Republic of Iraq
Ministry Of Higher Education And Scientific Research
University Of Misan
College Of Dentistry

Wave one gold instrumentation system

A project Submitted to the Council of the Collage of Dentistry at the University of Misan, Department of Conservative in Partial Fulfillment of the Requirement for B.D.S degree

By
Fatima Adel Mahmoud Taher
Maryam Salim Mutashar Khalaf
Mortada Mahmoud Shaker Abboud

Supervised by

Dr. Saad Abdul-Baqi

SUPERVISOR CERTIFICATION

I certify that the preparation of this project entitled Wave one gold instrumentation system. Prepared by Fatima Adel Mahmoud , Maryam Salim Mutashar , Mortada Mahmoud Shaker . Was made under my supervision at Conservative Department in partial fulfillment of the Requirements for the Degree of Bachelor of Science in Dentistry.

Name (supervisor) : Dr. Saad Abdul-Baqi

Signature:
Date:

Dedication

To my parents

Those who encouraged me and gave me all love and confidence until I reached here.

TABLE OF CONTENTS

TABLE OF FIGURES

1.1 Introduction

In the last several years mechanical devices and techniques have been developed to further improve the effectiveness of the instrumentation process and facilitate root canal preparation. The most important advance is the modification to the heat treatment of the M-Wire to develop the new gold alloy [1]. The gold technology is achieved when the instrument is warmed and then cooled slowly once the file is made, unlike the M- Wire technology. This metallurgical treatment gives the characteristic golden appearance to gold instruments [1] and greater flexibility than the one achieved by nickel titanium (NiTi) and M-Wire instruments [2].

Recently, the system with a reciprocal movement of a WaveOne Gold® single file was launched . The system is available in four sizes: small (size 20, conicity 0.07), primary (size 25, conicity 0.07), medium (size 35, conicity 0.06) and large (size 45, conicity 0.05). Its noteworthy features include a cross-sectional shape in a parallelogram with two edges, an 85o cutting angle, which according to the manufacturer improves the cutting ability and elimination of residues [3] . In addition, the reciprocating movement through which it is activated alleviates stress on the instrument by using counter clockwise movements (cutting action) and clockwise movements (release of the instrument), extending its durability and increasing its resistance to cyclical fatigue compared to systems that use continuous rotation [4] .

The primary file (size 25 , taper 0.07) has been found to be effective in laboratory research [5,6] . However, one study reported less effectiveness during removal of gutta-percha and sealer and more fractured instruments when comparing WaveOne files to a specifically designed NiTi system [7] . Only one study assessed the ability of the thermally treated WaveOne Gold primary file (size 25 with a taper of .07

over the first apical millimeters) that is characterised with an offset parallelogram-shaped cross section and found the instrument to be safe for retreatment procedures [8] .

1.2 History

The mechanical and biological objectives of shaping root canals were beautifully described by Herbert Schilder in 1974. 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 byproducts. Importantly, shaping the root canal provides the resistance form and facilitates filling the root canal system [9] .

1.2.1 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. 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. 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.Torsional failure caused by using too much apical force

occurs more frequently than flexural fatigue. 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 breaks.

1.2.2 From rotary to reciprocation

While the majority of commercially available NiTi systems are mechanically driven in continuous rotation , reciprocation has been used to drive endodontic instruments since 1958.

reciprocating systems offer an alternative to manual preparation, multiple file sequences, apical transportation, reduced cutting efficiency, inward pressure and limited debris removal remain issues. 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. A single file technique in conjunction with a novel reciprocating movement has been clearly shown to reduce both cyclic fatigue and torsional failure, preventing broken instruments.

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.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. Overall, reciprocating files are more resistant to fracture than are continuously rotating files**,** extrude less debris than do conventional multiple-file rotary systems and eliminate bacteria from root canal systems as efficiently as rotary systems. The shaping ability of reciprocating files is as good as and in many cases better than rotary files.Finally, it can be clearly stated that reciprocating files do not induce dentine cracks.

