

Shaping canals with confidence: WaveOne GOLD single-file reciprocating system

Julian Webber¹

¹ Dr Julian Webber has been a practising endodontist in London, England for over 35 years. He was the first UK dentist to receive a master's degree in endodontics from a university in the USA (Northwestern University, Chicago, IL) in 1978. He has lectured extensively and given many hands-on courses on endodontics worldwide. He has published in numerous peer-reviewed journals and contributed numerous chapters to endodontic texts.

Dr Webber is a former President of the British Endodontic Society and American Dental Society of London, a faculty member of the Pacific Endodontic Research Foundation in San Diego, CA, Honorary Professor at the University of Belgrade in Serbia, and an honorary member of the Ukrainian Medical and Stomatological Academy. He is a fellow of the International College of Dentists and an active member of the American Association of Endodontists. He is the editor-in-chief of *Endodontic Practice (UK)* and a board member of many prestigious dental journals.

(Images courtesy of Prof. Sergio Kuttler)

The mechanical and biological objectives of shaping root canals were beautifully described by Herbert Schilder in 1974.¹ As relevant today, in the era of automated canal preparation techniques, as they were in the days of hand preparation techniques, these objectives provide the rationale for the designs, tapers and tip sizes of modern-day endodontic instruments. Shaping the root canal facilitates 3-D irrigation and cleaning of the root canal system of all pulp tissue, bacteria and their related by-products.² Importantly, shaping the root canal provides the resistance form and facilitates filling the root canal system.^{1,3}

From hand to rotary

When manually shaping canals with multiple sequences of stainless-steel files and Gates–Glidden drills, root canal preparation techniques, old and new, have many deficiencies and iatrogenic problems, such as blocking, ledging, transportation and perforation, are common.⁴ The use of nickel-titanium (NiTi) files in continuous rotation driven by a dedicated endodontic motor capable of speed and torque control maintains the original pathway of the canal while limiting the amount of apically extruded debris.^{5,6} However, while the advantages of continuously rotating NiTi files are many, all commercially available file systems are influenced by cyclic fatigue and torque, especially in longer, narrower and more curved canals.

Cyclic fatigue, caused by the structural alteration and work hardening of the metal, is induced by repeated tensile–compressive stress, especially when preparing canals exhibiting curvature.⁷ Torsional failure caused by using too much apical force occurs more frequently than flexural fatigue.⁸ Specifically, taper lock results when an excessive length of a file's active portion binds in the canal during rotation. Undesirable taper lock promotes torsional failure and file breakage. When the canal diameter is narrower than the diameter of the rotating file, the latter has limited ability to progress deeper into the canal, binds and then potentially unwinds and/or breaks.⁹

From rotary to reciprocation

While the majority of commercially available NiTi systems are mechanically driven in continuous rotation, reciprocation—defined as any repetitive up and down or forward and reverse movement—has been used to drive endodontic instruments since 1958. Early attempts at reciprocation utilised alternating, but equal, forward and reverse angles of either 90 degrees or, more recently, smaller angles of 30 degrees. As such



Figure 1a: WaveOne GOLD file series, Small, Primary, Medium and Large.

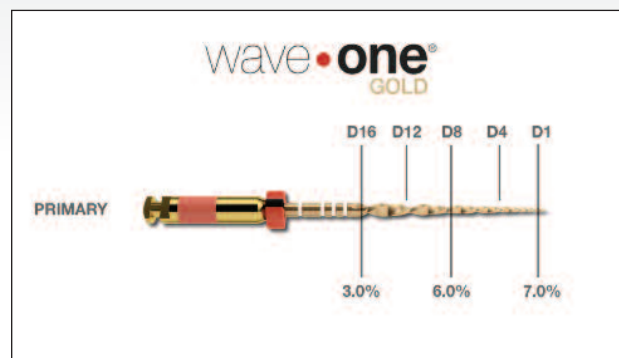


Figure 1b: WaveOne GOLD files have variable and reducing tapers, producing a more conservatively shaped canal compared with their WaveOne predecessor.

none of these instruments ever complete a full rotation. Although these reciprocating systems offer an alternative to manual preparation, multiplefile sequences, apical transportation, reduced cutting efficiency, inward pressure and limited debris removal remain issues.^{5,10} However, with a novel reciprocating movement of unequal bidirectional angles that complete a full forward rotation of 360 degrees after four 90-degree cutting cycles of reciprocation, just one single file can start and fully complete the preparation of a canal to a perfect shape.¹¹ A singlefile technique in conjunction with a novel reciprocating movement has been clearly shown to reduce both cyclic fatigue and torsional failure, preventing broken instruments.¹²

