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Root canal preparation with reciprocating instruments - A literature review and clinical application

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INTRODUCTION

It is well described that the presence of microbial flora in the pulp space of the tooth, and the inability of the immune system to remove these pathogens, are the major sources of peri-apical and radicular inflammation.[1] Eradication of these pathogens from the pulp and root canal space by means of cleaning, shaping, disinfecting and complete obturation is necessary to safeguard the health of the periodontal tissues from endodontic infection and subsequent breakdown.[2,3]

The basic objectives of cleaning and shaping of root canals include: (1) removal of all infected soft and hard tissues; (2) creating space for delivery of disinfectants and medicaments to the apical part of the canal; (3) facilitating three dimensional obturation and (4) preservation of radicular structures.[4]

Even modern endodontic file systems leave untouched areas on the root canal walls after preparation and show compaction of hard tissue debris.[5] This debris consists of pulp tissue remnants, bacteria and dentine chips of which most is found in the apical part of the prepared root canal system.[6] Aiming for a centred preparation that corresponds to the original canal anatomy accompanied by the lowest amount of canal transportation, especially in middle and apical parts of curved canals, will result in the most favourable post instrumented canal shape. The four optimal canal shaping objectives are: (1) to have a tapered funnel from orifice to apex, (2) maintenance of original anatomical canal pathway, (3) apical foramen position should remain constant and (4) leaving the apical opening as small as possible.[2,7]

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Importance of attaining and maintaining apical patency

Negotiating the canal to the apical terminus is the first significant step in setting up a glide path. Typically utilizing a very thin K-File and passing it through the apical extent of the root canal for 1 mm, will achieve patency.[8] This assists in accurate electronic measurement of the root canal length.[9] A strong tendency for debris to be compacted at the apex of the canal can lead to: apical blockage of the canal, loss of working length, risk of extruding bacterial infused debris into periodontium, preventing natural flow of enlarging instruments along the canal - predisposing to apical ledging and incomplete disinfection of the apical portion of the canal.[10,11]

Regular recapitulation of the canal during preparation with a thin K-File (size 08 or 10), maintaining patency throughout, drastically improves disinfection of the apical portion of the canal.[10,12]

Glide path preparation

Glide path is defined as a smooth reproducible pathway from the canal orifice to the apical portal of exit.[13] This will allow any shaping file system to easily pass along this route. As a rule no rotary or reciprocating system ought to be used before the canal has been negotiated and a reproducible glide path has been established by hand files.[14,15]

Many procedural errors can be reduced by preparing a proper glide path.[16] Pre-flaring of the coronal part of the canal will reduce instrument torque while preparing the apical portion, thereby reducing the risk of instrument fracture.[17] Torsional stresses on shaping instruments may also be reduced after effective glide path establishment.[18]

Occurrence of canal transportation, ledging and perforations are reduced, with improved centered preparations and more favourable amounts of dentine removal.[19] Initial preparation of a glide path shows quicker preparation times and lower fatigue fracture risk of reciprocating instruments.[20,21] Glide path preparation can be done with stainless steel K-Files, either by hand or in a reciprocating hand piece. Alternatively, newer rotary or reciprocating NiTi systems can be used in dedicated endodontic motors.[16]

This "glide path" will guide the non-cutting tips of the rotary/reciprocating NiTi files to working length.[16] It is recommended that the glide path size should be one size larger than the tip size of the first shaping file to be introduced.[17]

Glide path preparation using reciprocation

1. Reciprocation with hand stainless steel K-Files

Utilizing a stainless steel (SS) hand file inserted into a dedicated reciprocating hand piece can reduce fatigue and operating times with lower risk of instrument failure compared to NiTi rotary glide path files.[22]

Ti-Max Ti35L (NSK, Kanuma, Japan) and the M4 Safety Reciprocating Hand Piece (SybronEndo, Orange, CA, USA) (Figure 1) are some of the hand pieces that are available with 90° and 30° reciprocation angles respectively.[23] However, loss of physical perception on the file increases the risk of iatrogenic errors with this technique.[16,24]

Excess dentine removal, apical transportation and debris extrusions are reported with the use of larger files (greater than size 15), undue apical forces during canal instrumentation and over preparation of canals.[22,25]

Figure 1. M4 Safety Reciprocating Hand Piece (SybronEndo).

2. Dedicated reciprocation glide path systems

The three systems mentioned below all cut in a counter clockwise (CCW) direction and operate with a 150° CCW and 30° clockwise (CW) angle of rotation.[23]

a). WaveOne Gold Glider (Dentsply Sirona, Ballaigues, Switzerland) (Figure 2)

The WaveOne Gold Glider was introduced into the market in 2017. Utilizing proprietary post-manufacturing thermal treatments that modifies the transition between austenite and martensite to produce a distinctive gold coloured alloy (Gold Wire) that exhibits superior flexibility and cyclic fatigue resistance compared to M-Wire and conventional NiTi alloys.[26,27]

It is a single file system that has an ISO 15 tip size that is variable tapered from 2% at D0 to 6% at D16. Designed with a parallelogram shaped cross section and a semi-active tip.

