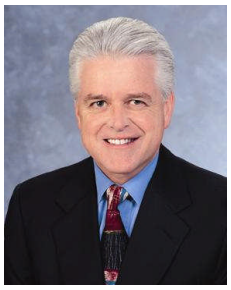
PROTAPER UNIVERSAL
WHATEVER YOU THOUGHT, THINK AGAIN



Clifford J. Ruddle

The continuous parade of NiTi files coming to market is an example of the unrelenting change occurring in the field of endodontics. Before deciding on which files to select, it would be wise for dentists to recall the old expression, "Model success, success leaves clues." ProTaper is currently one of the most successful file lines available as evidenced by their extensive utilization internationally. The secret to the ProTaper success story is simple.

ProTaper files have a unique design that enables any dentist to more easily duplicate the most predictably successful concept ever described for preparing a canal. More than thirty years ago, Dr. Herbert Schilder's article, entitled "Cleaning and Shaping the Root Canal System," was published.[1] In what has become a classic article, he presented brilliant concepts and defined the five mechanical objectives for shaping canals and cleaning root canal systems ***(Figure 1)***. Schilder completely understood that, logically, the dimensions of these smooth flowing funneled preparations would necessarily and appropriately vary relative to the anatomy of any given root. Schilder fully appreciated that well-shaped canals would exhibit "the look", improve the potential for three-dimensionally cleaning and filling root canal systems, and fulfill the biological objectives for the retention of critically essential teeth ***(Figure 2)***.

Schilder's genius was the innovative motion he used with a series of instruments to carve the shape and sequence the preparation. There are strategic advantages to removing restrictive dentin from the coronal two-thirds of the canal before initiating procedures in the deeper and typically more complicated apical region of the canal.[2] Schilder's shaping objectives are the standard against which all other preparation techniques are measured. This strategy of pre-enlargement is very different from the frequently used step-back and crown-down techniques. Each technique has been described in different ways, has something to offer, and was developed to advance canal preparation methods. Although each technique can theoretically produce the same final shape, each method is very different and has been designed to prepare a general region within the canal in a precise sequence. The following will briefly review the *step-back*, *crown-down*, and *pre-enlargement techniques*.

In the *step-back technique*, small-sized ISO hand files are initially used to negotiate the full length of canal. Larger files are then carried into the apical one-third until the desired master file reaches the chosen working length. The apical one-third of the preparation is deemed complete when the master file is snug at length and each consecutive larger file in the series is observed to uniformly step-back from the most apical extent of the preparation. When the apical one-third of the preparation has been completed, then the coronal two-thirds of the canal is flared and the overall length of the preparation smoothly blended.

Although this preparation method can be successful and is performed with slight variations, the technique has regrettably resulted in countless canals that have been blocked, ledged, transported, or perforated. These iatrogenic events frequently require additional procedures, such as nonsurgical retreatments, surgeries, and extractions.

In the *crown-down technique*, ISO instruments with varying D_0 diameters are generally selected and utilized from the bigger to smaller sizes. In general, the preparation is initiated at the orifice, continued through the body of the canal, and then terminated at the canal's most apical extent. As such, dentin is sequentially removed from the coronal, then the middle, and finally from the apical one-third of a canal. Although the crown-down technique overcame many of the frustrations associated with the step-back technique, the paradox is threefold. First, although the instruments initially selected aggressively plow away dentin with their bigger, stronger, and stiffer tips, it must be recognized that a large spinning file will over-simplistically cut a round hole. Preparing a round hole through an anatomical cross-section which commonly exhibits an irregular configuration compromises debridement and disinfection. Second, the taper of the ever-expanding preparation quickly duplicates the taper of the file used, especially in longer, smaller-diameter, and more curved canals. When a file has a long engagement over its active length, then dangerous taper lock results and the potential for breakage significantly increases. Third, the potential for file breakage increases as the smaller-sized files, utilized in the apical one-third, tend to engage and cut dentin toward their smaller, weaker, and less efficient blades.