In 2008, the concept of the “single-file technique” was adopted by DENTSPLY International as a project in collaboration with eight international clinicians to produce a more optimal, dedicated, safe, unique reciprocating single file and to identify the most suitable unequal bidirectional angles with a motor system to generate this movement. The outcome was the launch of RECIPROC (VDW) in 2010 and WaveOne (Dentsply Maillefer) in 2011. Both systems were marketed as simple, efficient and predictable automated methods to shape canals and embraced by many general dental practitioners looking to move into automated canal shaping after years of unsuccessful attempts with manual techniques and valued both in terms of time and cost savings.

WaveOne and RECIPROC file systems (reciprocating files) demonstrate considerably improved mechanical properties, superior to rotary files. While the cyclic fatigue properties of RECIPROC are superior to WaveOne, the resistance to torsional failure of WaveOne is superior to RECIPROC.^{13,14} Overall, reciprocating files are more resistant to fracture than are continuously rotating files,¹⁵ extrude less debris than do conventional multiple-file rotary systems¹⁶ and eliminate



Figure 2: The cross-section of WaveOne GOLD is a parallelogram with an 85-degree active cutting edge with alternate one and two point contact.

bacteria from root canal systems as efficiently as rotary systems.¹⁷ The shaping ability of reciprocating files is as good as and in many cases better than rotary files.¹⁸ Finally, it can be clearly stated that reciprocating files do not induce dentine cracks.¹⁹

WaveOne and RECIPROC were designed as true single-use instruments that cannot be sterilised and re-used. The ISO colour-coded ABS ring on the handle expands if sterilised and the file will not fit into its handpiece. Single use is based on sound scientific facts and common sense, as elimination of repeated use decreases the possibility of fracture due to both fatigue and torsional failure.²⁰ The inability to consistently clean and sterilise used instruments eliminates any concerns about crosscontamination,²¹ and disposal after single-patient use eliminates the cost of disinfecting, cleaning and sterilising, reducing costs overall.²² However, it should be understood and fully appreciated that a single reciprocating file performs the same task that would typically

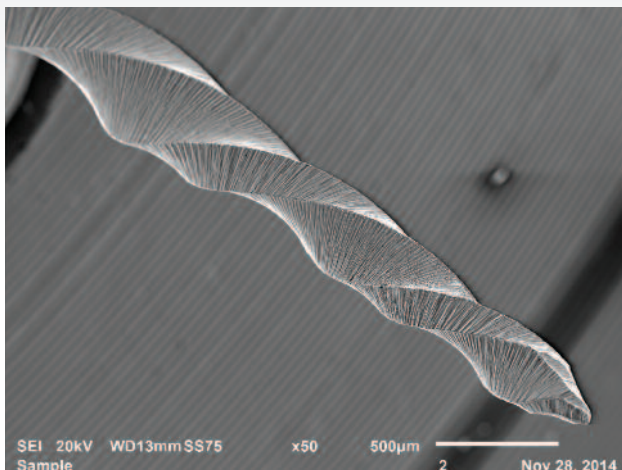


Figure 3a: WaveOne GOLD tip and profile.

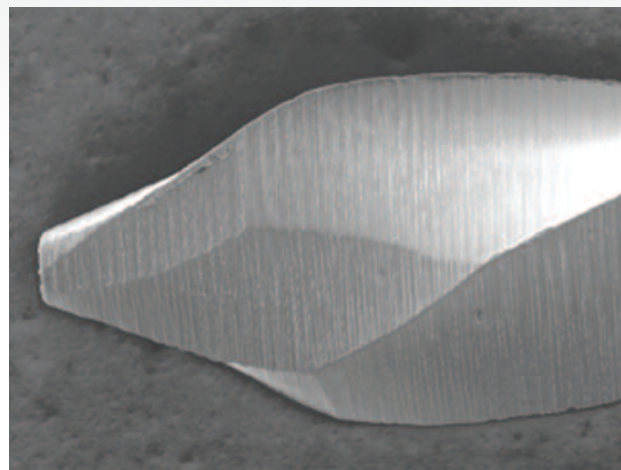


Figure 3b: WaveOne GOLD ogival tip design.

require three or more rotary NiTi files to accomplish. Logic dictates that single use is by far the best solution to reducing the incidence of file breakage with all its ethical, emotional and malpractice ramifications.