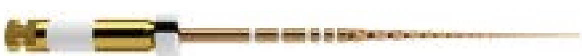

Figure 2. WaveOne Gold Glider (Dentsply Sirona).

b). EdgeOne Fire GlidePath (EdgeEndo Albuquerque, New Mexico, USA) (Figure 3)

EdgeOne Fire GlidePath file is also a single file system to be used in reciprocation motion. Made from the same trademarked "FireWire" as EdgeGlide Path files, they are also designed similarly to the WaveOne Gold Glider with a parallelogram cross-section but with an ISO tip size of 19. The file is recommended for use prior to final shaping with the EdgeOne Fire shaping system.[28]

According to the manufacturer, FireWire NiTi yields performance-enhancing durability providing flexibility of up to 90° curves and will expedite endodontic treatment.[29]

Figure 3. EdgeOne Fire GlidePath (EdgeEndo).

c). One File G Reciprocating Glide Path File (Pac-Dent, Brea, CA, USA) (Figure 4)

One File G Reciprocating Files are reciprocating endodontic files manufactured from heat-treated NiTi. The One File G Reciprocating Glide Path file has an ISO 15 tip with a 2% taper. The file has a square-shaped cross section and is used prior to shaping with the One File G Reciprocating Shaping System (Pac-Dent).[30]

Figure 4. One File G Reciprocating Glide Path File (Pac-Dent).

d). R-Pilot (VDW, Munich, Germany) (Figure 5)

The R-Pilot instrument is a glide path instrument manufactured from M-Wire and is used in reciprocating motion to prepare the root canal system before the shaping with a rotary or a reciprocating instrument. The R-Pilot instrument has a constant taper of 4%, an ISO tip size of 12,5 and an S-shaped cross section. It is a single-use instrument designed for use in no more than one molar.

The R-Pilot instrument can be used only in a reciprocating motion with a designated drive system using that uses the original Reciproc (VDW) settings. Failure to do so, according to the manufacturers can lead to instrument fracture and misuse. The instrument is not recommended for use in canals with abrupt apical curvatures in the apical region.

Figure 5. R-Pilot (VDW).

Rotation vs. reciprocation for root canal preparation

Introduction of NiTi endodontic instrumentation, paved the way for many machine assisted rotary systems to be developed which allowed for more efficient root canal preparation.[31,32] Recently, asymmetrical rotary systems have been added: Revo-S (MicroMega, Besancon, France), ProTaper Next and TruNatomy (Dentsply Sirona) as well as systems with variable cross section designs like OneShape (MicroMega).

ProTaper Next is made from M-Wire and has a off-centre rectangular cross section that moves in an asymmetrical fashion.[33] This "swaggering" action in the canal leaves more space to auger debris coronally and lowers apical debris extrusion with higher cutting efficiency and less dentine crack formation compared to conventional rotary systems.[34-36] Less dentine engagement due to fewer contact points at any given time, lowers generated forces on the root canal walls and might attribute to higher fracture resistance of the instrument.[37]

The new TruNatomy system features slimmer files with a unique off-centered cross sectional design. Designers claim that the files are three times more flexible than ProTaper Next, due to post-grinding thermal treatments, that operates at higher speeds of 500 rpm. As a single-file system, they also allow for more conservative, minimal invasive canal preparation, without straight-line ccess to the canal.[38,39]

Even though NiTi reciprocating instrumentation has only recently been introduced, reciprocating motion with SS files has been utilized widely in the progress of mechanical root canal preparation systems.[40] Early hand pieces like Giromatic (MicroMega) from the 1960's with 90° reciprocation, prepared canals comparable to the manual technique,[41] but the risk of iatrogenic errors increased.[42,43]

Many of these drawbacks was attributed to the mechanical rigidity of SS instruments.[44] Modern trends advocate the use of SS files in reciprocation hand pieces only with initial canal negotiation and glide path management. The M4 Safety hand piece (SybronEndo) features a chuck that engages a normal hand file to assist with this.[22]

Yared[47] (2008) first introduced single-file NiTi reciprocation. He experimented with a F2 ProTaper Universal (Dentsply Sirona) rotary file in a 16:1 reduction contra-angle motor that allows for reciprocation. Set at 4/10ths of a circle CW followed by 2/10ths CCW the instrument would require five cycles to complete a full 360° rotation.

In this way he completed single file shaping of a root canal (after traditional canal negotiation and glide path preparation). A technique that lowered cost, used less instruments, eliminated cross-contamination, and lead to faster treatments.[45-47] This also improved safety whereby the instrument is not exceeding its elastic limits and causes less instrument fatigue.[48] Reciprocation seems to employ the "balanced-forced" concept advocated by Roane.[49]

Different types of reciprocatory movements include:[40]

i. Vertical (in-out) only reciprocation like Racer (Cardex, Austria) and Self-Adjusting file (ReDent Nova, Israel).[50]
ii. Complete reciprocation - horizontal. With no completion of any rotations and no vertical movements. Giromatic (MicroMega), M4 Safety hand piece (SybronEndo).[22]
iii. Complete reciprocation with vertical oscillations. Canal-Finder (Fa. Societe Endo Technique, Marseille, France) introduced by Lévy.[51]
iv. Partial reciprocation. Complete rotations completed, dependent on unequal angles of reciprocation. WaveOne Gold (Dentsply Sirona) and Edge One Fire (EdgeEndo).
v. Hybrid reciprocation. TF Adaptive System (SybronEndo) that can interrupt continuous rotation (CR) (600° CW cutting motion) with 50° CCW movement if undue torsional stresses is detected.[52]

The majority of endodontic treatments can now be completed utilizing only a single-file, even in teeth with multiple canals (post glide path preparation).