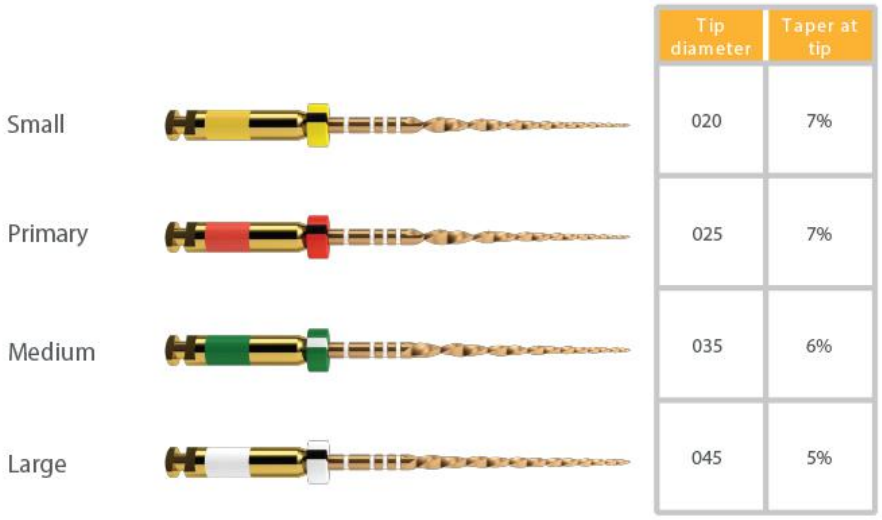
WaveOne and RECIPROC were designed as true single- use instruments that cannot be sterilized and re-used. The ISO colour-coded ABS ring on the handle expands if sterilised and the file will not fit into its handpiece.Single use is based on sound scientific facts and common sense, as elimination of repeated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

1.3 System & Design

Design

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. Canal preparations that have sufficiently tapered resistance form are ideal for irrigant exchange and removal of debris, 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, 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 crosssection 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 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. [9] .



