Single-File Shaping Technique:
Achieving a Gold Medal Result

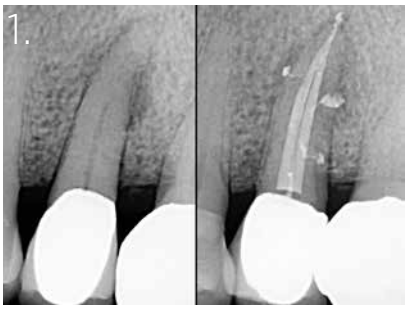
Clifford J. Ruddle, DDS, FICD, FACD

There are many factors that serve to influence which endodontic mechanical file system or hybrid technique is selected to prepare any given canal. Altruistically, the most important factor should be the desire to produce a predictably successful shaping result. Clinically, the shaping experience is measured by safety, cutting efficiency, and the fewest number of files required to minimally or fully prepare a root canal.[1] Certainly, the cost associated with preparing any given canal is a factor that is influenced by the market, and the clinical and business practice models.[2] Regardless of the preparation philosophy, methods should be utilized that promote the exchange of irrigant, 3D disinfection, and filling root canal systems **(Fig. 1)**.

Most shaping systems are described by whether any given file has active vs. passive cutting edges, a fixed vs. variable taper along its active portion, or a more traditional vs. unique cross-sectional design. Further, it is useful to know whether a file has benefitted from heat treatment, as this technology improves flexibility and the resistance to cyclic fatigue. Additionally, a file is categorized as to whether it has a centered vs. offset mass of rotation, works with a rotary vs. reciprocating motion, and in the instance of reciprocation, whether the clockwise (CW) and counterclockwise (CCW) angles are equal vs. unequal. Finally, mechanical systems are identified as to whether a single-file vs. a multi-file sequence is required to shape a canal.

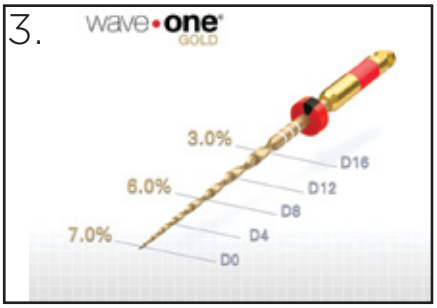
Although these classifications prognosticate performance, sway choices, and instigate trends, endodontic behavior is further manifested in the time-honored expression, "Who you are is where you were when." Dentists make decisions based on where and when they were trained and who trained them, as well as whether they practice as general practitioners or specialists. From several decades of practicing and teaching endodontics, I have learned there are other conscious and subconscious decisions influencing file selection. For example, the selection of a shaping file system is oftentimes determined by whether a dentist practices solo, in a private group practice, or is employed in corporate dentistry.

Balancing treatment objectives with technical and humanistic factors, the WaveOne single-file shaping system was conceived and came to market in 2011.[3] Since then, much has been learned,[4] and through this process, a new generation has emerged that provides excellent safety, effortless efficiency, and super simplicity. This vastly improved system has been branded WaveOne Gold *(Dentsply Sirona)*. The following article will identify the critical distinctions between shaping canals using continuous rotation vs. a reciprocation method. Focus will be on a concept, technology, and technique that enable transitioning an unshaped canal to a fully shaped canal with typically one single file.



Note pre- and post-treatment images, WaveOne shapes, EndoActivator disinfection, and 3D filling (Courtesy of Dr. David Landwehr; Madison, WI).

The Small, Primary, Medium and Large WaveOne Gold files.



A decreasing percentage tapered design improves flexibility and conserves remaining dentin in the body of the prepared canal.