Cyclic fatigue and torsional resistance

The biggest drawback of using a rotary instrument in a root canal is the high incidence of file fractures.[53] CR could be one of the main contributing factors.[31] As previously mentioned these files are subject to cyclic fatigue and torsional forces.[54-56]

Reciprocation, firstly reduces the number of rotations the file makes in a curved canal, reducing the amount of bending (compression and tension) forces it subjected to, lowering the risk of cyclic fatigue fracture.[57] Secondly it reduces the amount of torsional forces placed on the instrument by counter rotating the file before the metal reaches its elastic limit while binding into the dentine, thereby decreasing the risk of torsional fracture.[47,58]

The metal's elastic limit of each individual system dictate the cutting speed and angle of reciprocation. As an example Reciproc (VDW, Munich, Germany) uses 150°/30° at 300 rpm and WaveOne (Dentsply Sirona) with M-Wire uses 170°/50° at 350 rpm.[59]

CR system files show a higher risk of instrument fracture when compared to systems utilizing reciprocation.[60,61] De-Deus confirmed in 2010 the extended lifespan and reduced cyclic fatigue of the ProTaper Universal F2 file (used by Yared[47] in 2008) in reciprocation movement compared to CR.[62]

Kim et al.[59] compared two reciprocating file systems to the ProTaper Universal F2 file in CR and found them to have improved mechanical properties with increased fatigue and torsional resistance. Greater torsional and cyclic fatigue resistance with reciprocation is confirmed in a number of other studies.[63-65]

Importantly, many other factors influence the cyclic fatigue and torsional resistance of these instruments. Metallurgic properties differ between Reciproc (VDW) M-Wire and heat treated Reciproc Blue, rendering the M-Wire counterpart more torque resistant.[66] WaveOne Gold Primary (Gold Wire) (Dentsply Sirona) exhibited greater cyclic fatigue than the M-Wire counterparts Reciproc R25 and WaveOne primary.[67] WaveOne Gold also shows higher torsional resistance and flexibility compared to Reciproc (VDW) and Twisted File (Axis/ Sybron Endo).[68]

A higher angle of reciprocation (increasing the angle of progression for every reciprocating cycle) is directly associated with reduced cyclic fatigue resistance.[62]

Cross sectional design features like diameter and shape also seems to play a role, but some studies suggest otherwise.[69-71] Hülsmann et al.[72] recently concluded in a critical appraisal on cyclic fatigue, that there are extensive differences in both static and dynamic tests. These studies are difficult to compare and some cases contradictory.

Dynamic fatigue testing is closer to clinical situations and usually show higher resistance figures. Seeing that temperature plays a significant role in study outcomes, many room temperature studies are however rendered inaccurate. All taken into account, including the move to new single-use instruments, cyclic fatigue should not be a major factor in clinical situations any more.

Maintaining original canal anatomy

The interaction of three main instrument factors can have an effect on the preservation of the original canal anatomy: the cross section design of the file, kinematics and the alloy of the NiTi instrument.[53] Although still controversial, the establishment of a glide path prior to final shaping does show to better maintain original anatomy.[19,23]

The effectiveness of the shaping system can be evaluated by assessing the centering ability and the amount of canal transportation, both mid root and apically.[19] WaveOne Gold (Gold-Wire, in reciprocation) combined with the ProGlider (M-Wire in CR) (Dentsply Sirona) showed the best canal shaping ability with most conservative removal of dentine, when compared to M-Wire instruments, ProTaper Next and OneShape (MicroMega) in CR.[73]

Early comparisons of reciprocating and CR instruments by You et al.[74] showed no increased transportation values, even in the apical portion of curved canals. Paqué et al.[75] revealed similar results, with no statistical difference in shaping outcomes between single file ProTaper Universal F2 and full sequence CR ProFile instruments (Dentsply Sirona).

Franco et al.[76] concluded with better centered preparations on simulated canals using reciprocation. Canal modifications were reduced with WaveOne primary reciprocating file compared to the ProTaper Universal system.[77]

On the other hand a study by Saleh et al.[78] showed better anatomy preservation and less dentine removal by OneShape (CR) than the WaveOne or Reciproc systems in S-shaped canals.[78]

Newer studies on WaveOne Gold compared to OneShape showed no statistical significance at any level for canal transportation and centering ratio.[79] Bürklein et al.[80] concluded that Gold and Blue heat treated files were not associated with an improved shaping ability. Reciprocation has been shown to adequately shape and preserve the anatomy of root canals, although no system is yet able to completely prepare all the dentine, eliminate all micro-organisms or remove all obturation material from the root canal system.[53]

Debris removal

Cleaning effectiveness is accessed by the histological evaluation of the amount of debris compaction or remaining smear layer in the root canal after instrumentation.[81,82] Usually inaccessible area's like isthmus, fins and the apical third are more prone to impaction of debris.[83] Although some studies indicate more debris accumulation with reciprocating technique,[84] compared to multiple consecutive CR files, overall cleaning effectiveness has been shown to be equal or comparable[81,85] and, in some, better[86] than traditional rotary systems.