	Tip diameter	Taper at tip
Small	020	7%
Primary	025	7%
Medium	035	6%
Large	045	5%

Figure 1 a 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

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

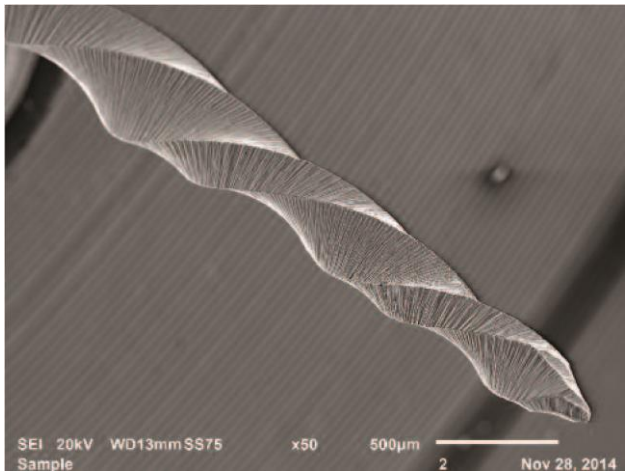


Figure 3 WaveOne GOLD tip and profile

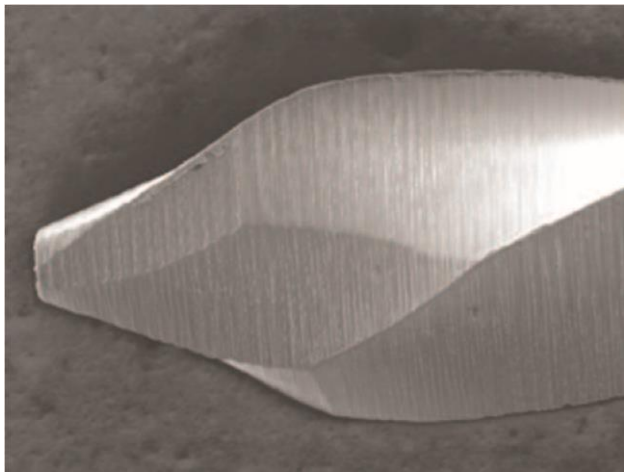


Figure 4 WaveOne GOLD tip design

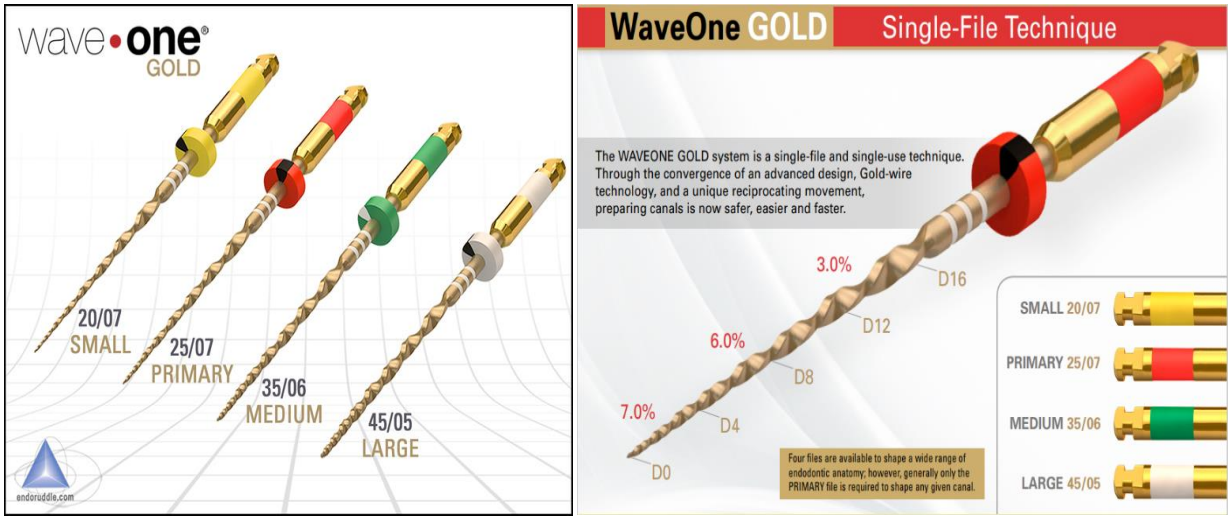


Figure 6 wave one taper design

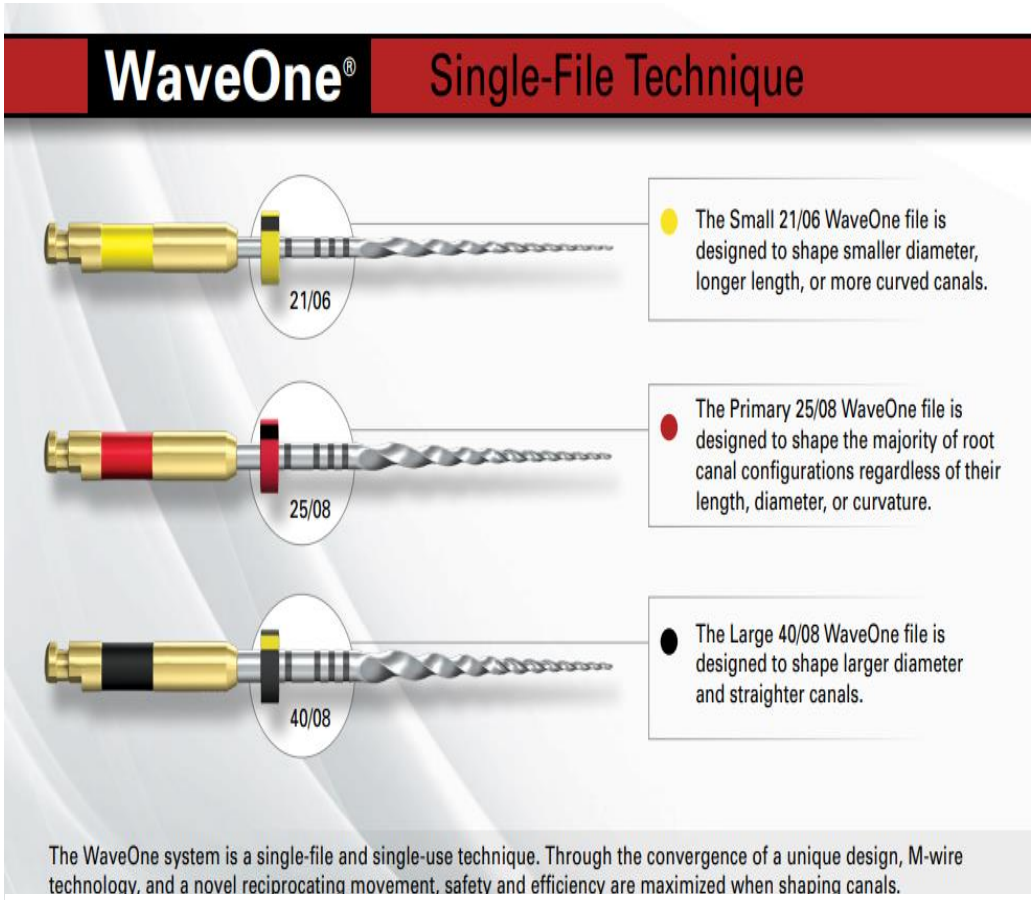


Figure 5 wave one system

1.4 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 Tulsa Dental Specialties and Dentsply Maillefer) (Figure 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.[10] 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%.[11] 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