Rotation Vs. Reciprocation

There are both advantages and disadvantages associated with utilizing a continuous rotation vs. a reciprocation movement when shaping canals. The greater tactile touch and cutting efficiency gained when continuously rotating NiTi files in longer, narrower, and more curved canals must be balanced with the inherent risks associated with torque and cyclic fatigue failures. Fortunately, these risks have been considerably reduced due to continuous improvement in file designs, NiTi heat treatment, and emphasis on glide path management (GPM).[1,5] In general, continuous rotation requires less inward pressure and improves augering debris out of a canal, compared to a reciprocation method that utilizes *equal* bidirectional angles of reciprocation.[6]

On the other hand, while a repetitive CW/CCW reciprocating motion reduces risks associated with continuous rotation, systems that utilize *equal* CW/CCW angles have recognized limitations. These include decreased cutting efficiency, more required inward pressure, and a limited capacity to auger debris out of a canal.[3,6] Further, motors that drive shaping files through equal CW/CCW angles generally require multi-file sequences to safely prepare a canal. Fortuitously, in the late 1990s, Prof. Pierre Machtou first proposed utilizing *unequal* CW/CCW angles. Dr. Ghassan Yared, his former student, subsequently identified the precise angles that led to a revolutionary reciprocating single-file shaping technique.[7]

Single-File/Single-Use Concept

Like WaveOne, WaveOne Gold is a single-file technique. Over several years, our designer group team prepared several thousand canals and validated that a single size Primary file was able to transition an unshaped, yet *secured*, canal to a well-shaped canal more than 80% of the time.[6] It is a single-use concept due to the obvious work and resultant wear a single file encounters when fully preparing one or more canals in any given tooth. Further, peer-reviewed publications have reported the potential for cross-contamination when files are reused, regardless of the sterilization protocol utilized.[8] The following will describe how a patented design, superior alloy, and an unequal bidirectional movement synergistically enable a single-file/single-use technique.

System & Design

There are 4 WaveOne Gold files available in various lengths to more effectively address a wider range of endodontic anatomy compared to its WaveOne predecessor. The 4 files are termed *Small* (yellow 20/07), *Primary* (red 25/07), *Medium* (green 35/06), and *Large* (white 45/05) **(Fig. 2)**. Each file has a fixed taper from D1-D3, yet a progressively decreasing percentage tapered design from D4-D16, which serves to preserve dentin **(Fig. 3)**. For example, the Primary file has diameters of 0.85 mm and 1.0 mm at D9 and D12, respectively, or the length this file typically extends below the orifice during canal preparation. Fortuitously, the Primary 25/07 file is generally the only file required to fully shape virtually any given canal.

Another unique design feature is that each file has an alternating offset parallelogram-shaped cross-section. This design limits the engagement between the file and dentin to only 1 or 2 points of contact at any given cross-section, subsequently reducing taperlock and the screw-effect **(Fig. 4)**. Engineering research has shown this new cross-section improves safety, increases cutting efficiency, and provides more chip space to auger debris coronally, as compared to the original Primary WaveOne file.[9] Additionally, each WaveOne Gold file has a newly designed, semi-active guiding tip, which enables the file to more readily follow and safely progress along manually reproduced and secured canals.

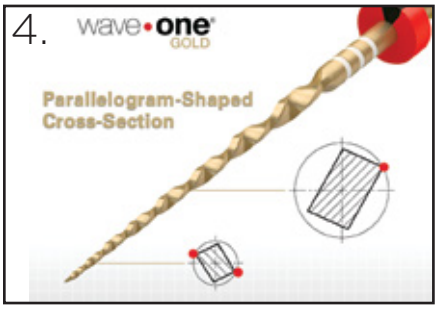
Superior Alloy

Engineers have identified the desired phase-transition point between martensite and austenite that serves to produce a more clinically optimal metal than NiTi, itself. This thermal process and post-machining procedure have generated a new supermetal that is commercially termed Gold-Wire. Specifically, the Primary WaveOne Gold file is at least 80% more flexible, 50% more resistant to cyclic fatigue, and 23% more efficient, compared to its Primary WaveOne M-Wire predecessor.[9] The new patented cross-section and supermetal serve to improve shaping results in anatomically longer, narrower, and more apically curved canals, while decreasing the potential for iatrogenic events.