It has been suggested that file design is more responsible for effective cleaning than the kinematics of a system.[86]

Apical debris extrusion

As already discussed, apical extrusion of debris can cause negative outcomes and post-operative flair ups.[87] De Deus et al.[88] reported positive results, showing no difference in debris extrusion between the original ProTaper Universal F2 in reciprocation and full sequence ProTaper Universal rotary systems.

Unfortunately many conflicting results exist in the literature, and may well be clarified by the difference in study designs,[53] and other physiological factors like the absence of periodontal tissue back pressure in *ex vivo* studies.[89] Bürklein et al.[46] described higher extrusion of debris from WaveOne and especially Reciproc compared to full rotary systems ProTaper Universal and Mtwo (VDW). This was backed up by two other studies.[90,91] Opposing results demonstrating lower amounts of extrusions created by reciprocating movements compared to other systems is also present.[92-94] Some studies even show no difference between the two.[95]

A recent systematic review on the incidence of postoperative pain (usually the main symptom of apical extrusions) after root canal treatment with either reciprocating or rotary systems, concluded that rotary systems showed a negative impact on postoperative pain, and even more so after 48 hours.[96]

Independent of the system used, apical debris extrusions is possible by incorporating additional irrigation protocols to conventional procedures. These include passive ultrasonic irrigation and negative pressure irrigation systems which will reduce apical extrusions.[97,98]

Reduction of intracanal bacteria

Reducing the bacterial load inside the root canal remains the cornerstone for a successful endodontic treatment outcome.[1] Mechanical disruption of the bio-film is required to adequately remove and destroy the micro-organisms.[99]

Reduction of the bacterial load were found to be similar in both reciprocating and rotary systems. Studies by Machado et al.[100], Nabeshima et al.[101] and a systematic review by Siddique and Nivedhitha[102] confirmed these findings.

Dentinal cracks

It is well described that endodontic treatment can have a negative impact on root dentine.[103] Most shaping systems will in some way cause defects or micro cracks in the root dentine, which could further extend and lead to complete root fractures or endodontic failure due to bacterial invasion.[104,105]

An initial pilot study on cadavers could not show a relationship between different shaping techniques and the incidence of micro cracks.[106] Further investigations ultimately showed a clear relationship between both reciprocating and rotary systems predisposing to higher incidences of dentinal defects.[107,108]

One study showed that reciprocating files, Reciproc and Self-Adjusting File (ReDent-Nova, Israel) actually cause less cracks than the rotary ProTaper Universal and One-Shape files.[109] Another by Deus et al.[110] observed no association between these cracks and shaping with Reciproc, WaveOne and BioRaCe (FKG Dentaire) systems.

Ultimately it seems that reciprocating files could be more favourable, with lower incidence of dentinal defects and cracks.[53]

Efficiency and shaping times

Having faster treatment times, allow for shorter and more economical treatments. Additionally it allows more time for important irrigation protocols.[53] Some evidence suggest that shaping times are reduced with single-file reciprocation systems, compared to full rotary systems,[45,75,86] while some show no significant difference.[111]

Reciprocating root canal shaping systems

After glide path enlargement, final shaping of the root canal can be completed. As mentioned before, Yared[47] was the first to propose that reciprocating single-file systems are safe, cost effective and efficient.[45,47,48]

Reciprocating instruments has been shown to cause less transportation with better centered preparations compared to continuous rotary systems, keeping in mind that other factors like design features and metallurgic properties of the instrument could attribute to these results.[77,112]

Unequal CCW movement and CW movements ensures that elastic limit of instrument is not exceeded, more effective coronal advancement of debris and better progression with less apical pressure is promoted compared to equal CCW/CW movements.[113]

Although no instrumentation system can render the canal free of bacteria, reciprocation systems seem to perform equally to rotary systems in reducing bacterial load in the canal.[114]

All these systems advocate single-use with already pointed out benefits.[47] Three reciprocating shaping file system analogues, operated by the same endodontic motor with identical settings will be reflected upon.

a). WaveOne Gold (Dentsply Sirona)

WaveOne Gold is a reciprocating root canal shaping system with a unique alternating offset parallelogram-shaped cross-section design with two 85° cutting edges that reportedly limits the engagement between the file and dentine to only one or two points of contact at any given cross-section. This reduces taper-lock and the screw-effect, improves safety, increases cutting efficiency, and provides more chip space to auger debris coronally.[67,68,80,115]

WaveOne Gold is manufactured from Gold-Wire, a new super-metal that is said to render this system 80% more flexible, 50% more resistant to cyclic fatigue, and 23% more efficient than its predecessor, WaveOne (Dentsply Sirona), manufactured from M-Wire.[113,116] WaveOne Gold cuts in a CCW direction in reciprocating angle of 150° with a 30° CW disengaging angle at 300 rpm.[117]