In the *pre-enlargement technique*, a series of ISO instruments with varying D_0 diameters are selected, appropriately precurved, and utilized from the smaller to bigger sizes. Especially in longer, smaller-diameter, and more curved canals, the shaping instruments are initially restricted to the coronal two-thirds of the canal. Each consecutive larger instrument will generally work short of the previously used smaller files, progressively carve away restrictive dentin, and serve to funnel the coronal and middle two-thirds of the canal. However, since these instruments are used from small to big, their more flexible tips are typically loose and safely follow the secured portion of the canal. Importantly, depending on the extent of curvature, any given ISO instrument will cut a shape larger than its taper would suggest. Specifically, when the Envelope of Motion (EOM) technique is employed, each instrument will randomly cut dentin on the outstroke toward its larger, stronger and more active blades. Properly performed, pre-enlargement procedures improve access to the typically more challenging anatomy in the apical one-third of the canal. Fortuitously, following pre-enlargement procedures, finishing files are completely loose within the body of the canal and can be more predictably directed apically. In this technique, emphasis is placed on shaping and blending the apical one-third of the preparation into the body of the canal. Finishing the canal is the *sine quo non* of preparation excellence.

Over many years, the pre-enlargement technique has grown in popularity as this method for shaping canals has proven to be predictably successful. However, this method for preparing canals frequently requires many instruments, several recapitulations through a series of files, and as such, is perceived to be difficult and time-consuming. Hence, it seemed wise to design a set of files with innovative geometries that would both duplicate and simplify the Schilder technique. The unique geometries of each ProTaper NiTi file unite the most enduring shaping method from the past with the newest technological advancements in machining today. As such, ProTaper files fulfill the age-old adage, "Everything old is new again."

In 1995, the opportunity was present to develop an improved set of NiTi files. The goal was to create a simple set of easy-to-use files that would significantly improve the benchmark for safety and efficiency. In collaboration with the engineers from Maillefer, Drs. Pierre Machtou, John West and I agreed to develop a set of files that would precisely duplicate the Schilder shaping concept. We envisioned three Shaping and three Finishing files with unique geometries. Each Shaping file would have increasing percentage tapers over the length of its cutting blades. Each Finishing file would have a fixed taper in its apical extent, then importantly, decreasing percentage tapers over the coronal two-thirds length of its blades. This was an innovative idea at that time and required Maillefer to build new machines to manufacture progressively tapered files. The early instruments were initially called Variable Taper (VT) and were thoroughly tested over the next 5 years. In 2001, the VT file concept was commercially launched as ProTaper, as this name better represented the progressively tapered file design. Dentsply Maillefer attained patents to intellectually protect the concept of both increasing and decreasing percentage tapers over the blades of a single file. It has been easy for both inexperienced and experienced dentists to incorporate the ProTaper line of files into everyday practice. This is because, in longer, narrower, and more curved canals, dentists can consistently achieve "the look" oftentimes with only three instruments.

The ProTaper system is the alternative to all other file systems which are machined with fixed tapers. Specifically, the ProTaper Shaping files' small-sized tips act as guides to passively follow the path of the canal previously secured with hand files. Increasingly larger percentage tapers over the active length of each Shaping file ensures each sequential instrument works away from its apical extent. Importantly, an increasing percentage tapered file selectively cuts dentin towards its larger, stronger, and more efficient blades. The ProTaper variably tapered design and method of use precisely follows the Schilder technique where precurved reamers were sequentially selected, rotated in an "envelope of motion", and cut dentin on the withdrawal stroke. ProTaper Shaping files have a cross-section similar to reamers, and as such, 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 laterally and selectively cut dentin on the outstroke. A brushing action creates lateral space which will facilitate the Shaping file's larger and more active blades to safely and progressively move deeper into the canal. Strategically, this brush-cutting action can be used to more effectively shape into fins, isthmuses, and canal irregularities or to relocate the coronal aspect of a canal away from furcal danger. As has been shown using µCT, this lateral brushing motion with the ProTaper Shaping files consistently contacts more than 90% of the internal walls of the shaped canal. Indeed, when the ProTaper files are used correctly, µCT on extracted teeth and clinical results have consistently shown these instruments produce a centered preparation, even in significantly curved canals ***(Figures 3,4)***.[3] In this method of use, it is remarkable to note that the Shaping files are essentially loose during the majority of their work within a canal.