Figure 7 ProGlider's progressively tapered design and M-Wire technology make GPM safer, easier, and faster…and importantly, more effective

1.5 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 glide path management (GPM) (Figure 8).[10] 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.[12] 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

smallersized 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 a smooth, reproducible glide path is verified (Figure 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 (Figure 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 (Figure 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 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 (Figure 9c) [10,12]

The Primary 25/07 WaveOne Gold file will generally reach the full working length in about 3 passes (Figure 12). 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, 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 (Figure 13a). Another method to determine the size of the foramen is to use a gauging technique.[13] In this instance, if a size 25/02 NiTi hand file is snug at length, the shape is done (Figure 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 one-third taper, as deep shape promotes the exchange of irrigants, 3D cleaning, and filling root canal systems ((Figure 14).[14-15] 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 (Figure 15). Clinically, the preparations produced by WaveOne Gold fulfill the mechanical objectives for shaping canals, and promote 3D disinfection and filling root canal systems (Figure 16).

Figure 8 This image depicts a mandibular bicuspid with complex endodontic anatomy.

Figure 9 a. Working length is established when a size 10 file has manually reproduced the original canal pathway to the terminus

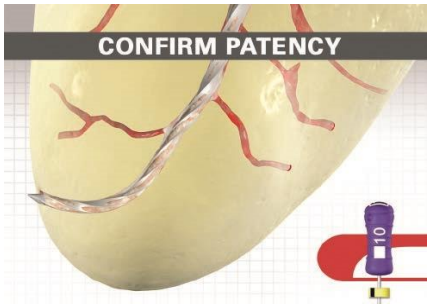


Figure 9b. Patency is confirmed when a 10 file can be gently, deliberately, and reproducibly inserted to and minutely through the terminus of a canal

Figure 9c. 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

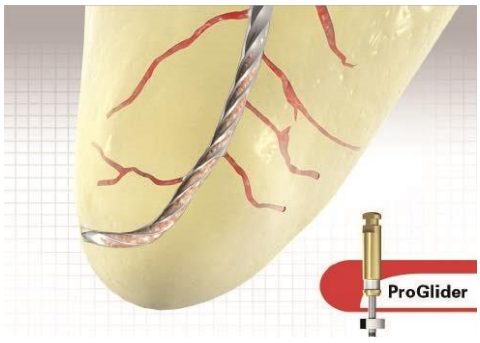


Figure 10 A mechanically-driven and metallurgically enhanced ProGlider is utilized to safely and rapidly pre-shape virtually any manually secured can

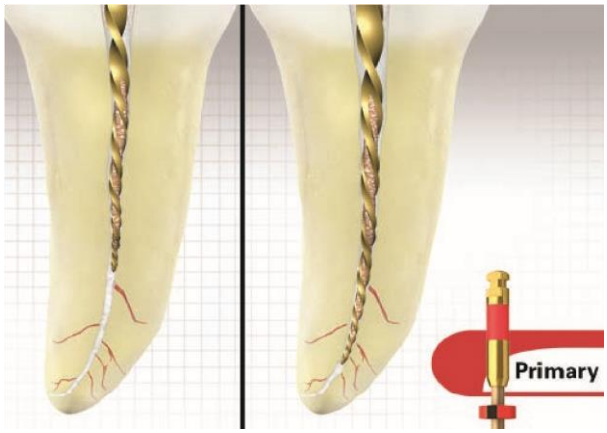


Figure 11. These 2 graphic images show the Primary 25/07 WaveOne Gold file following the glide path and progressively shaping toward length