Unique Movement

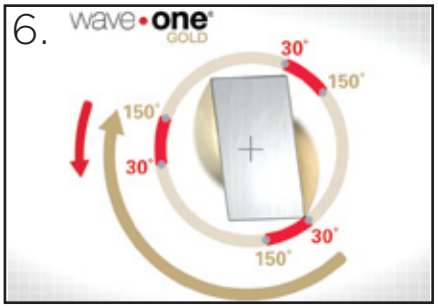
The ProMark, e3, X-Smart Plus, or X-Smart iQ motors (*Dentsply Sirona)* produce both continuous rotation and a feature-specific reciprocation motion. The new cordless iQ motor is paired by Bluetooth to an iPad mini; touch screen features enable customized file sequences, treatment reports, and patient education **(Fig. 5)**. Due to the reverse helix design, the WaveOne Gold CCW engaging angle is 150º, whereas the CW disengaging angle is 30º. Therefore, after 3 CCW/CW cutting cycles, the file will have rotated 1 full circle **(Fig. 6)**. This method has been shown to be 4 times safer and almost 3 times faster than using multiple rotary files to achieve the same final shape.[10-11]

There are 3 major clinical advantages to WaveOne Gold's unique movement. One, compared to continuous rotation, there is improved safety, as the CCW engaging angle is designed to be less than the elastic limit of each file. Two, opposed to *equal* CW/CCW angles, *unequal* CW/CCW angles enable a file to more readily advance toward the desired working length without using excessive and potentially dangerous inward pressure.[7] Three, compared to *equal* CW/CCW angles, *unequal* angles strategically enhance auguring debris out of the canal.[12] These 3 advantages serve to improve safety, cutting efficiency, and simplicity, while promoting the shapes that encourage 3D disinfection and filling root canal systems.



This image depicts how an alternating offset and transitioning parallelogram-shaped cross-section limits the engagement between the file and dentin

The X-Smart iQ motor pairs a cordless handpiece to an iPad mini. This technology may be used for patient education, setting file sequences, and gathering, capturing, and transferring treatment data.



The WaveOne Gold files utilize unequal bidirectional angles to improve inward movement, cutting efficiency, and hauling debris out of the canal.

Misinformation

There have been a few published reports linking mechanically-driven files to initiating micro cracks in dentin when shaping canals. These reports are dominantly attributable to failure to follow the Directions for Use (DFU) or overpreparing canals within small root forms. Importantly, cracks may result from forcing files with large tip diameters to length, further exacerbated by insufficient emphasis on GPM. Additionally,

these findings often result from using excessively low torque or failure to progressively prepare canals using a multiple pass shaping method.[1,6] It is important to note, however, that dentinal cracks are almost always technique-related, and not due to the inherent design or movement of any given file.

Recommended Protocol

The *Primary* 25/07 WaveOne Gold file is invariably used first in any canal that has a verified glide path equivalent to at least 0.15 mm. Traditionally, stainless steel (SS) sizes 10 and 15 hand files have been used to meet this objective. As an alternative to using a SS size 15 hand file, a ProGlider is recommended *(Dentsply Sirona)* **(Fig. 7)**. A progressively tapered and metallurgically enhanced ProGlider will cut a safer and more fully tapered pathway to length compared to a fixed tapered SS size 15 file.[1] The good news is, in more complex canals, research has shown that dedicated, mechanically-driven glide path files, like ProGlider, reduce the time expended performing GPM procedures by 40%.[13]

The *Small* 20/07 WaveOne Gold file is used when the Primary 25/07 file will not passively progress apically through a manually reproduced and secured canal. Its smaller tip size will more readily progress along the glide path of smaller diameter, longer length, or more apically curved canals. In certain canals, when the Small file reaches the working length, the clinician may deem the preparation completed or, alternatively, may desire more deep shape. In these latter instances, when the clinician elects to transition to the larger D0 diameter Primary 25/07 file, the Small 20/07 is considered a "bridge file". Even in these instances, the technique is safe, quick, and is a simple 2-file sequence compared to virtually all other mechanical shaping systems.

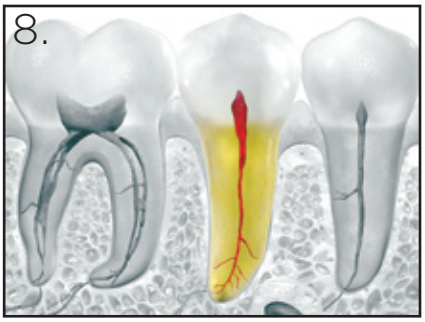
The *Medium* 35/06 and *Large* 45/05 WaveOne Gold files are used to complete the shape in larger diameter and typically straighter canals. Examples include certain maxillary incisors, some single-canal bicuspids, and larger diameter canals within maxillary and mandibular molar teeth. Recall, the WaveOne Gold protocol is to initiate shaping procedures using the Primary 25/07 file. However, after carrying the Primary file to the full working length, visual inspection of this file may reveal that its terminal flutes are not fully loaded with dentine mud. In these instances, the clinician may use the Medium 35/06 and, perhaps, the Large 45/05 files to prepare these larger, typically more straightforward canals.