New developments

With today's increased focus on minimally invasive endodontics²³, the conclusions from the literature and taking into account feedback from clinicians using WaveOne since its introduction in 2011, four of the original opinion leaders involved in the initial development of the file, Drs Clifford Ruddle (US), Sergio Kuttler (US), Wilhelm Pertot (France) and Julian Webber (UK), worked in collaboration with the research and development team at DENTSPLY in Ballaigues, Switzerland, to further improve the cutting efficiency and

mechanical properties of the file and give a new level of confidence to the many clinicians still wary of automated techniques for shaping canals.

The result is the recent launch of WaveOne GOLD, a new generation of reciprocating files offering simplicity, safety and single use in shaping canals.

Advanced metallurgy

WaveOne GOLD instruments are manufactured utilising a new DENTSPLY proprietary thermal process, producing a super-elastic NiTi file. The gold process is a post-manufacturing procedure in which the ground NiTi files are heat-treated and slowly cooled. From a technical perspective, the heat treatment modifies the transformation temperatures (austenitic start and austenitic finish), and this has a positive



Figure 4: The WaveOne GOLD file engages 150 degrees CCW and 30 degrees CW, turning 360 degrees after three cycles of reciprocation.



Figure 5: The new X-Smart iQ motor operated by the DENTSPLY iOS app downloaded on to an iPad mini 2 is a full digital solution with a cordless Bluetooth 8:1 reducing handpiece.

effect on the instrument properties.^{24,25} While this process gives the file its distinctive gold finish, more importantly, it considerably improves its strength and flexibility far in excess of its predecessor. DENTSPLY internal testing has shown the following: the cyclic fatigue resistance of WaveOne GOLD Primary is 50% greater than that of WaveOne Primary (which itself was twice as great as most standard rotary file systems), and the flexibility of WaveOne GOLD Primary is 80% greater than that of WaveOne Primary.²⁶

Design features

There are four tip sizes in the WaveOne GOLD single-file reciprocating system: Small (20.07, yellow), Primary (25.07, red), Medium (35.06, green) and Large (45.05, white) (Fig. 1a), available in 21, 25 and 31mm lengths.

The various tip sizes and tapers afford the clinician the ability to clinically prepare a wider range of apical diameters and endodontic anatomy commonly encountered in daily practice.²⁷ Canal preparations that have sufficiently tapered resistance form are ideal for irrigant exchange and removal of debris,²⁸ thus promoting 3-D disinfection and filling of the root canal system.

WaveOne GOLD has active cutting lengths of 16mm, shortened 11mm handles for improved posterior access and the same expanding ISO colour-coded ABS ring as WaveOne, maintaining the philosophy of single use. Variable and reducing tapers ensure a more conservatively shaped canal with greater preservation of tooth structure at D16, the coronal extent of the preparation (Fig. 1b). While the concepts of “minimally invasive endodontics” lack documented and meaningful studies,²⁹ any shaping objective that removes less of the existing tooth structure while optimising efficient 3-D irrigation and obturation is a positive step in an effort to preserve the integrity of the natural tooth.

The cross-section of WaveOne GOLD is a parallelogram with two 85-degree cutting edges in contact with the canal wall, alternating with a patented DENTSPLY off-centred cross-section where only one cutting edge is in contact with the canal wall (Fig. 2). Decreasing the contact area between the file and the canal wall reduces binding (taper lock) and, in conjunction with a constant helical angle of 24 degrees along the active length of the instrument, ensures little or no screwing in. The additional space around the instrument also ensures additional space for improved debris removal. The tip of WaveOne GOLD (Figs. 3a & b) is ogival, roundly