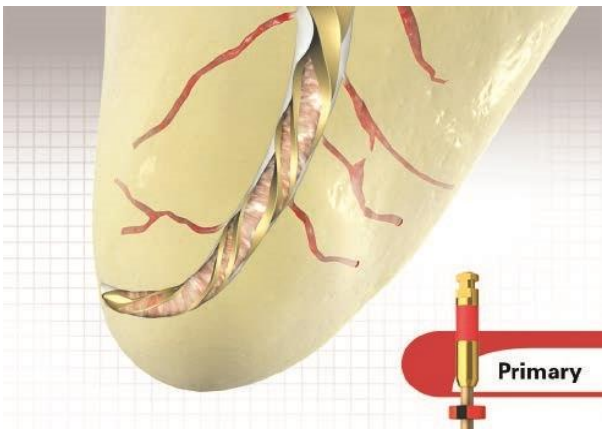
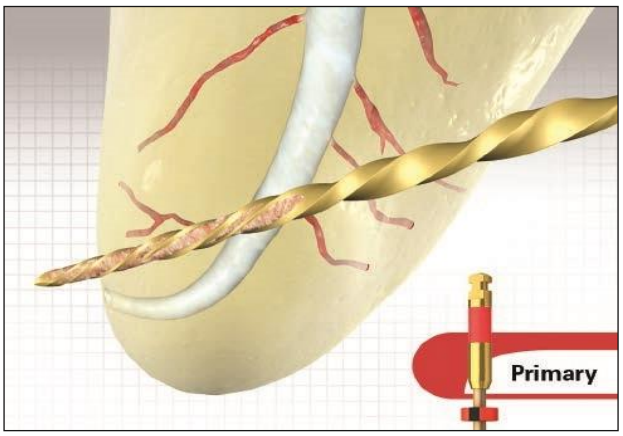


Figure 12. This graphic image shows the Primary 25/07 WaveOne Gold file has cut its shape around curvature, is at length, and its apical flutes loaded



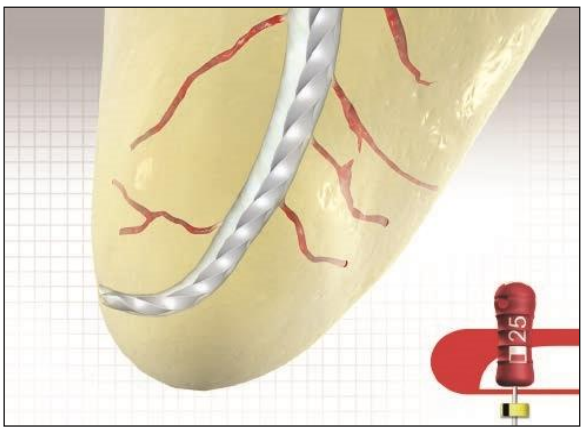


Figure 13 a.(left) When the apical flutes of the Primary file are fully loaded with dentin, then this confirms this file has cut its shape and the "finishing criteria" is fulfilled

Figure 13b.(right)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.

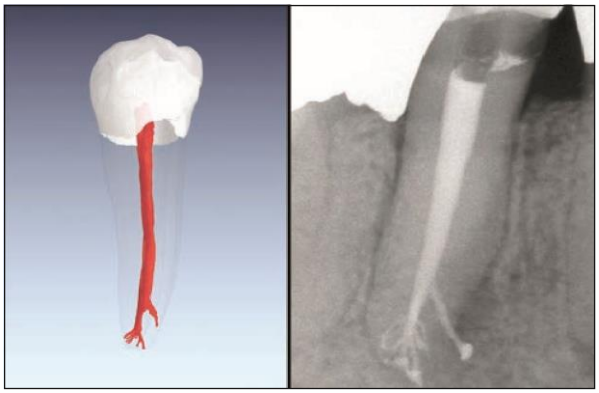


Figure 14. A µCT image of a mandibular bicuspid (Courtesy of Dr. Frank Paque; Zurich, Switzerland). A post-treatment image demonstrates similar anatomy

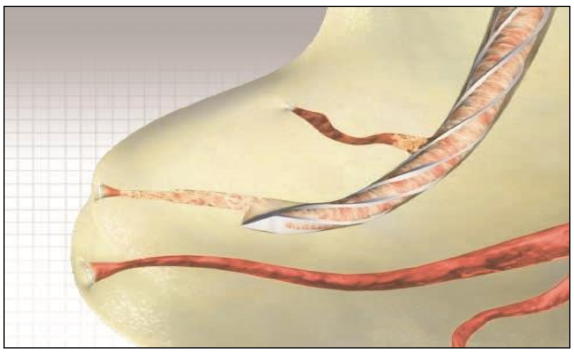


Figure 15 This image demonstrates that an apically blocked and curved canal oftentimes predisposes to an apically ledged canal.

