Fida EL Tawil Karam

SINGLE FILE PREPARATION:RECIPROC® AND RECIPROC®Blue

Universidade Fernando Pessoa

Faculdade de Ciências da Saúde

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Dissertação apresentada à Universidade Fernando Pessoa como parte dos requisitos para obtenção do grau de Mestre em Medicina Dentária

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« What You Are Is Where You Were When…..AGAIN » Morris Massey.

« Whatever you thought,think again. » Willem Meiners.

« Ils le peuvent parce qu'ils pensent qu'ils le peuvent. » Virgile.

A Edward,mon trésor , mon premier amour,
A karl mon bien aimé ,
A Nadim mon cadeau ,
Et à toi Pierre mon âme soeur,
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SUMÁRIO:

O uso universal dos procedimentos do canal radicular de instrumentos rotativos de níquel-titânio (NITI) levou ao desenvolvimento de uma ampla variedade em formas, modelo e aplicações. Esta revisão da literatura apresenta a preparação com um único instrumento. A primeira parte desenvolve a metalurgia da liga NITI. A segunda parte concentra-se movimento recíproco. Na última parte, apresentamos os sistemas recíprocos e comparamos as suas propriedades mecânicas.

Para a realização do presente trabalho, foi feita uma revisão bibliográfica, este ano, utilizando vários motores de busca on-line; Pubmed e artigos dos websites oficiais da VDW e DENTISPLY.

Palavras-chave: "NITI liga";"instrumento NITI " ;" Movimento Reciproc"; "Reciproc" ; "WaveOne".

ABSTRACT:

The expanded use of nickel-titanium (NITI) rotary instruments root canal procedures has led to the development of a wide variety in shapes,designs and applications.This literature review present the single file preparation.The first part develops the metallurgy of the NITI alloy.the second part focus on the reciprocating movement. In the last part we present the reciprocating systems and compare their mechanical properties.

For the accomplishment of the present work a bibliographical revision was made, this year, using several online search engines ; Pubmed and articles from VDW and DENTISPLY official sites.

Keywords: "NITI alloy";"NITI files" ;"Reciprocating movement"; "Reciproc" ; "WaveOne".

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I. INTRODUCTION

Shaping the root canal system is one of the most important stages in Endodontics.Over the decades, they have been numerous instruments concepts, strategies, and techniques for preparing canals. Each generation of files has advanced canal preparation methods through innovations in design, material, and movement (Ruddle,2012).

The expanded use of nickel-titanium (NiTi) rotary intruments in root canal procedures has led to the development of a wide variety in shapes, designs and applications. Root canal anatomy has not changed, however, the same challenges exist in both initial treatment and the revision of unacceptable treatment (Walia,1988).

The challenges include application with high levels of achievement and low to no levels of adverse effects (Gutmann and Gao, 2011).

To that end, during the last decades, many manufacturers have been seeking ways to alter the presently available and wide range of root canal instruments designs, to provide clinician with safer and more efficient instruments. For that purpose they designed many cross-section, flute design, raw material and manufacturing process (Shen et al,2013).

In the last years, they focus on altering the surface of the alloy or altering the alloy microstructure with post-machining or post-twisting heat treatment (Gutmann and Gao, 2011).

1. Materials and Methods

In this thesis, we clarify and summarize further on advantages and limitations of the reciprocity motion. Advantages of this technique include reduction of cyclic fatigue, this reduction of fractures, reduction of working time and learning curvature by the simplicity of this technique.

Is reduction of working time a limitation or advantage of this technique?

The articles obtained for the accomplishment of this literature review were the result of data based on research using different online search (Pubmed,VDW and DENTISPLY official sites) to find maximum informations(1988-2017).
463 articles were found.
30 articles directly related to the subject were used.
Keywords: "NITI alloy";"NITI files" ;"Reciprocating movement"; "Reciproc" ; "WaveOne".

II. DEVELOPMENT

1. METALURGY OF NITI ALLOY AND APPLICATIONS IN ENDODONTICS.

The composition of Nickel-Titanium alloys used in Endodontics is approximately 56% of Nickel and 44% of Titanium. In some NiTi alloys, 2% of Nickel can be replaced by cobalt. The Ni Ti ratio, incorporation of other trace elements in the alloy composition, and heat treatment can dramatically change the properties of the NiTi alloys.
The properties and the mechanical behavior of NiTi alloys arise from their crystalline structures and the character of these structures.
The austenite phase, a body-centered cubic structure, exists at higher temperatures and lower stresses. In contrast, the martensite phase at lower temperatures and higher stresses, and has a closely packed hexagonal structure.

