S1 and S2 to the RT, particularly in more curved canals, working length should be reconfirmed, as a more direct path to the terminus has been shaped.

FINISH THE APICAL ONE-THIRD

The PTG Finishing files all have fixed tapers from D1-D3, then decreasing percentage tapers from D4-D16. The most frequently used Finishing files are F1 (20/07), F2 (25/08), and F3 (30/09). These PTG Finishing files have a maximum flute diameter at D16 of about 1.0 mm versus 1.32 mm, 1.53 mm, and 1.77 mm, respectively, if their fixed tapers were to continue over the length of their active portions. Interestingly, this strategic design feature occurred more than a dozen years before the first report of the concept of minimally invasive endodontics.[7]

The PTG F1 (20/07) is selected and passively used in a brushing manner to move deeper into the canal. If F1 ceases to readily advance toward length, recognize its blades are loaded with debris, which, in turn, limits its capacity to engage, cut, and get pulled deeper into the canal. In these instances, remove the file, irrigate, recapitulate with a size 10 hand file, then re-irrigate. Continue with F1, in one or more passes, until the terminus is reached ***(Figure 15)***. When F1 achieves length, the instrument is removed, and its apical flutes are inspected.

FINISHING CRITERIA

The "Finishing Criteria" is fulfilled whenever 3-5 mm of the most apical flutes of any given PTG Finishing file are fully loaded with dentin. If the apical flutes of F1 are loaded with dentin, then visual evidence supports that the shape has been cut and is done. However, upon removing any given Finishing file, the clinician may observe the apical flutes are partially loaded or not loaded at all. If the apical flutes of F1 are not fully loaded with dentin, then the clinician proceeds to the next sequential Finishing file, or F2 (25/08).

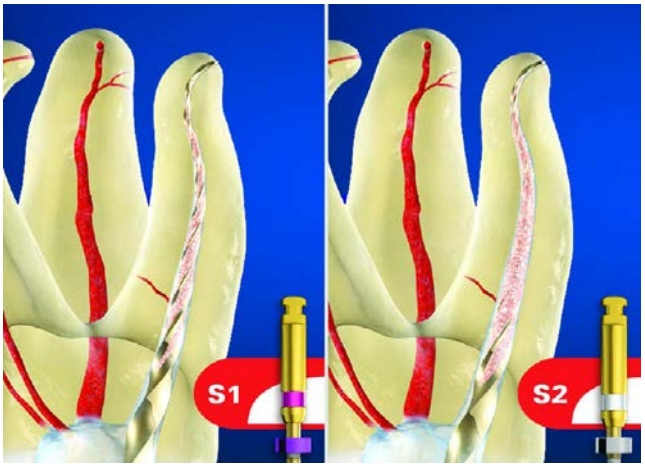

Figure 14. *Left: S1 is used with a brushing motion on the outstroke and allowed to passively advance inward along the glide path and to length. Right: Following S1, S2 is used, as described for S1, until working length is reached.*

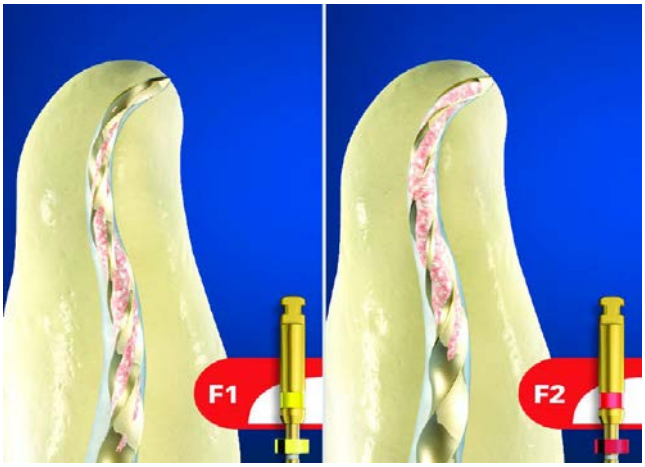

Figure 15. *Left: F1 is used in a brushing manner, in one or more passes, until the working length is reached. Right: If the F1 apical flutes are partially loaded, or not loaded at all, proceed with the F2 until working length is reached.*

Figure 16. *When the apical flutes of a PTG Finishing file are fully loaded with dentin, then the shape is cut and the finishing criteria is fulfilled.*

In a bath of fresh NaOCl, F2 is progressively carried to length in one or more passes ***(Figure 15)***. Upon reaching length, F2 is removed and the apical flutes are inspected. If its apical flutes are fully loaded, then visual evidence confirms the shape is done ***(Figure 16)***. If the apical flutes of F2 are partially loaded or not loaded at all, then continue to the PTG F3 Finishing file, or F4 or F5 as indicated. The ProTaper sequence is always the same and will produce the shapes that promote 3D disinfection and filling root canal systems ***(Figure 17)***.