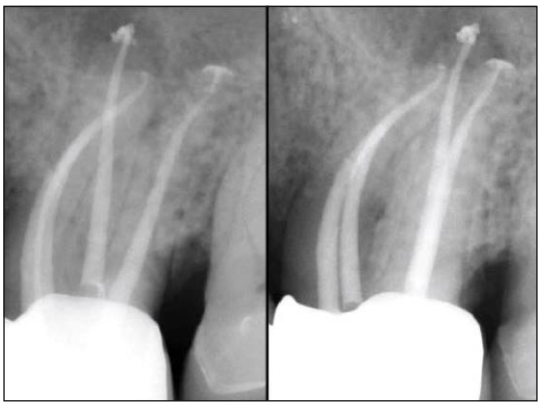


Figure 16 a(left). This post-op image demonstrates flowing, multi-planar shapes prepared with a single WaveOne Gold file (Courtesy of Dr. Wilhelm Pertot; Paris, France)

Figure 16b(right). A post-op image demonstrates 4 smooth-flowing shapes prepared with one single WaveOne Gold file (Courtesy of Dr. Julian Webber;

1.6 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).[17,18] 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.[19] 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.[20]

1.6.1 Reciprocating movement

The counterclockwise (CCW) movement of 150 degrees is capable of advancing the instrument apically as the dentin on the root canal wall is engaged and cut. This movement is followed by a 30-degree clockwise (CW) movement, which ensures that the instrument disengages before excessive torsional stress is transferred onto

the metal alloy and before the instrument can bind (taper lock) into the root canal. Three sequential reciprocating cycles will complete one whole reverse CCW rotation, and the repeated cutting and release process allows the instrument to advance apically into the root canal.

This unequal CW/CCW reciprocating motion of the WaveOne Gold system has the following advantages over continuous rotation systems:

- Binding of the instruments into the root canal dentin walls is less frequent, reducing torsional stress (Varela-Patiño, et al., 2008).
- The reduction of the number of cycles within the root canal during preparation results in less flexural stress on the instrument (Sattapan, Palamara, Messer, 2000).
- Improved safety, as the CCW disengaging angle is designed to be less than the elastic limit of the instrument (Ruddle, 2016).
- There is decreased risk of instrument fracture (Yared, 2008; Varela-Patiño, et al., 2008).
- It allows the file to easily progress toward working length without using potentially dangerous inward pressure (Yared, 2008; Ruddle, 2016).
- It enhances the augering of cutting debris out of the canal during canal preparation (Ruddle, 2016; De-Deus, et al., 2010).

Reciprocating movement as a repeated backward and forward (clockwise/counter-clockwise) movement, has been extensively used in endodontics for many years and can be applied to many endodontic files.

There are many variations of RM, including:

1.6.1.1.1 Complete reciprocation-Horizontal:

There is no completion of any rotations and also no vertical movements .This type of reciprocation can be defined as complete oscillating reciprocation, similar to the classic watch-winding movement used with manual SS files .

1.6.1.1.2 Complete reciprocation with vertical oscillations:

Reciprocating handpieces, vertical stroke handpieces were introduced. The range of the stroke was inversely related to opposition during instrumentation . If a forward motion (i.e., toward the apex) was not possible (it would stop in the canal), a 90 degree horizontal rotational RM would substitute the vertical stroke.

1.6.1.1.3 Partial reciprocation:

Complete rotations completed, dependent on dissimilar angles of reciprocation.

1.6.1.1.4 Hybrid reciprocation :

that can interrupt continuous rotation (CR) (600° CW cutting motion) with 50° CCW movement depending on whether undue torsional stresses are detected. The innovative automatically adapts to instrumentation stress. Studies have reported higher fatigue resistance than Reciprocating files.

Hybrid reciprocation can be fixed or flexible — i.e., it can shift from one type of reciprocation to the other in the canal based on mechanical resistance and torque.

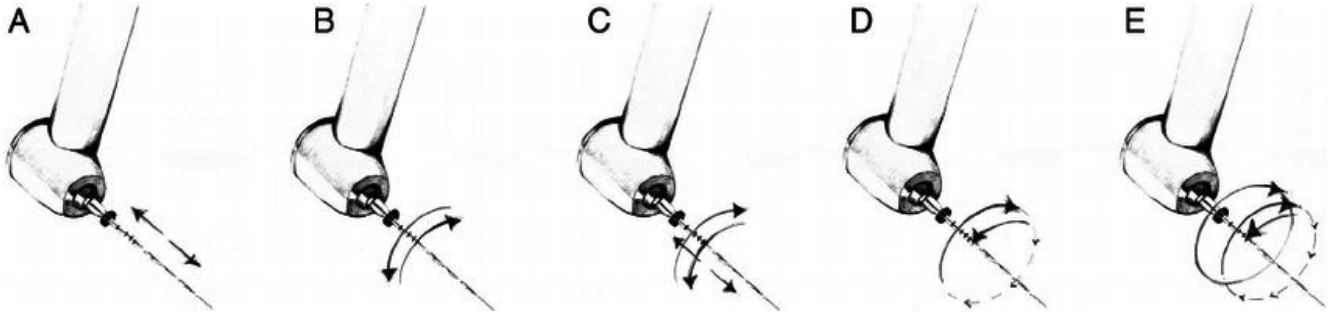


Figure 17 Different types of RM for endodontic instrumentation: (A) complete reciprocation with vertical oscillations m (B) complete reciprocation with horizontal rotational . (C) complete reciprocation with combined oscillations , (D) partial reciprocatio