Phase 1: Transformation between these two phases is reversible and depends on the transformation temperature range.
Phase 2: The R-phase is an intermediate phase that can form during the transformation between austenite and martensite phases.
Phase 3: The phenomenon of transformation causes a change in the physical properties of the alloy and gives rise to the change memory characteristic.

When heating the alloy above its transformation temperature, the deformation can be reversed.
The alloy has the capacity to return to its original structure and orientation as the body-centered cubic austenite with a stable energy condition (Thompson, 2000).

This is the shape memory of NiTi. With this effect, it is possible to place the NiTi alloy into a given configuration at a given temperature. Reduction in the TTR can be achieved:

By the manufacturing process

- Thermal work
- Cold work

By the alteration of the nickel: titanium ratio in favor of:

- Exceeding Nickel
- Decreasing Nickel (by substituting cobalt for nickel, atom for atom). The transformation temperature can be decreased progressively by continued substitution of cobalt for nickel.(Testarelli,Plotino and Al-Sudani,2011)

1.1. New generations of Nickel-Titanium files

To improve fracture resistance of NiTi files, manufacturers have either introduced new alloys to manufacture NiTi files or developed new manufacturing processes (Vieira, 2011).

i. Memory Wire

NiTi rotary instruments made from memory wire submitted a thermo-mechanical processing procedure. This technology allows the NiTi instruments more flexibility and resistance to cyclic fatigue compared with non M-Wire NiTi instruments.
In a metallurgical analysis, Shen et al. reported that at 37 degrees Celcius conventional super-elastic NiTi wire has the austenite structure, whereas M-Wire is a mixture of nearly equal amounts of R-phase and austenite.
Those data are in accordance with previous studies that found that the conventional super-elastic NiTi file has an austenite structure, whereas NiTi file with thermal processing would be essentially in the martensite condition at body temperature. As we know the martensitic phase of NiTi has some unique properties, its transformation has

excellent energy absorption, remarkable fatigue resistance, and characteristics of its twinned phase structure (Shen et al, 2011).

ii. Blue alloys

Gao et al, (2012) subjected in their study different instruments to testing for fatigue resistance, torsional properties, flexibility and Vickers microhardness. Vortex Blue was ranked first in both fatigue and flexibility by M-Wire, super-elastic wire, and stainless steel. For torsional strength and microhardness, stainless steel and M-Wire were ranked first and second, respectively.

1.2. Cause of Fracture

i. Torsional fracture:

Torsional fracture occurs when the instrument (generally the tip) becomes locked in the canal while the file shank continues to rotate. Subsequently fracture of the file occurs when the elastic limit of the alloy is exceeded. Instruments that fracture as a result of torsional overload, reveal evidence of plastic deformation such as unwinding, straightening and twisting.

ii. Flexural cyclic fatigue:

Flexural fatigue occurs when the instrument continuously rotates freely in a curved canal generating tension/compression cycles at the point of maximum flexure, which eventually results in fracture. It is proposed that repeated tension-compression cycles caused by the rotation within curved canals increases cyclic fatigue of the instrument over time. Flexural fatigue fracture occurs essentially due to overuse of the metal alloy (McGuigan et al, 2013).

2. RECIPROCITY MOTION

Reciprocating motion can be defined as a repetitive up-and-down or back-and-forth motion. In Endodontics it is the alternative rotation of a file in the canal: clockwise and counterclockwise (Ruddle, 2012).

Initially, all reciprocating motors and related handpieces rotated files in equal angles of clockwise and counterclockwise rotation.

Those systems recognized limitations, including decreased cutting efficiency, more required inward pressure and a limited capacity to auger debris out of a canal.

Based on the balanced force concept, Ghassan Yared presented in 2007 his paradigm shift in the field of Endodontics: Canal preparation using only one NiTi rotary instrument.

Roane's concept is now seen in mechanical version.

Ghassan Yared performed exhaustive work to identify the precise unequal clockwise/counterclockwise angles that would enable a single reciprocating 25/08 proTaper file to optimally shape any canal. The clockwise and the counterclockwise rotations are set on the motor at four-tenth (144 degrees) and two-tenth of a circle (72 degrees).