Conclusion

A dentist who has never used PTU for preparing canals typically loves the performance of PTG, as is. If a dentist is an experienced PTU user, then this colleague may prefer the PTU Shapers in that they offer a little more resistance to lateral brushing; this attribute makes them feel more efficient to some clinicians. However, any dentist performing endodontics will benefit from gold metal technology, which enables gold medal shaping results. Glide path management and shaping canals are the sine qua non of 3D disinfection and filling root canal systems. ▲

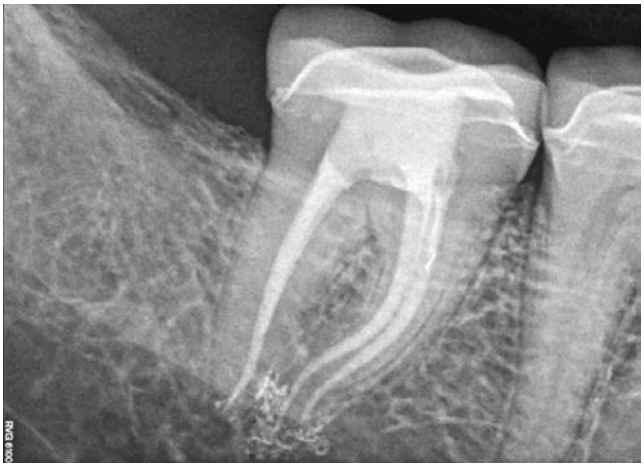

Figure 17a. *This image reveals multi-planar shapes skillfully prepared with ProGlider and PTG (Courtesy of Dr. Thomas V. McClammy; Scottsdale, Arizona).*

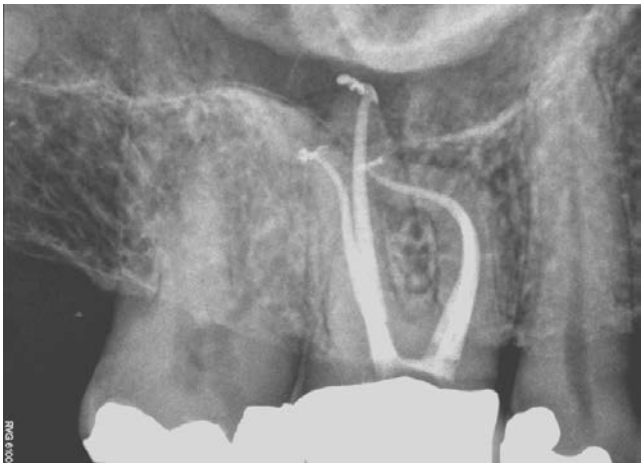

Figure 17b. *This image demonstrates significant midroot curvatures exquisitely shaped with PTG (Courtesy of Dr. Jordan West; Tacoma, Washington).*

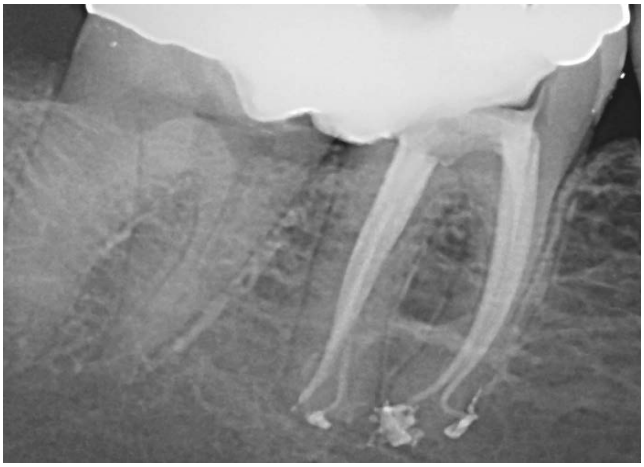

Figure 17c. *This image shows the management of difficult apical curvatures utilizing PTG (Courtesy of Dr. Michael W. Nimmich; Sumter, South Carolina).*

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