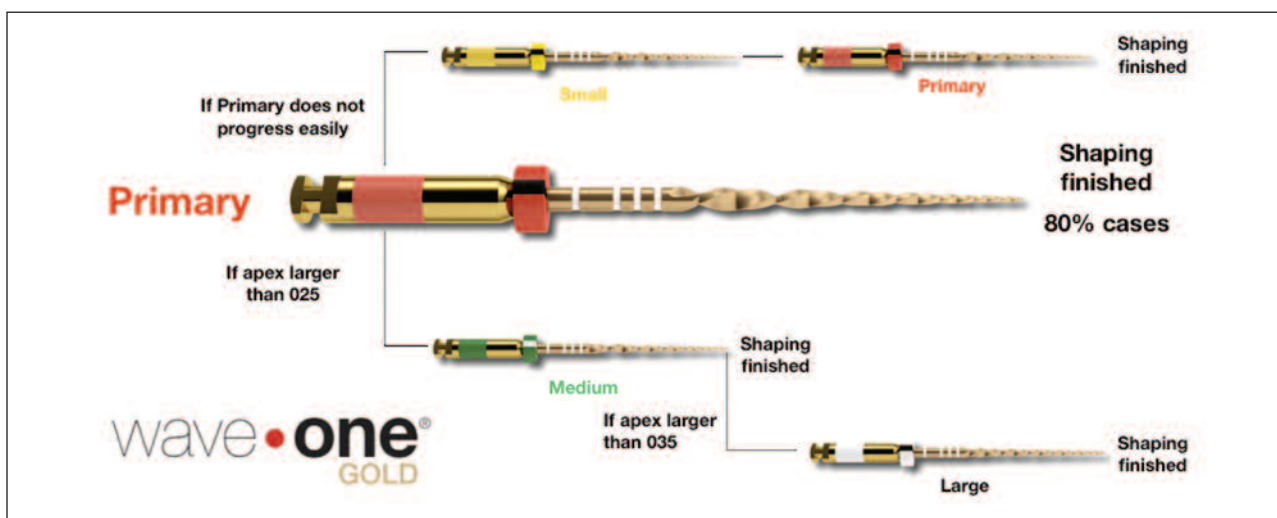


Figure 6: Summary of the WaveOne GOLD shaping technique: 80% of cases start and finish with the Primary file. At completion of shaping, gauging with hand files or inspecting flutes for debris confirms whether either the Medium or the Large file is needed.

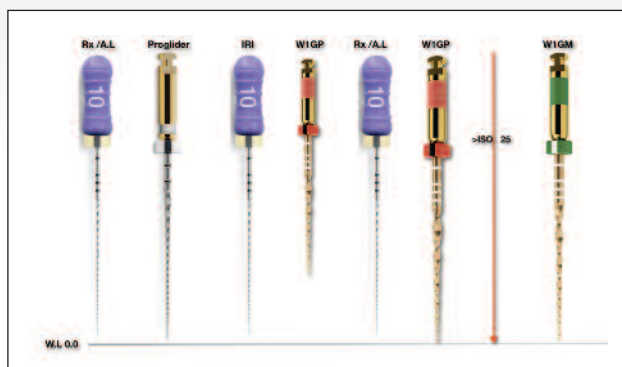


Figure 7a: WaveOne GOLD procedural flow chart where a #10 hand file is able to establish length: confirm patency and verify the glide path. ProGlider will expand any confirmed, verified and reproducible glide path prior to the shaping procedure with the Primary file. (Rx: radiograph; AL: apex locator; IRI: irrigate, recapitulate and irrigate again).

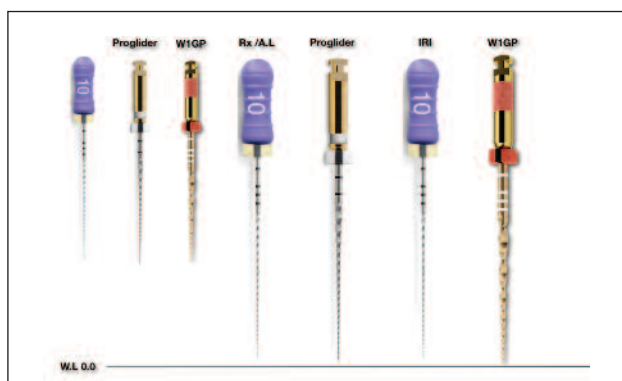


Figure 7b: WaveOne GOLD procedural flow chart for more restrictive canals: use a #10 hand file in any region of the canal to create a glide path. ProGlider will expand any confirmed, verified and reproducible glide path.