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. The X-Smart iQ (Fig. 17) 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.[21]

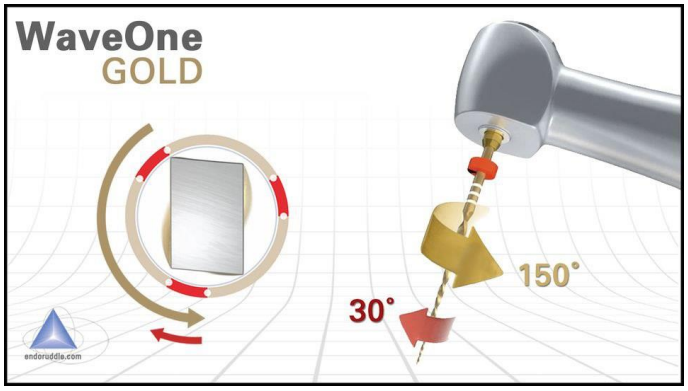


Figure 19 The WaveOne Gold files utilize unequal bidirectional angles to improve inward movement, cutting efficiency, and hauling debris out of the canal.

Figure 18 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

1.7 Controversy of single-file systems

Currently, controversy exists regarding the tendency of reciprocating single-file systems to extrude debris into the periapical tissues. While one study found that the use of reciprocating single file systems was associated with greater amounts of apically extruded debris, other investigations reported contradictory results. However, concerning the tendency of rotary single-file systems to extrude debris apically, the available data indicate that these systems caused less debris extrusion than the reciprocating single-file systems. Although the currently available data are limited, the use of rotary single-file systems does not appear to be associated with an increased risk of debris extrusion. On the other hand, the impact of reciprocating canal preparation with particular single-file systems is currently

debatable. In this context, a recent meta-analysis study showed a trend that the use of reciprocating single-file systems was associated with greater amounts of extruded debris compared to full-sequence systems. The reciprocating movement could have favored apical packing of debris and dentin, that might result in transportation of this debris beyond the apical foramen. However, the cross-sectional design of the instruments was found to be the most relevant parameter that affected debris extrusion. Instruments having greater cross-sectional areas extruded more debris apically and caused greater expression of neuropeptides (substance P and CGRP) than instruments having an S-shaped cross-sectional design. Clearly, a sufficient chip space is a crucial design feature of root canal instruments that seems to have a direct impact on the amount of apically extruded material. Finally, this meta-analysis showed that the number of instruments used has an impact on apical debris extrusion, although current evidence supporting this conclusion is very limited. The results of this meta-analysis are at least partially supported by the findings of two clinical studies Gambarini et al.262 assessed post-treatment pain after root canal treatment using three different engine-driven instruments: the reciprocating single-file system WaveOne, Twisted Files instruments (Kerr/SybronEndo, Orange, CA, U.S.A.). A statistically significant difference was found between WaveOne and the two other instruments. Following canal preparation with WaveOne, about 26.6% of patients experienced severe pain. None of the patients of the Twisted File group and only about 6.6% of the Twisted File adaptive group reported pain. In a randomized clinical trial, root canals of 42 patients were prepared using the full-sequence rotary ProTaper systems and the reciprocating WaveOne instrument (both from Dentsply/ Maillefer). Treatments were performed in two appointment and postoperative pain was assessed using a numerical rating scale (NRS) score. Duration of pain and analgesic consumption were also evaluated. After both appointments, the NRS scores and the duration of

pain were significantly higher in the WaveOne group. After the first appointment the analgesic consumption was significantly higher in this group as well. The authors explained these findings by the fact that the single-file WaveOne instrument may create a “piston effect” inside the root canal thereby extruding more debris apically than the instruments used in a continuous clockwise rotation.

In summary it can be concluded that

• Currently, the use of any types of instrument or preparation technique is associated with some debris extrusion.