These degrees of rotations were determined from the torsional fatigue profile of the F2 ProTaper instrument. These values were less than the degree of rotation at which the F2 instrument would fracture if bound in dentine.

The CCW rotation was greater than the CW rotation. When the instrument is rotated CW, it will screw in the canal. When rotated CCW, the instrument will unscrew out of the canal. As the CW rotation is greater than the CCW rotation, the end result is a screwing in effect and an advancement of the instrument in the canal. Consequently, only very light apical pressure should be applied on the instrument as its advancement would be almost automatic.

3. ADVANTAGES OF THE TECHNIQUE

3.1. Centering ability

Fabiani et al (2011), demonstrated that the reciprocating movement shaped a preparation in a more uniform symmetrical manner centered on the original canal, and so it enlarged almost equally in both the inner and outer directions. This action would result in a greater contact area between the instrument and the canal walls, thus producing a debridement quality as effective as the continuous rotation when considering round canals.

3.2. Safety:

A rotary instrument can also fracture if it binds in the canal, especially at its tip. When using a rotary system the tip of the instrument may bind in the canal; the motor will keep rotating the instrument while its tip is bound and the instrument will eventually fracture at a specific angle of rotation. In reciprocation, clockwise and counterclockwise angles determine the amplitude of reciprocation, the right and left rotations. These angles, stored in the motor, are significantly lower than the angles at which the instrument would usually fracture. If the instrument binds in the canal, it will not fracture because it will never reach the angle at fracture. In this respect, single file reciprocation is safer than rotary techniques because fracture by binding (fracture by taper lock or torsional fracture) is eliminated.

One RECIPROC instrument replaces several hand and/or rotary instruments for a canal preparation procedure. Therefore, the RECIPROC instrument is subjected to cyclic fatigue and should be discarded after the completion of a case. The plastic band on the handle of the instrument deforms if the instrument is autoclaved; this safety feature eliminates fatigue fracture due to repeated use in more than one case (Yared, 2008).

3.3. Shorter working time:

Working time was four times faster with the single file reciprocation in comparison with a NiTi rotary preparation technique (unpublished results)(Yared,2008).

3.4. Faster Learning:

92% of RECIPROC users were able to prepare three canals consecutively without errors compared to 30% of the continuous rotary NiTi system users (unpublished results) (Yared, 2008).

3.5. Less Procedural errors:

A lower incidence of complications such as canal transportation, ledging and blockage was observed with the single reciprocation technique than with a major rotary technique (Yared, 2008).

3.6. Elimination of cross-contamination between patients:

The instrument is discarded after each case; cross-contamination among patients is eliminated and Cross-contamination involving the staff is minimized because the assistant(s) will discard the instrument immediately after completing the case instead of manipulating the instrument to clean it (Yared, 2008).

Sontag et al, (2007) showed that single use of rotary instruments is therefore recommended to prevent the transmission of infectious diseases and to reduce the hazard of corrosion.

4. RECIPROCATING SYSTEMS.

4.1. WaveOne:

WaveOne is manufactured using M-wire technology, improving strength and resistance to cyclic fatigue.

There are three files in the WaveOne single-file reciprocating system available in lengths of 21, 25 and 31mm and D 16mm.

	Narrow canals	Continuous 6%	ISO 21
	Medium and wide canal	apical taper 8% that reduces towards the coronal end	ISO 25
	Large canal	apical taper 8% that reduces towards the coronal end	ISO 40

Table 1: *Design of WaveOne files, indications for use and special feature*

The instruments are designed to work with a reverse cutting action.WaveOne engage and cut dentine in a 150 degrees CCW direction and then, before the instrument has a chance to taper lock, disengages in a 30 degrees CW .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 and gradually advances into the canal with little apical pressure required.

All instruments have a modified convex triangular cross-section at the tip end (Fig. 30A) and a convex triangular cross-section at the coronal end (Fig. 30B). This design improves instrument flexibility overall. The tips are modified to follow canal curvature accurately (J Webber, 2011).