In a CBCT study comparing the shaping ability of 2Shape (MicroMega), WaveOne Gold, and ProTaper Gold, WaveOne Gold preparations resulted in better maintenance of original canal anatomy and removed less excess dentine than its rotary multiple file counterpart ProTaper Gold, made from the same heat treated Gold wire.[118]

Differences of nanoscale surface profiles, after preparing four curved root canals, between WaveOne, WaveOne Gold, Reciproc and Reciproc Blue instruments were described by AlRahabi and Atta.[119] This study revealed WaveOne and WaveOne Gold as having the highest level of surface distortion, possibly due to different manufacturing processes. Feghali et al.[120] showed by means of scanning electron microscopy that WaveOne Gold file produced less debris and smear layer in the apical third of root canals compared its Reciproc Blue counterpart.

While evaluating structural and torsional properties of WaveOne and WaveOne Gold files, Paula Ribeiro et al.[115] showed that WaveOne files exhibit higher torsional resistance than WaveOne Gold, probably due to geometric and metallurgic differences. While WaveOne Gold has higher angular deflection values due to the superior flexibility of Gold wire properties.

In a comparative study to evaluate the appearance of dentinal defects in root canal walls after machine driven instrumentation with WaveOne Gold and ProTaper Universal systems, the WaveOne Gold group showed less dentinal cracks (up to 30%) in the apical and coronal thirds compared to the ProTaper system.[121]

In a 2017 study by Asiye et al.[122] they evaluated the amount of apical extrusions post root canal preparation and found that WaveOne Gold and Twisted File Adaptive (TFA, SybronEndo) produced less apical extrusions than the ProTaper Next system. The study further indicated reduced shaping times for TFA and WaveOne Gold compared to ProTaper Next.

In another 2018 study, comparing canal shaping ability of the Primary WaveOne Gold instrument - preceded by different glide path techniques. No difference in canal transportation values, or canal centering ability was noted after canal preparation, irrespective of preceding glide path and system used, or no glide path at all.[123]

The system is available in four files with different tip sizes (**Figures 6-9**) and come in 21mm, 25mm, and 31mm lengths. These tips are ogival, roundly tapered (pointed arch) shape that is semi-active that is able to better follow the secured glide path. A variable and reducing taper design from D1 to D16 will result in a more conservatively shaped canal.

- Primary (Red) – ISO 25 tip 7% Taper (D1-D3) – Used in 80% of cases from Orifice to Apex (Figure 6).

Figure 6. WaveOne Gold Primary File (25/07).

- Small (Yellow) - ISO 20 tip 7% Taper (D1-D3) - Used as bridging file when Primary file does not seem to progress passively (**Figure 7**).

Figure 7. WaveOne Gold Small File (20/07).

- Medium (Green) ISO 35 tip 6% Taper (D1-D3) - When Primary did not cut sufficient dentine or the apex is larger than ISO size 25 (**Figure 8**).

Figure 8. WaveOne Gold Medium File (35/06).

- Large (White) ISO 45 tip 5% Taper (D1-D3) - When the apex is larger than ISO 35 and not sufficient cutting was done with Medium file (**Figure 9**).[117]

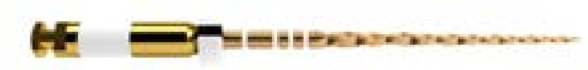

Figure 9. WaveOne Gold Large File (45/05).

Distinctively these files exhibit less memory effect than M-Wire or conventional NiTi and is super elastic. This allows for a certain amount of pre-curving of the instrument before canal penetration (and it will retain its shape) and naturally follows the canal shape better.[116]

b). EdgeOne Fire (EdgeEndo) Shaping Files

EdgeEndo is one of the largest suppliers of endodontic NiTi file systems.[124] EdgeOne Fire is a reciprocating shaping system manufactured from trademarked FireWire and is available in 21mm, 25mm, and 31mm lengths with Primary (Red) - ISO 25 tip 6% Taper (D1-D3), Small (Yellow) - ISO 20 tip 6% Taper (D1-D3), Medium (Green) ISO 35 tip 4.5% Taper (D1-D3) and Large (White) ISO 45 tip 3% Taper (D1-D3) (**Figure 10**).

These files are to be used in the same way as WaveOne Gold, with similar reciprocating angles and 300rpm.[125] This familiar sequence, according to EdgeEndo, will ensure the switch to EdgeOne Fire will be seamless.[28]

The manufacturers claim that the heat-treated FireWire NiTi construction of EdgeOne Fire tests at five times the cyclic fatigue resistance compared to WaveOne Gold-Wire,[28] Gambarini et al.[125] tested the cyclic fatigue resistance at two times in a severe 90° canal. The manufacturer claims that EdgeEndo files can be used in place of competitors like WaveOne Gold, at half the cost.