In the pre-enlargement technique, once the coronal two-thirds of the preparation has been optimally shaped, then the apical one-third of the canal is negotiated, working length established, patency confirmed, and the glide path verified. When there is a reproducible glide path, then the ProTaper S1 and S2 are carried to length, in one or more passes, prior to using the ProTaper Finishing files. The Finishing files have fixed tapers from D_1 to D_3, then decreasing percentage tapers from D_4 to D_{16}. This design feature improves flexibility, decreases the engagement zone, and limits the Finishing files to working in their apical extents. Importantly, a decreasing percentage tapered design respects external root concavities, reduces the possibility of overpreparing the coronal two-thirds of a canal, and maximizes remaining dentin.

Even though the ProTaper line has experienced 5 years of explosive growth in the international market, several changes have recently been made to improve the existing market version. Although any particular change may seem unimportant, the changes in concert are synergistic and together represent a significant step forward for ProTaper. The most noticeable change will be the addition of two larger Finishing files, namely F4 (40/06) and F5 (50/05). These two files may be used in anatomically larger canals or by those dentists who philosophically subscribe to making anatomically smaller-sized canals larger. Other improvements include removing the transition angle between the safe-end of the file and the first cutting blade, balancing the work more evenly from file to file within the series, electropolishing, providing ProTaper in 31 mm lengths, and increasing the flexibility of the larger-sized Finishing files. Regarding flexibility, if one compares the D_0 diameter and taper of any given ProTaper file against any comparably-sized instrument of another brand-line, ProTaper will be judged to be significantly more flexible. Together, these improvements will enable ProTaper to address a greater variety of anatomical situations. Importantly, these instruments will decrease the perceived need for dentists to use hybrid file techniques.

ProTaper files will be relaunched this year and will be termed ProTaper Universal ***(Figure 5)***. It is an exciting time in dentistry as new technologies potentially drive new practice-building techniques and the expectation for greater clinical efficiency and success. In this time of unrelenting change, it would be wise to pause and remember the early pioneers of modern dentistry and reflect on the enormous contributions they made to create the biological and clinical foundations on which we stand. Dr. Herbert Schilder is one of these pioneers and his innovative concepts have remained enduring and relevant over the decades. For new technologies to be meaningful, clinical results must hold up to scientific scrutiny and compliment time-honored principles. The ProTaper concept for shaping canals has enabled both inexperienced and experienced dentists to consistently duplicate the most predictably successful concept ever described for preparing a canal. With this philosophy at its core, ProTaper continually moves forward. The message regarding ProTaper is “Whatever you thought, think again!” ProTaper Universal promises to raise the bar even higher.———————————

1. Schilder H: Cleaning and shaping the root canal system, *Dent Clin North Am* 18:2, pp. 269-296, 1974.

2. Ruddle CJ: Ch. 8, Cleaning and shaping root canal systems. In *Pathways of the Pulp*, 8th ed., Cohen S, Burns RC, eds. St. Louis: Mosby, pp. 231-291, 2002.

3. Ruddle CJ: The protaper technique, *Endodontic Topics* 10:187-190, 2005.

FIGURE DESCRIPTIONS

Figure 1a This image serves to emphasize root curvatures, external root concavities, and root canal system anatomy.

Figure 1b At a higher magnification, this image demonstrates that shaping facilitates three-dimensional cleaning, and shaping facilitates filling root canal systems.

Figure 2 Sequencing the preparation facilitates shaping canals and cleaning root canal systems. Complete endodontic treatment is the foundation of perio-prosthetics.

Figure 3 This figure compares before and after instrumentation with the ProTaper S1, S2, and F1 files. Note the shapes are full, smooth flowing and centered, and the files have physically contacted virtually all the internal anatomy. *(Courtesy of Dr. Lars Bergmans and BIOMAT Research Cluster, Catholic University of Leuven, Belgium)*

Figure 4a The canals of this mandibular molar were shaped with ProTaper files and three-dimensionally filled. Note the flowing shapes, apical one-third curvatures and multiple portals of exit. *(Courtesy of Dr. Jason West, Tacoma, Washington)*

Figure 4b The canals of this maxillary molar were prepared with ProTaper files. Note that the ProTaper files perfectly follow significant curvatures and carve smooth flowing shapes. *(Courtesy of Dr. John West, Tacoma, Washington)*

Figure 5 ProTaper files represent a revolutionary progression in efficiency and safety when preparing root canals. The ProTaper rotary files may be easily converted to manual files using color-coded, snap-on handles.