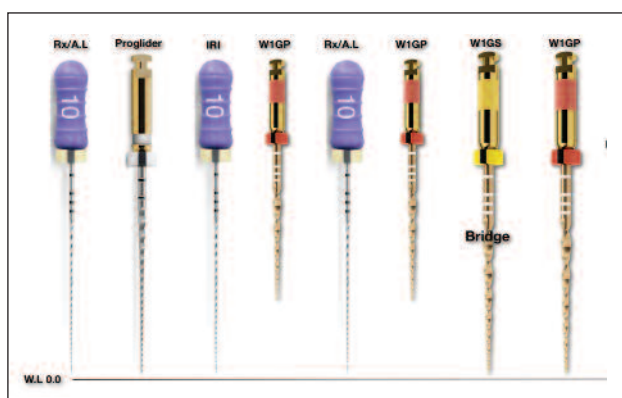


Figure 7c: WaveOne GOLD procedural flow chart when the Primary file does not progress: use the Small file in one or more passes to working length and then use the Primary file to working length to optimise the shape.

tapered and semi-active, modified to reduce the mass of the centre of the tip and improve its penetration into any secured canal with a confirmed, smooth and reproducible glide path.

Collectively, these design features result in a reciprocating movement that is very smooth, eliminating the need to push on the file, and thereby promoting safety and considerably improving cutting efficiency. This reduces shaping time by a further 19% in canals when compared with WaveOne.²⁶

Reciprocating movement

WaveOne GOLD files are designed with a reverse cutting helix, engage and cut dentine in a 150-degree counter-clockwise (CCW) direction and then, before the instrument has a chance to taper lock, disengages 30 degrees in a clockwise (CW) direction. The net file movement is a cutting cycle of 120 degrees and therefore after three cycles the file will have made a reverse rotation of 360 degrees (Fig. 4).

The X-Smart iQ (Fig. 5) launched in conjunction with WaveOne GOLD is an endodontic motor and cordless 8:1 handpiece designed for reciprocation and continuous motion. The handpiece is Bluetooth controlled by a DENTSPLY Apple iOS iQ app downloaded on to an iPad mini 2 (Apple). As a complete digital solution, it is designed for all stages of the endodontic procedure, including patient management, file selection, torque control training and patient education. The X-Smart iQ also offers electronic apex locator functionality. Currently available DENTSPLY reciprocating file motors and their respective handpieces, the X-Smart Plus motor (Rest of the World) and Pro-Mark and e3 Torque Control motors (North America), can be used without modification when using the complete range of WaveOne GOLD files. All reciprocating file motors are preprogrammed to produce the reverse bidirectional movement, but the CCW/CW angles, torque and speed settings cannot be altered. These motors can, of course, be used for continuous rotation when the clinician is able to adjust the speed and torque, as desired.

Shaping technique (Fig. 6)

The WaveOne GOLD Primary (025.07) is always used first to initiate the shaping procedure. It will create optimal shape in approximately 80% of canals as a true single-file technique and is used in canals that have a confirmed, smooth and reproducible glide path. An expanded glide path is a perfect set-up for the safe apical progression of any mechanically driven endodontic file.³⁰



Figure 8: A ProGlider progressing apically expands the glide path.



Figure 9: WaveOne GOLD Primary progressing apically through the expanded glide path.

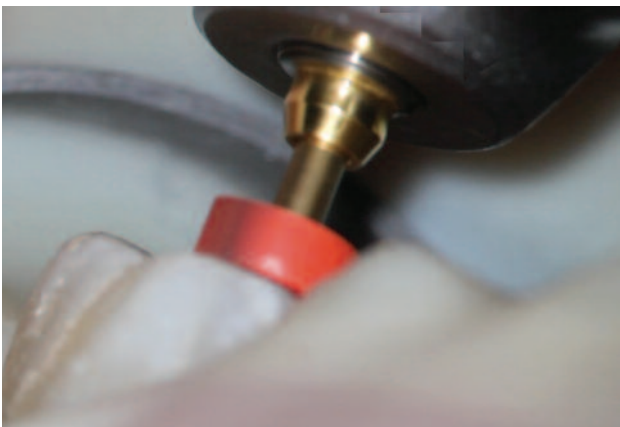


Figure 10: WaveOne GOLD Primary at full working length.



Figure 11: WaveOne GOLD Primary loaded with debris, especially in the apical extent of the file, indicating that full shape has been achieved.

The WaveOne GOLD Small (020.07) file should be thought of as a bridge file, as the resulting shape is considered too small to allow disinfection and filling of the root canal system. When the Primary file will not passively advance through the glide path, which has been verified to length, the Small file is used to transition and expand the shape. The Primary file is then re-utilised to reach the full working length. Although a two-file sequence is the exception, this method must be considered a safer and more efficient option compared with most other commercially available rotary shaping techniques.