Single-File Shaping Technique

The WaveOne Gold single-file shaping technique is remarkably safe and simplistic when attention is focused on the access preparation and GPM **(Fig. 8)**.[1] The access preparation is deemed complete when the internal axial walls are finished, the orifice(s) pre-enlarged, and all internal triangles of dentin eliminated. GPM starts with the desire to find, skill to follow, and patience to secure any given canal to its terminus.[14] With an estimated working length and in the presence of a viscous chelator, insert a size 10 file into the orifice and determine if this file will easily move toward the terminus of the canal. This file is used to either confirm existing space is available or, alternatively, to create space so that the tip of a mechanical file can safely follow.

However, in longer, narrower, and more curved canals, the size 10 file oftentimes cannot be safely worked to length. In these instances, there is generally no need to use smaller-sized hand files to reach the terminus of the canal at this moment. Simply work the size 10 hand file, within any region of the canal, until it is completely loose. Any portion of a secured canal may be pre-enlarged with, for example, the Primary 25/07 file. After the apical one-third of a canal has been negotiated, then working length is established, patency is confirmed, and

ProGlider's progressively tapered design and M-Wire technology make GPM safer, easier, and faster...and importantly, more effective.

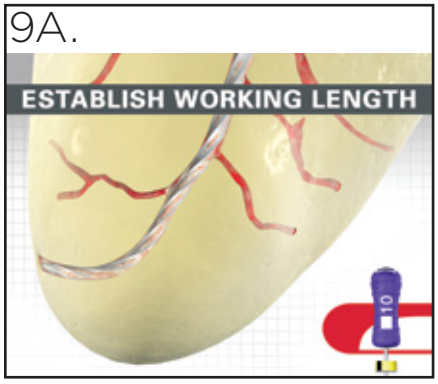


This image depicts a mandibular bicuspid with complex endodontic anatomy.

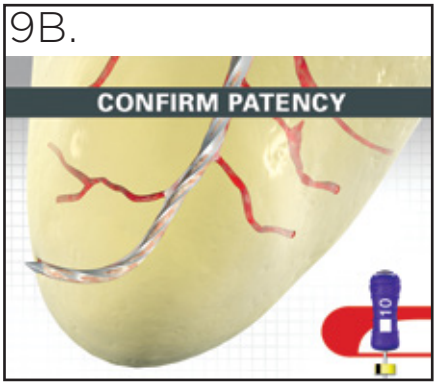
a smooth, reproducible glide path is verified **(Fig. 9)**. When necessary, the terminus of a catheterized and secured canal may be pre-shaped to a size more than 0.15 mm, using a ProGlider **(Fig. 10)**.

Shaping can commence, within any partially or fully secured canal, starting with the Primary 25/07 WaveOne Gold file. In the presence of a 6% solution of NaOCl, the Primary file is selected and allowed to passively progress inward until it meets light resistance. When the Primary file meets resistance and bogs down, remove this file and clean and inspect its flutes. Upon removing any mechanical shaping file from any canal, it is wise to irrigate, recapitulate with a size 10 file to break up debris and re-confirm the glide path, then re-irrigate. Typically, the Primary file will run inward, progressively advance, and incrementally move deeper within any region of the canal that has a confirmed, smooth, and reproducible glide path **(Fig. 11)**.