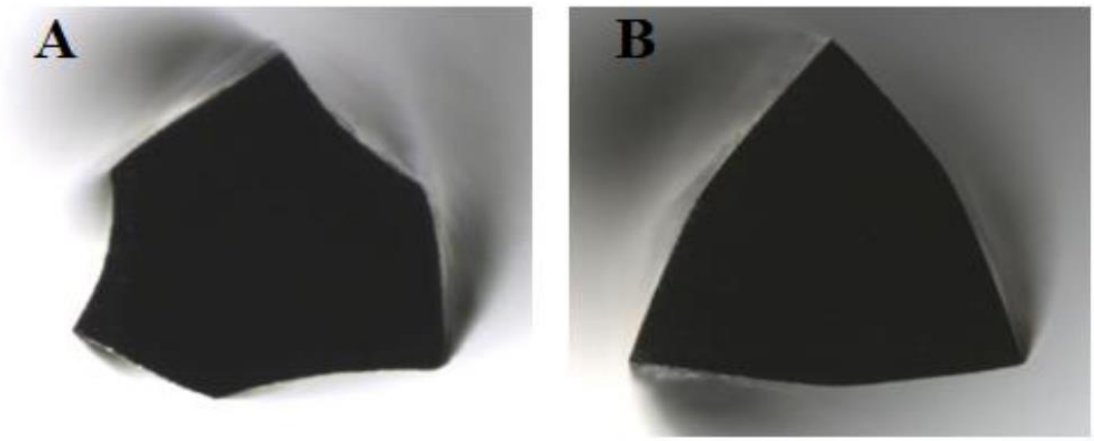


Figura 1: The variable pitch flutes along the length of the instrument considerably improve safety .

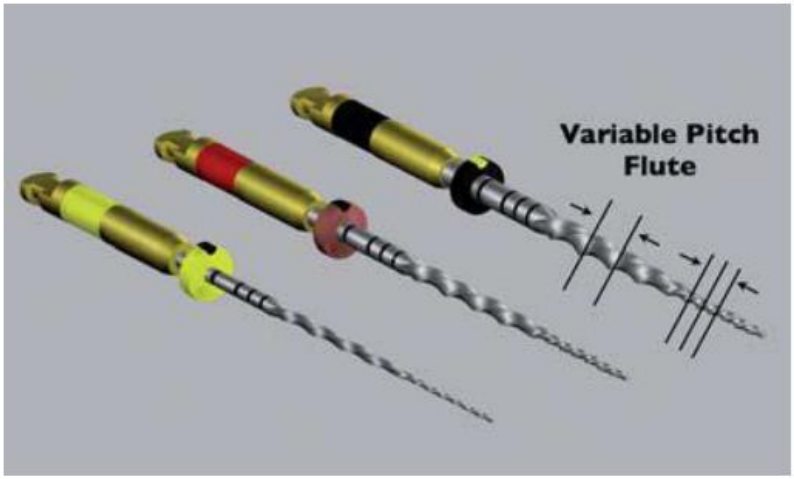


Figura 2: variable pitch flute

The WaveOne motor is rechargeable battery operated with a 6:1 reducing handpiece. The pre-programmed motor is set for the angles of reciprocation and speed for WaveOne instruments.

All brands of NiTi files can be used with the WaveOne motor, as it has additional functions for continuous rotation.

4.2. RECIPROC

As in WaveOne the files are manufactured using M-Wire technology.

There are three files in the Reciproc single-file reciprocating system available in lengths of 21, 25 and 31mm and D 16 mm (Table 2).

They have an S-shaped cross-section and a non active tip design.

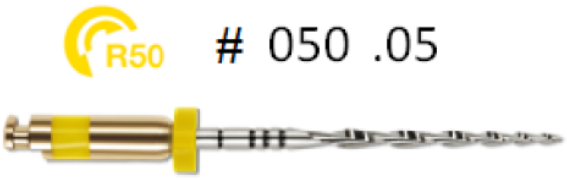
File	Indications	Taper	Tip size
	Narrow canal	apical taper 8% that reduces towards the coronal end	ISO 25
	Medium and wide canal	apical taper 6% that reduces towards the coronal end	ISO 40
	Large canal	apical taper 5% that reduces towards the coronal end	ISO 50

Table 2: *Design of Reciproc files, indications for use and special feature*

i. RECIPROC Technique

The technique is extremely simple. In the majority of canals, only one RECIPROC instrument is used in reciprocation to complete the canal preparation

Selection of the appropriate RECIPROC instrument.