After the Primary file reaches length, the flutes are inspected and if full of debris would indicate shaping is finished. If the Primary file is loose at length with no dentinal

debris on the apical flutes, shaping continues with WaveOne GOLD Medium and/or WaveOne GOLD Large until the apical flutes are loaded. Apical gauging with ISO #25 or 35 hand files, respectively, will also confirm whether the apical foramen diameter is larger and that a Medium or Large file is required.

WaveOne GOLD files are used in a brushing action to reduce resistance and more effectively instrument canals that exhibit irregular cross-sections. Brushing eliminates coronal interferences, creates lateral space, and promotes the inward advancement of the file. Further, a brushing action reduces the contact between the file and dentine, mitigates undesirable taper lock, and allows the instrument to run more freely. In order to avoid transportation, never brush at length.



Figure 12: WaveOne GOLD obturating solutions with matching paper points, gutta-percha points and Thermafil.

The files are used with a gentle inward 'stroking' motion of short 2–3mm amplitude, to passively advance the file along a smooth, reproducible glide path.

Reduced shaping time with WaveOne GOLD means there is more time available to focus on active irrigation methods. In order to enhance irrigation and improve effectiveness

Table 1: WaveOne GOLD tips.

- Always initiate shaping procedures with WaveOne GOLD Primary.
- Irrigate abundantly and frequently with sodium hypochlorite after removing any given WaveOne GOLD file from a canal.
- Remove the WaveOne GOLD file when it does not easily progress. Clean and inspect the cutting flutes for wear and/or distortion and then irrigate, recapitulate with a #10 hand file and re-irrigate.
- Owing to the unique WaveOne GOLD post-manufacturing process, the files may appear to be slightly curved. This is not a defect and it is not necessary to straighten the file before use. Place the tip of the file in the canal entrance and start the motor. The file will follow the glide path conforming to the natural curvature. The advantage is that a slightly curved file can be more easily placed into canals of posterior teeth where access is restricted.

activation with sonic and ultrasonic irrigation is now well accepted.³¹ Dynamic irrigation in the apical one-third of highly curved canals has been shown to significantly improve disinfection.³²

The stages of the shaping procedure can be summarised as follows (Figs. 7a–c):

- Establish straight-line coronal and radicular access with emphasis on flaring, flattening and finishing the internal axial walls.³²
- In the presence of a viscous chelator, use a #10 hand file to verify a glide path to length. In more restrictive canals, use a #10 hand file in any region of the canal to create a glide path.
- Expand this glide path to at least 0.15mm using either a manual or a dedicated mechanical file, such as the ProGlider or PathFile (DENTSPLY) (Fig. 8).
- Initiate the shaping procedure with the Primary file in the presence of sodium hypochlorite (Fig. 9).
- Use gentle inward pressure and let the Primary file passively progress through any region of the canal that has a confirmed glide path. After shaping 2–3mm of any given canal, remove and clean the Primary file, irrigate, recapitulate with a #10 hand file and re-irrigate.
- Continue with the Primary file, in two to three passes, to pre-enlarge the coronal two-thirds of the canal.
- In more restrictive canals, use a #10 hand file in the presence of a viscous chelator and negotiate to the