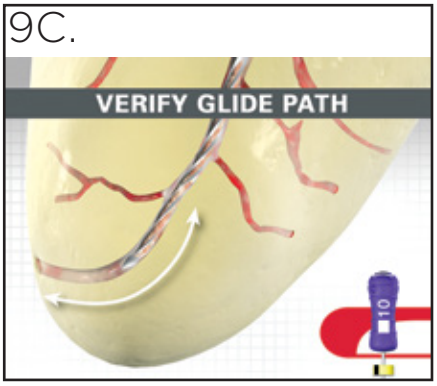
A brushing motion should be utilized to eliminate coronal interferences, remove internal triangles of dentin, or to enhance shaping results in canals which exhibit an irregular cross-section. Initially removing canyons of restrictive dentin from the coronal two-thirds of a canal creates a more direct path to the apical one-third of this same canal. In longer, narrower, or more apically curved canals, a pre-enlarged



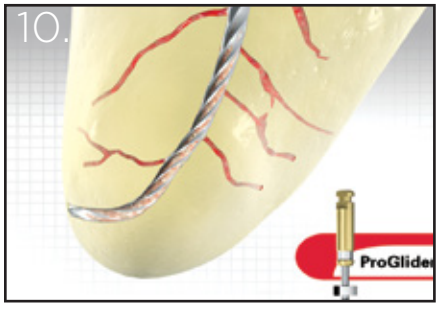
Working length is established when a size 10 file has manually reproduced the original canal pathway to the terminus.



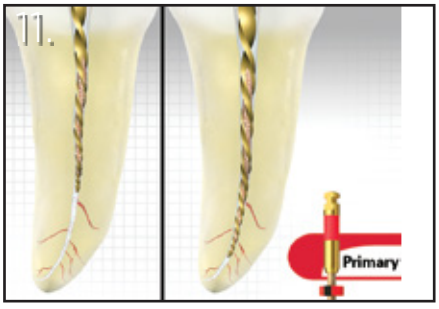
Patency is confirmed when a 10 file can be gently, deliberately, and reproducibly inserted to and minutely through the terminus of a canal.



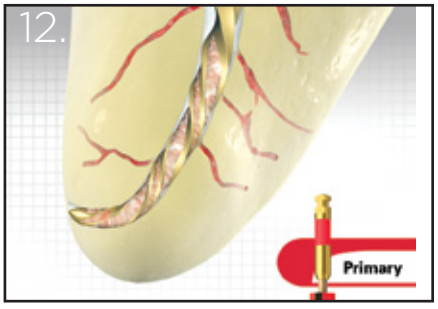
A glide path is verified and the canal is secured when a 10 file can reproducibly slip, slide, and glide over the apical one-third of a canal.



A mechanically-driven and metallurgically enhanced ProGlider is utilized to safely and rapidly pre-shape virtually any manually secured canal.



These 2 graphic images show the Primary 25/07 WaveOne Gold file following the glide path and progressively shaping toward length.



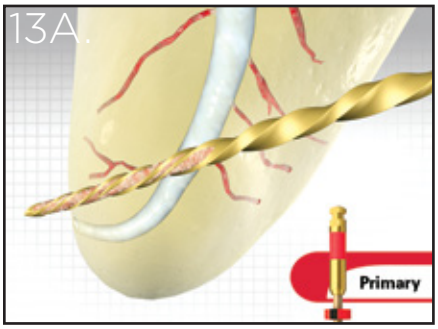
This graphic image shows the Primary 25/07 WaveOne Gold file has cut its shape around curvature, is at length, and its apical flutes loaded with debris.

canal improves the ability to more readily insert and direct a precurved small-sized hand file to the full working length. A glide path is verified and the canal is termed secured when a size 10 file can reproducibly "slip, slide, and glide" along the apical one-third of this same canal **(Fig. 9C)**.[1,14]

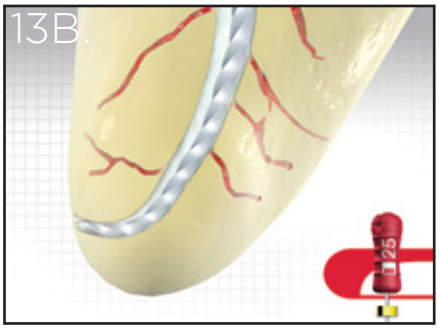
The Primary 25/07 WaveOne Gold file will generally reach the full working length in about 3 passes **(Fig. 12)**. As previously mentioned, when the Primary file will not readily advance, then the *Small* 20/07 file is utilized. Because of the initial bodywork performed by the Primary, the Small file will typically reach the desired working length quite easily. This file may be the only shaping file taken to the full working length in more apically and abruptly curved canals, or in longer and thinner roots that exhibit deep external concavities. However, as previously mentioned, when more shape is desired, the Small 20/07 may be thought of as a bridge file to facilitate carrying the Primary 25/07 file to the full working length.