• Full-sequence rotary NiTi instruments seem to extrude less debris than hand instruments.

• Full rotary single-file systems seem to extrude less debris than reciprocating single-file systems.

• Reciprocating single-file systems seem to extrude more debris than rotary full-sequence systems. [22]

Figure 20 Debris extruded beyond the apical foramen during root canal preparation.

1.8 Obturation

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. 21) . The new nanotechnologyengineered gutta-percha points with their extended heat flow are ideal for all warm vertical compaction (WVC) techniques . WaveOne GOLD shapes can also be effectively obturated with GuttaCore (DENTSPLY), the cross-linked gutta-percha core obturator.

Figure 21 WaveOne GOLD obturating solutions with matching paper points, gutta-percha points and Thermafil

RESOURCES:

1. Hieawy A, Haapasalo M, Zhou H, Wang ZJ, Shen Y.Phase transformation behavior and resistance to bending and cyclic fatigue of ProTaper Gold and ProTaper Universal instruments. J Endod 2015; 41: 1134-1148.
2. Elnaghy AM, Elsaka SE. Effect of sodium hypochlorite and saline on cyclic fatigue resistance of WaveOne Gold and Reciproc reciprocating instruments. Int Endod J 2017;50: 991-998.
3. Dentsply S. WaveOne Gold Brochure. Available at: https://www.dentsply.com/content/dam/dentsply/pim/manufacturer/Endodontics/Obturation/Obturators/Size_Verifiers/WaveOne_Gold_Size_Verifiers/W1GBrochure-EN-jb8mf2z-en-1508.pdf.
4. Plotino G, Grande NM, Testarelli L, Gambarini G. Cyclic fatigue of Reciproc and WaveOne reciprocating instruments. Int Endod J 2012; 45: 614-618.
5. Fruchi, L.C., Ordinola-Zapata, R., Cavenago, B.C., et al. (2014). Efficacy of reciprocating instruments for removing filling material in curved canals obturated with a single-cone technique: A micro-computed tomographic analysis. J Endod 40 (7): 1000-1004
6. Silva, E.J., Orlowsky, N.B., Herrera, D.R., et al. (2015). Effectiveness of rotatory and reciprocating movements in root canal filling material removal. Braz Oral Res 29: 1-6.
7. Jorgensen, B., Williamson, A., Chu, R., et al. (2017). The efficacy of the WaveOne reciprocating file system versus the ProTaper retreatment system in endodontic retreatment of two different obturating techniques. J Endod 43 (6): 1011-1013.

8. Ugur, A.Z., Keskin, N.B., and Ozyurek, T. (2019). Effect of Reciproc blue, XP-endo shaper, and WaveOne gold instruments on dental microcrack formation: A micro-computed tomographic evaluation. Microsc Res Tech 82(6):856-860.
9. Dr Julian Webber (2015). Shaping canals with confidence: WaveOne GOLD single-file reciprocating system INTERNATIONAL DENTISTRY – AFRICAN EDITION VOL. 6, NO. 3
10. Ruddle CJ: Shaping complex canals: clinical strategy and technique, Dent Today 33:11, pp. 88-95, 2014.\
11. 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 pre flaring in simulated root canals, J Endod 35:3, pp. 408-412, 2009
12. West JD: The endodontic glidepath: "secret to rotary safety," Dent Today 29:9, pp. 86, 88, 90-93, 2010.
13.. Ruddle CJ: Gauging the terminus: a novel method, Endodontic Practice US 5:6, pg. 56, 2012
14. Ruddle CJ: Endodontic disinfection: tsunami irrigation, Endodontic Practice 11:1, pp. 7-15, 2008.
15. 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.
16. Schilder H: Filling root canals in three dimensions, Dent Clin North Am pp. 723-744, November 1967
17. 1. Ruddle CJ: Shaping complex canals: clinical strategy and technique, Dent Today 33:11, pp. 88-95, 2014.

18. 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.

19. Ruddle CJ: Endodontic canal preparation: WaveOne single-file technique, Dent Today 31:1, pp. 124, 126-129, 2012.

20. Yared, G: Canal preparation using only one NiTi rotary instrument: preliminary observations, Int Endod J 41:4, pp. 339-344,2008

21. Webber J, Machtou P, Pertot W, Kuttler S, Ruddle CJ, West JD: The WaveOne single-file reciprocating system, Roots 1:28-33, 2011.

22. Ilan Rotstein, John I. Ingle **Ingle's Endodontics** [7th Edition] PMPH USA 2019 p607-608