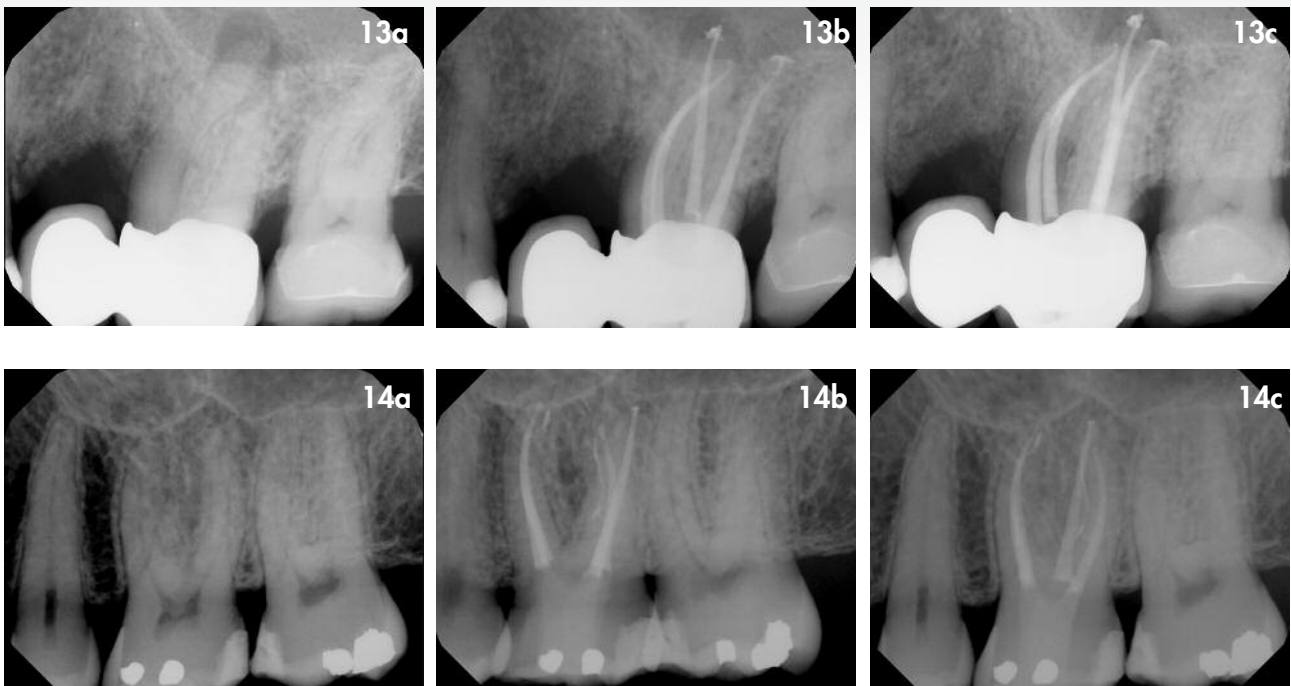


Figure 13a–c & 14a–c: The series of pre- and post-op radiographs of tooth #26 demonstrates the ability of WaveOne GOLD to shape considerable curvatures in canals that are long, curved and narrow, following the apical anatomy. All canals were obturated with WVC.



Figure 15a–c: The series of pre- and post-op radiographs of tooth #46 demonstrates the ability of WaveOne GOLD to shape considerable curvatures in canals that are long, curved and narrow, following the apical anatomy. All canals were obturated with WVC.

terminus of the canal. Gently work this file until it is completely loose at length.

- Establish working length, confirm patency and verify the glide path.
- Expand this glide path to at least 0.15mm using a manual or mechanical glide path file.
- Carry the Primary file to the full working length (Fig. 10) in one or more passes. Upon reaching working length,

remove the file to avoid over-enlarging the apical foramen. Inspect the apical flutes; if they are loaded with dental debris, then the shape is finished (Fig. 11).*

- If the Primary file does not progress, use the Small file (020.07 yellow) in one or more passes to working length and then use the Primary file to working length to optimise the shape.
- When the shape is confirmed, proceed with 3-D

disinfection protocols.

* If the Primary file is loose at length with no dentinal debris on the apical flutes, continue shaping with the Medium or Large file.

Obturation solutions

Obturation of the root canal system is the final step of the endodontic procedure. The WaveOne GOLD system includes matching paper points, guttapercha points and Thermafil obturators (Fig. 12). The new nanotechnology-engineered gutta-percha points with their extended heat flow are ideal for all warm vertical compaction (WVC) techniques (Figs. 13a–c, 14a–c & 15a–c). WaveOne GOLD shapes can also be effectively obturated with GuttaCore (DENTSPLY), the cross-linked gutta-percha core obturator.

Conclusion

WaveOne GOLD is a safe, efficient and simple system for preparing canals. Sophisticated metallurgy and design result in improved flexibility and cyclic fatigue life with less binding

and torsional stress on the file during work. The fear of instrument breakage should be eliminated for many clinicians by using WaveOne GOLD. Root canal preparation with WaveOne GOLD is very cost-effective, since 80% of cases can be completed with the single Primary instrument. Single use eliminates the need to spend valuable time and unnecessary expense in sterilising procedures, with further benefits in cost savings. Faster preparation time allows the clinician to focus on the most important aspect of clinical endodontics, disinfection, thus fulfilling the mechanical and biological objectives of shaping canals.

WaveOne GOLD has set a new standard and shaping canals with confidence is now a clinical reality for all.

Editorial note: The author has a commercial interest in WaveOne and WaveOne GOLD file systems.

A list of references is available from the publisher.

Reprinted with permission by Roots 1_2015