Once the Primary 25/07 WaveOne Gold file has reached the full working length, it is removed. The finishing criteria is fulfilled when the apical flutes of this file are visually loaded with dentin **(Fig. 13A)**. Another method to determine the size of the foramen is to use a gauging technique.[15] In this instance, if a size 25/02 NiTi hand file is snug at length, the shape is done **(Fig. 13B)**; if this file is loose at length, it simply means the foramen is larger than 0.25 mm. As such, gauge the foramen with a size 30/02 NiTi hand file and, if this file is snug at length, the shape is done. If the size 30 hand file is loose at length, proceed to the *Medium*, or if necessary, the *Large* file, utilizing the finishing criteria concept just described.

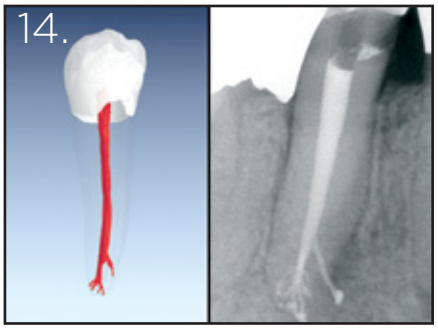
When preparing canals, clinicians should fully understand and appreciate the interrelationship between terminal diameter and apical one-third taper. Rather than over-preparing the foramen, emphasis should be on developing more apical



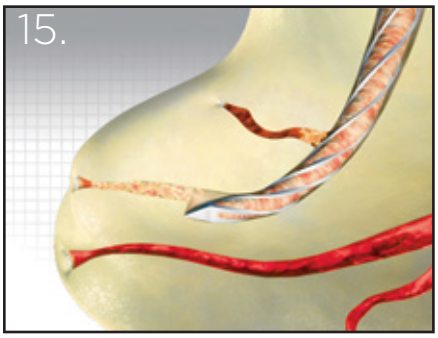
When the apical flutes of the Primary file are fully loaded with dentin, then this confirms this file has cut its shape and the "finishing criteria" is fulfilled.



This image shows an alternative "finishing criteria" gauging method. A 25/07 shape is confirmed when a size 25/02 NiTi file is snug at length.

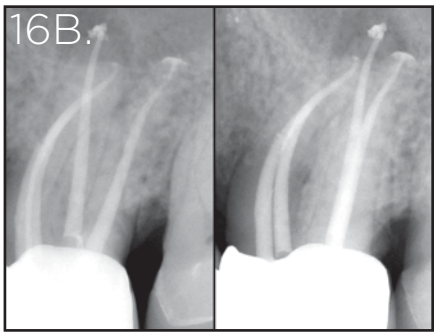


A μCT image of a mandibular bicuspid (Courtesy of Dr. Frank Paque; Zurich, Switzerland). A post-treatment image demonstrates similar anatomy.



This image demonstrates that an apically blocked and curved canal oftentimes predisposes to an apically ledged canal.

This post-op image demonstrates flowing, multi-planar shapes prepared with a single WaveOne Gold file (Courtesy of Dr. Wilhelm Pertot; Paris, France).



A post-op image demonstrates 4 smooth-flowing shapes prepared with one single WaveOne Gold file (Courtesy of Dr. Julian Webber; London, U.K.).

one-third taper, as deep shape promotes the exchange of irrigants, 3D cleaning, and filling root canal systems **(Fig. 14)**.[16-18] Much of endodontic iatrogenics could be eliminated if educators would stop insisting on needlessly grinding files with large tip diameters to the full working length **(Fig. 15)**. Clinically, the preparations produced by WaveOne Gold fulfill the mechanical objectives for shaping canals, and promote 3D disinfection and filling root canal systems **(Fig. 16)**.