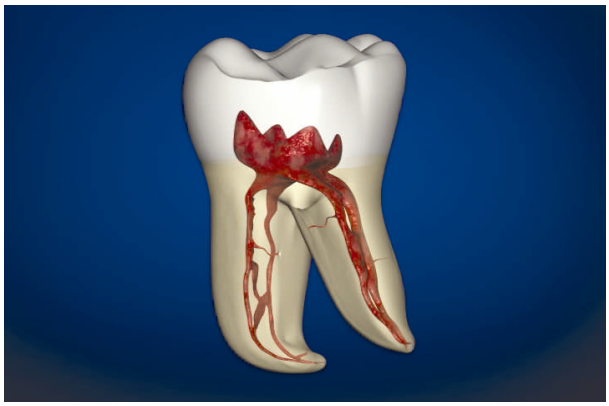


Fig 1a

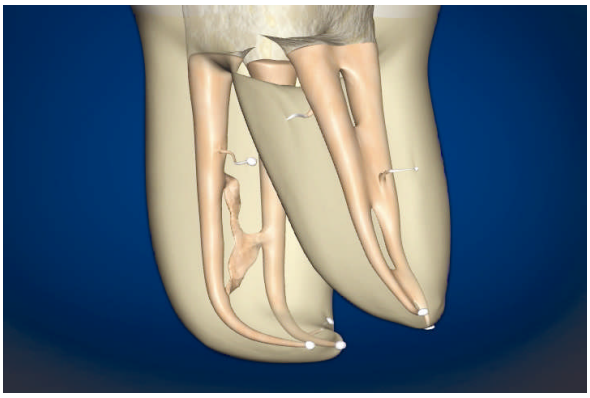


Fig 1b

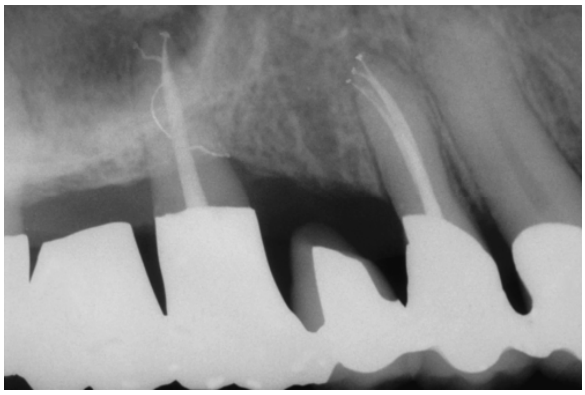


Fig 2

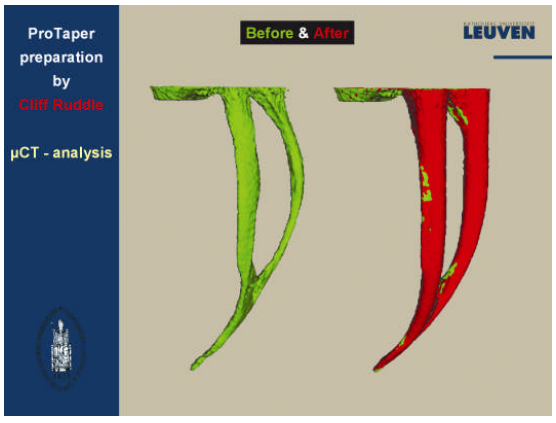


Fig 3

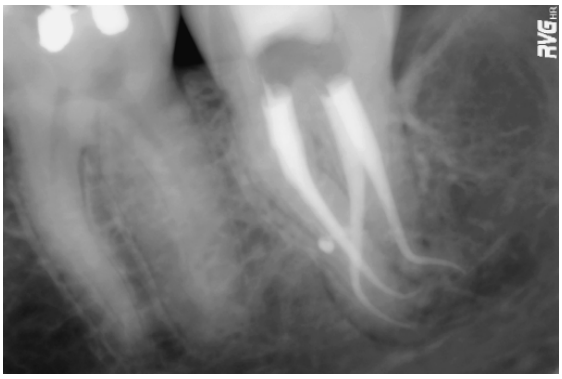


Fig 4a

Fig 4b

Fig 5