EdgeOne Fire has a similar cross-sectional design, three dimensional characteristics and tip sizes as the WaveOne Gold system.[125] FireWire exhibits the same metallurgic CME, showing no "bounce-back" to retain apical anatomy.[126]

After testing cyclic fatigue by number of cycles to fracture of three different NiTi rotary files at different temperatures, EdgeFile out performed Vortex Blue (Dentsply Sirona) and ESX (Brasseler, USA), at all tested temperatures. While all systems showed a decrease in resistance with rising temperatures.[127]

Figure 10. EdgeOne Fire (EdgeEndo), Small (Yellow 20/06), Primary (Red 25/06), Medium (Green 35/045) and Large (White 45/03) .

c). One File G Reciprocating Shaping File (Pac-Dent)

One File G Reciprocating Shaping Files (Pac-Dent) is a system that shapes canals in a reciprocating motion and is compatible with the same motor, hand piece, and settings as WaveOne Gold instruments.

According to the manufacturer, One File G Reciprocating Shaping Files are made using proprietary heat-treated NiTi Wire, which increase its cyclic fatigue resistance and imparts a unique shape memory to the files.

Figure 11. One File G Reciprocating Shaping File (Pac-Dent), (Yellow) (ISO 20/07), Primary (Red) (ISO 25/07), Medium (Green) (ISO 35/06), and Large (White) (ISO 45/05).

The file has a parallelogram cross section, and recommended for use after the One File G Glide Path File. They are available in the same sizes, lengths and tapers as the other two systems: Small (Yellow) ISO 20 tip 7% Taper, Primary (Red) ISO 25 tip 7% Taper, Medium (Green) ISO 35 tip 6% Taper, and Large (White) ISO 45 tip 5% Taper (Figure 11).[30]

d). Reciproc Blue (VDW)

Reciproc Blue (Fig. 12), based on its predecessor Reciproc, was recently launched by VDW (Munich, Germany). Blue NiTi is a newly developed alloy that is obtained through a proprietary-specific oxide surface layer thermo- mechanical manufacturing process.

Like M-Wire and Gold, Blue NiTi is thermally treated NiTi designed to improve the mechanical properties of endodontic instruments such as fatigue resistance, flexibility, cutting efficiency, and canal centering ability.[128,129]

Thermal treatment modifications, in addition to the reciprocating motion, have already been shown to extend the life span of a NiTi instrument and its resistance to fatigue in comparison with continuous rotation movement.[130,131]

Reciproc Blue has an S-shaped cross-section and is available in sizes 25 (with a taper of 8%), 40 (with a taper of 6%) and 50 with a taper of 5% (Figure 12).

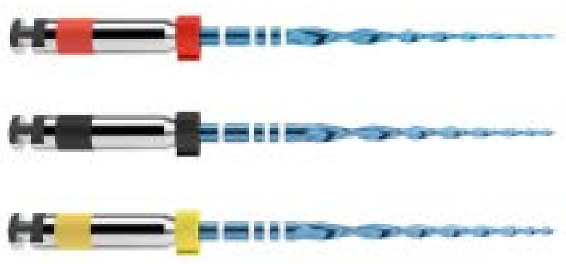

Figure 12. Reciproc Blue (VDW)– 25 (red), 40 (black) and 50 (yellow).

Instruments are used in an unequal forward and reverse reciprocating cutting motion at 10 cycles of reciprocation per second. Manufacturer recommend cutting in amplitudes of no more than 3-4 mm per cutting cycle with an in- and out movement.[132]

A recent study compared the bending resistance and cyclic fatigue of conventional Reciproc files to Reciproc Blue.[133] The study concluded that the Blue thermally treated NiTi files showed overall improved performan-

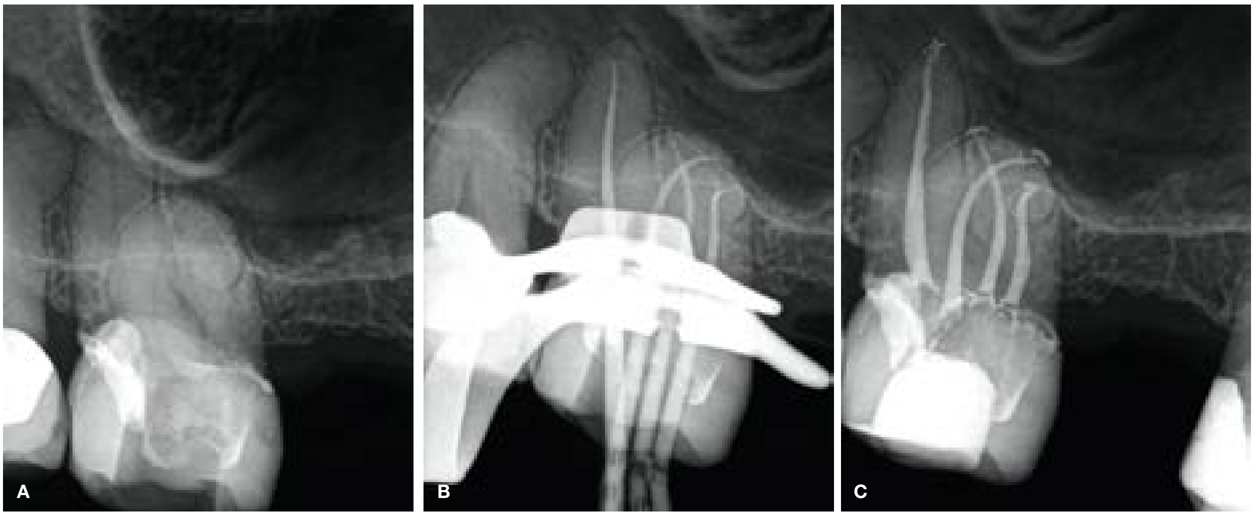

Figure 13. (A) Preoperative periapical radiograph revealed very narrow and calcified root canal systems. (B) Cone-fit radiograph to confirm the fit of the four size 20/07 gutta-percha points; (C) Final result after root canal obturation.