Conclusion

The original WaveOne reminds me of the old expression, "Whatever you thought, think again." WaveOne Gold will completely change the reciprocation shaping experience, while still fulfilling the 3 sacred tenets for shaping canals: namely, safety, cutting efficiency, and simplicity. In recent years, this system has become a globally adopted method for shaping canals and has gained legitimate traction in dental schools, teaching hospitals, and in private practice. John Naisbitt, the author of the New York Times bestseller *Megatrends* and specialist in future studies said, "We must learn to balance the material wonders of technology with the spiritual demands of our human race." Emphasizing this balance, WaveOne Gold promises to take the shaping experience to profoundly greater heights. Catch this wave of the future! **OH**

Reprinted with permission. Originally published in *Dentistry Today,* January 2016.

References:

1. Ruddle CJ: Shaping complex canals: clinical strategy and technique, *Dent Today* 33:11, pp. 88-95, 2014.
2. Ruddle CJ: Focus on: endodontics, *Dent Today* 34:2, pg. 18, 2015.

3. Webber J, Machtou P, Pertot W, Kuttler S, Ruddle CJ, West JD: The WaveOne single-file reciprocating system, *Roots* 1:28-33, 2011.
4. Ruddle CJ: A retrospective report on WaveOne: observations of 1,200 prepared canals, *Endodontic Practice US* 5:4, pg. 56, 2012
5. Berutti E, Negro AR, Lendini M, Pasqualini D: Influence of manual preflaring and torque on the failure rate of ProTaper rotary instruments, *J Endod* 30:4, pp. 228-230, 2004.
6. Ruddle CJ: Endodontic canal preparation: WaveOne single-file technique, *Dent Today* 31:1, pp. 124, 126-129, 2012.
7. Yared, G: Canal preparation using only one NiTi rotary instrument: preliminary observations, *Int Endod J* 41:4, pp. 339-344, 2008.
8. Letters S, Smith AJ, McHugh S, Bagg J: A study of visual and blood contamination on reprocessed endodontic files from general dental practice, *Br Dent J* 199:8, pp. 522-525, 2005.
9. Dentsply Maillefer engineering and testing, Ballaigues, Switzerland, 2014.
10. Gambarini G, et al: Cyclic fatigue resistance of nickel-titanium rotary instruments used in reciprocating or continuous motion, *J Endod* 36:3, p. 563, 2010.
11. You SY, et al: Efficiency of reciprocating preparation in curved root canals, *J Endod* 36:3, p. 584, 2010.
12. De-Deus G, Brandao MC, Barino B, Di Giorgi K, Fedel RA, Luna AS: Assessment of apically extruded debris produced by the single-file ProTaper F2 technique under reciprocating movement, *Oral Surg Oral Med Oral Pathol Radiol Endod* 110:3, pp. 390-394, 2010.
13. Berutti E, Cantatore G, Castellucci A, Chiandussi G, Pera F, Migliaretti G, Pasqualini D: Use of nickel-titanium rotary PathFile to create the glide path: comparison with manual preflaring in simulated root canals, *J Endod* 35:3, pp. 408-412, 2009.
14. West JD: The endodontic glidepath: "secret to rotary safety," *Dent Today* 29:9, pp. 86, 88, 90-93, 2010.
15. Ruddle CJ: Gauging the terminus: a novel method, *Endodontic Practice US* 5:6, pg. 56, 2012.
16. Ruddle CJ: Endodontic disinfection: tsunami irrigation, *Endodontic Practice* 11:1, pp. 7-15, 2008.
17. Albrecht LJ, Baumgartner JC, Marshall JG: Evaluation of apical debris removal using various sizes and tapers of ProFile GT files, *J Endod* 30:6, pp. 425-428, 2004.
18. Schilder H: Filling root canals in three dimensions, *Dent Clin North Am* pp. 723-744, November 1967.

Dr. Clifford J. Ruddle is Founder and Director of Advanced Endodontics, an international educational source, in Santa Barbara, California. He is an Assistant Professor of Graduate Endodontics at Loma Linda University and University of California, Los Angeles, is an Associate Clinical Professor at University of California, San Francisco, and is an Adjunct Assistant Professor of Endodontics at University of the Pacific, School of Dentistry. As an inventor, Dr. Ruddle has designed and developed several instruments and devices that are widely used internationally. He is well known for providing endodontic education through his lectures, clinical articles, training manuals, videos, and DVDs. Additionally, he maintains a private practice in Santa Barbara, California. He can be reached at (800) 753-3636 or www.endoruddle.com.