Selection of the RECIPROC instrument is based on an adequate preoperative radiograph. If the canal is partially or completely invisible on the radiograph, the canal is considered narrow and the R25 is selected. In the other cases, where the radiograph shows the canal clearly from the access cavity to the apex, the canal is considered medium or wide . A size 30 hand instrument is inserted passively (with a gentle watch winding movement but without filing action to the working length. If it reaches the working length, the canal is considered large; the R50 is selected for the canal preparation. If the size 30 hand file does not passively reach working length, a size 20 hand file is inserted passively to the working length. If it reaches working length, the canal is considered medium; the R40 is then selected for the canal preparation. If the size 20 hand instrument does not reach the working length passively, the R25 is selected.

Before commencing preparation, the length of the root canal is estimated with the help of an adequately exposed and angulated pre-operative radiograph. The silicone stopper is set on the RECIPROC instrument at 2/3 of that length. The RECIPROC instrument is introduced in the canal with a slow in-and-out pecking motion without pulling the instrument completely out of the canal. The amplitude of the in-and out-movements should not exceed 3-4 mm. Only very light pressure should be applied. The instrument will advance easily in the canal in an apical direction. After three in-and out-movements, or when more pressure is needed to make the instrument advance further in the canal, or when resistance is encountered, the instrument is pulled out of the canal to clean the flutes. A #10 file is used to check patency to 2/3 of the estimated working length. The canal is copiously irrigated.

The RECIPROC instrument is used until it has reached 2/3 of the estimated working length as indicated by the stopper on the instrument. The instrument is then removed from the canal, the canal is irrigated and a #10 file is used to determine the length. The RECIPROC instrument is then re-used in the same manner until the working length has been reached. As soon as the working length has been reached, the RECIPROC instrument is withdrawn from the canal. The RECIPROC instrument can also be used in a brushing motion against the lateral walls of wide canals.

Creating a glide path during the use of the RECIPROC instruments: indication and management

Just as with any continuous rotary NiTi system, it is also possible to use the RECIPROC reciprocating file after creating an initial glide path with hand instruments to a size 10 or 15.

A glide path may also have to be created in some canals when the RECIPROC instrument stops advancing in the canal or if advancement becomes difficult. In this case, pressure should not be exerted on the RECIPROC® instrument. The instrument should be removed from the canal, and the canal irrigated. If the RECIPROC instrument still advances with difficulty or if it does not advance, it should be removed from the canal and the canal irrigated once again. At this point, hand files #10 and 15 should be used to create a glide path to the working length. The RECIPROC instrument would then be used until the working length has been reached. If, however, the progress of the RECIPROC instrument is still difficult or not possible, the canal preparation would need to be completed with hand files.

Using hand files to finish the apical canal preparation

In some canals, the #10 file used for the working length determination (after the RECIPROC instrument has reached 2/3 of the estimated working length) has to be pre-curved, otherwise it cannot reach working length. This indicates the presence of an abrupt apical curvature . The use of the RECIPROC instruments is contra-indicated in this instance. The canal preparation has to be finished with hand files. However, in most of the cases, the size 10 file used for the working length determination will reach that length without being pre-curved (indicating the presence of a gradual curvature) . The RECIPROC instrument will be used to working length to complete the preparation.

Increased apical enlargement.

In some canals an increased apical enlargement (based on gauging the canal, for example) may be required. A larger RECIPROC instrument or a hand instrument may be used for this purpose following the R25 and the R40, and a hand instrument is used following the R50 (Yared, 2008).

4.3. Wave one Gold

file	Indications	Taper	Tip size
SMALL 	Used in narrow canals as a bridge file before the PRIMARY	Apical taper 7% that reduces towards the end	ISO 20
PRIMARY 	Regular canals	Apical taper7% that reduces towards the end	ISO 25
MEDIUM 	Medium canals	Apical taper 6% that reduces towards the end	ISO 35
LARGE 	Large canals	Apical taper 5% that reduces towards the end	ISO 45

Table 3: Design of Waveone Gold files, indications for use and special feature

WaveOne GOLD instruments are manufactured utilising a new DENTSPLY proprietary thermal process, producing a super-elastic NiTi file. The gold process is a postmanufacturing procedure in which the ground NiTi files are heat-treated and slowly cooled.

The system includes different diameters and decreasing percentage tapered design wich improves flexibility and conserves remaining dentin in the body of the prepared canals.

The new patented cross section (parallelogram) and supermetal serve to improve shaping results in anatomically longer, narrower, and more apically curved canal.CJ.Ruddle (2016).