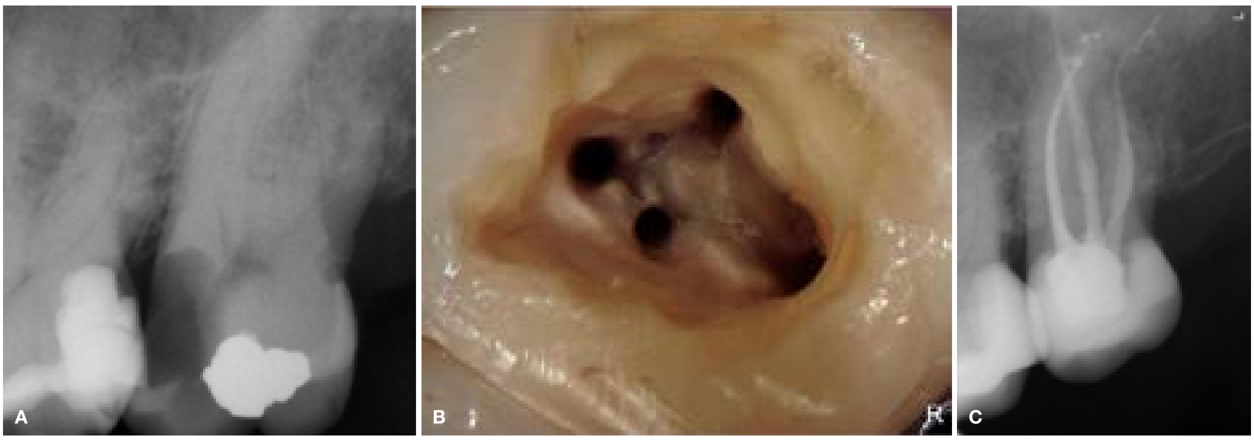

Figure 14. (A) Preoperative periapical radiograph of the left maxillary second molar. (B) Magnified view of the pulp chamber showing the four root canal systems that were located. (C) Final result after root canal obturation.

ces when they were compared to conventional M-Wire super-elastic NiTi. Reciproc Blue demonstrated improved flexibility, fatigue resistance and reduced microhardness while at the same maintaining similar characteristics of the surface.

CASE REPORT 1

The patient, a 62 year old female presented with a history of an unsuccessful attempted emergency root canal treatment on her maxillary right first molar. A preoperative periapical radiograph (Figure 13A) and CBCT scan revealed very narrow and calcified root canal systems.

After canal location and negotiation with size 08 K-Files and C+ Files, the glide paths were enlarged using a WaveOne Gold Glider (Dentsply Sirona). The four root canals systems were prepared with the Small WaveOne Gold (20/07) (Dentsply Sirona) instrument.

Figure 13B illustrates the cone-fit radiograph to confirm the fit of the four size 20/07 gutta-percha points. The final result after root canal obturation is shown in Figure 13C.

CASE REPORT 2

The patient, a 58 year old male presented with irreversible pulpitis as a result of extensive decay on the mesial aspect of his left maxillary second molar. After caries removal the pulp was exposed and four root canal systems were detected.

After glide path enlargement with the EdgeOne Fire GlidePath (EdgeEndo) all four root canal systems were prepared with the Primary EdgeOne Fire (EdgeEndo) file. Figure 14B illustrates the intra pulpal view after root canal preparation, and Figure 14C the final result after obturation.

CASE REPORT 3

The patient, a 32 year old male presented with a non-vital maxillary left first premolar (Figure 15A). After glide

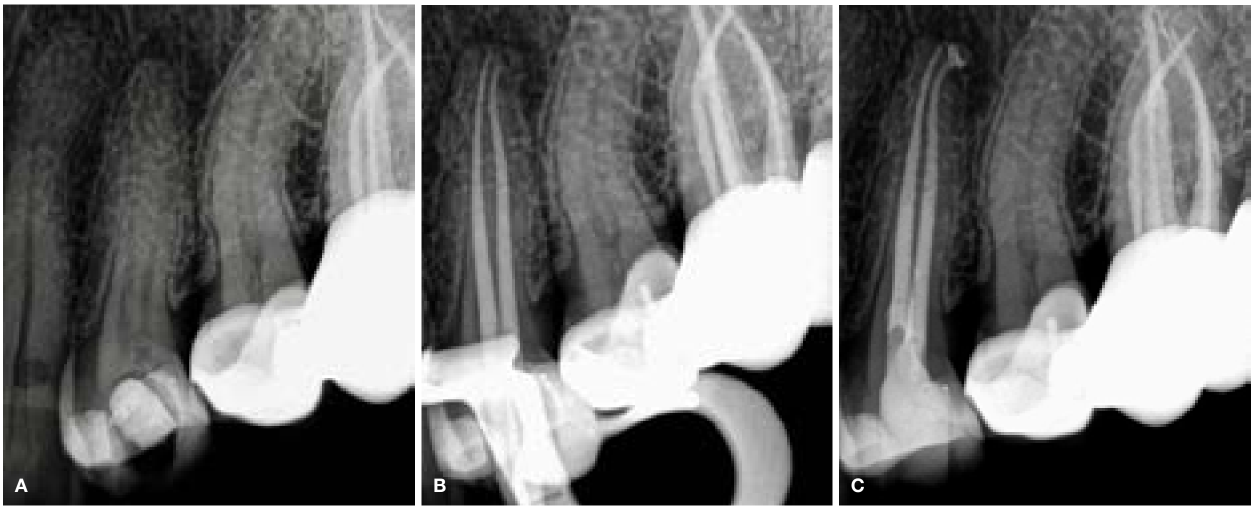

Figure 15. (A) Preoperative periapical radiograph of the maxillary left first premolar. (B) Cone-fit radiograph to confirm the fit of the two gutta-percha points. (C) Final result after root canal obturation.

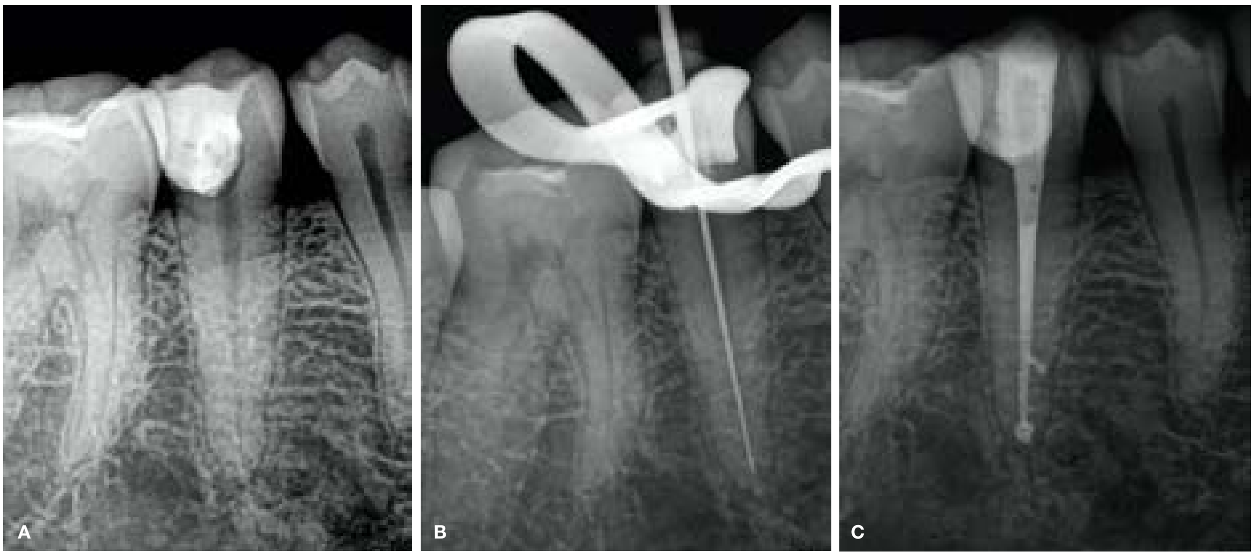

Figure 16. (A) Preoperative periapical radiograph of the mandibular right second premolar after a previous an emergency root canal treatment. (B) Length determination radiograph. (C) Final result after root canal obturation and core build up.

path enlargement with the One File G Glide Path file instrument (Pac-Dent) both root canal systems were prepared with the One File G Primary (25/07) instrument 9 (Pac-Dent). Figure 15B illustrates the cone-fit radiograph to confirm the fit of the two gutta-percha points and the final result after root canal obturation is shown in Figure 15C.

CASE REPORT 4

The patient, a 41 year old male presented with a history of an emergency root canal treatment on his mandibular right second premolar (Figure 16A). Length determination was done using an electronic apex locator and confirmed radiographically (Figure 16B).

Glide path preparation was completed using the R-Pilot file (VDW) and root canal preparation was completed using the Reciproc Blue (VDW). Figure 16C illustrates the final result after root canal obturation and core build up.

CONCLUSION

Reciprocation increases treatment safety, without compromising cutting efficiency or shaping ability, respecting the anatomical pathway of the root canal. Reciprocating movement extends the life span and increases fracture resistance of instruments, with equally effective debris removal and bacterial load reduction, when compared to continuous rotation.[57,86,130]

Reciprocation systems allow for single-file root canal shaping and single-use instruments that make it highly unlikely that these instruments will be used above their thresholds.[15] There is however still some contradicting evidence on the amount of apical extrusions, shaping times and the contribution of reciprocation to the development of dentinal defects and cracks.

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