4.4. RECIPROC Blue

file	Indications	Taper	Tip size
	Narrow canals	Apical taper 8% that reduces towards the coronal ends	ISO 25

	Medium canals	Apical taper 6% that reduces towards the end	ISO 40
	Large canals	Apical taper 5% that reduces towards the end	ISO 40#

Table 4: Design of Reciproc Blue files, indications for use and special feature

VDW placed the next generation of the successful RECIPROC® instruments on the market in autumn 2016. When RECIPROC® instruments have been manufactured, they are then subjected to a specific heating process that changes the colour of the file – it turns blue.

Thermomechanical trearmtent produces a NITI alloy that is softer and more ductible than traditional one.

There are 3 files in the RECIPROC®blue system available in lengths of 21, 25 and 31mm.

They have the same S-shaped cross section as their predecessors.

III. DISCUSSION

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 (Dagna et al, 2014). Overall, reciprocating files are more resistant to fracture than are continuously rotating files, (You et al, 2010), extrude less debris than do conventional multiple-file rotary systems(DE-Deus et al,2015) and eliminate bacteria from root canal systems as efficiently as rotary systems. Moreover, Uzun et al(2016) found that Reciproc was associated with less apical debris extrusion compared to several other systems including WaveOne. In regards to postoperative pain and analgesic intake, kherlakian et al (2016) showed that there was no significant difference between Reciproc, WaveOne and continuous rotation systems. When considering the shaping ability, Saber et al (2015) concluded that Reciproc and WaveOne instruments respected the original canal curvatures with no significant differences between them. However, Reciproc was significantly faster for preparing root canals and demonstrated statistically higher cutting efficiency than WaveOne

(Plotino et al, 2014) . Lim et al (2013) reported that a glide path larger than #15 should be established before using the WaveOne file. In contrast, Coelho et al (2016) reported no significant differences between both files in regard to maintaining centric ability with or without glide path , and that glide path seems to be unnecessary and would only result in increased working time.

Heat treatment of the M-wire significantly improves the mechanical properties of the alloy:

Specifically,the primay WaveOne Gold is at least 80% more flexible ,50% more resistant to cyclic fatigue,and 23% more efficient,compared to its Primary WaveOne M-wire.

RECIPROCBlue is 2.3 times more resistant to cyclic fatigue and 40% more flexible than the RECIPROC instrument (.DE-Deus et al,2017)Moreover it revealed significantly lower microhardness than its predecessor.

Comparing WaveOne Gold and RECIPROC, WaveOne Gold had a significantly higher torsional resistance and lower resisitance to bend than RECIPROC.

Comparing many instruments Gundogar et al(2017)found that the cyclic fatigue resistance of RECIPROCBlue files was significantly higher than WaveOne Gold files. Topcuoglu et al(2017)showed that the cyclic fatigue resistance of WaveOne Gold files was higher than that of RECIPROC files. Besides RECIPROC Blue's novel heat treatment manufacturing method, its S-shaped cross section was found to show better cyclic fatigue resistance than the rectangular cross section (Cheung et al,2011). It is believed that the reason for RECIPROC Blue files having higher cyclic fatigue resistance than WaveOne Gold files is the different heat treatments used during their production processes and their S-shaped cross section.

Both reciprocating systems were designed as true single-use instruments that cannot be sterilized and re-used. 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.

IV. CONCLUSION

Since the beginning of Endodontics, there have been numerous concepts, strategies, and techniques for preparing canals. Over the decades, a staggering array of files has been

produced for negotiating and shaping canals. Each new generation of files has advanced canal preparation methods through innovations in design, material, and movement.

However, the future of shaping the root canal system has now begun with new systems that have been designed combining the reciprocating movement with the performing metal M-wire. This new approach is replacing the continuous rotation with the conventional NiTi files.

The reciprocating movement is more performing and secure. It had reduced the incidence of file breakage and had produced a continuous tapered preparation . Its time reduction can be a double-edged sword. Presumably, after only few minutes of mechanical instrumentation, the root canal space can be well shaped, but a minimum standard of debridement is reached if the irrigant didn't take time to react into the canal.Reduced shaping time means there is more time available to focus on an active irrigation method.

With the reciprocating system the old saying:"In Endodontics time is the biggest enemy"turns milder.

It is the beginning of the reciprocating era; Reciprocating systems take simplicity of the preparation to another level.

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