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REVIEW ARTICLE

Rotary Endodontics or Reciprocating Endodontics: Which is New and Which is True?

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ABSTRACT

In the past, shaping of root canals was done using stainless steel (SS) hand files. The introduction of rotary instrumentation has revolutionized the art and science of endodontic practice in the last decade with predictable success. The rotary files have been subjected to constant evolution in the form of metallurgy, design features, and the manner in which these instruments are driven (rotary/reciprocation), etc., resulting in revolution, both within the canal and in the area of contemporary endodontics. The purpose of this review is to identify publications regarding the evaluation, to present comprehensive and critical summaries of current knowledge, and to provide an update of the rotary and reciprocating concept, which is new and which is true.

Keywords: Reciproc, Reciprocating motion, Rotary motion, Single file, WaveOne.

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INTRODUCTION

Successful endodontic treatment depends on accuracy of diagnosis and on adequate mechanical preparation of the pulp space for restoration. The armamentarium of endodontics has grown in complexity over the past 40 years. Different techniques of root canal preparation have been described in the related literature. Stainless steel (SS) instruments have been traditionally used for canal preparation.[1] Introduction of rotary instrumentation has revolutionized the art and science of endodontic practice in the last decade with predictable success. The rotary files have been subjected to constant evolution in the form of metallurgy, design features, and the manner in which these instruments are driven (rotary/reciprocation), etc., resulting in revolution, both within the canal and in the area of contemporary endodontics.

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HISTORY

A new generation of endodontic instruments, made from a remarkable alloy – nickel and titanium, has added a striking new dimension to the practice of endodontics. The super elasticity and shape memory of nickel-titanium (NiTi), the properties that allow it to return to its shape following significant deformation, differentiate it from other metals, such as SS that sustain permanent deformation and retain the shape change. These properties make NiTi endodontic files more flexible and better able to conform to the canal curvature, resist fracture, and wear and tear less than SS files. In the early 1960s, the super elastic property of NiTi alloy, also known as Nitinol, was discovered by Buehler and Wang at the US Naval Ordnance Laboratory.

Rotary instrumentation has the following advantages over hand instrumentation:

- Enhanced ability to collect and remove debris from the canal system
- Continuous clockwise rotation will convey debris only in a coronal direction from the canal ramifications and apical foramen
- Mechanical rotation provides a more constant 360° engagement of the file tip in the canal that forces it to follow the canal and results in better control for maintaining the central axis of the canal, reducing the incidence of ledging or perforation[2]
- The most obvious benefit for continuous rotation is the reduction in the time required for instrumenting the canal
- Produces greater taper in canal preparation.

Disadvantages include:

- Conventional NiTi instruments in rotary movement one, subjected to structural fatigue that if continued will lead to fracture.[3-6]
- Increased canal preparation and increased microcrack.

RECIPROCATION

Definition: It is defined as any repetitive back and forth motion that has been clinically utilized.[7]

Interestingly, the combination of axial and rotational reciprocation was first introduced in 1928 (Cursor filing contra angle; W&H, Burmoos, Austria) followed by axial reciprocation in 1958 (Racer; W&H, Burmoos, Austria) and rotational reciprocation (Giromatic; MicroMega, Beasancon, France) in 1964. Since then, several handpieces were developed to drive the endodontic instruments a reciprocal movement.

In 1985, Roane et al[8] introduced the balanced force using instruments in rotational reciprocation for the preparation of curved root canals. They were the first to report the use of hand file with unequal clockwise (CW) and counterclockwise (CCW) movements in reciprocation. Numerous reports indicated good results that were obtained with this technique for further preparation of curved canals. Without or with only minimal straighten, it rekindled the interest in rotational reciprocation for canal preparation.[8-20]

Consequently, handpieces using rotational reciprocation (referred to as reciprocation/reciprocal in the text) systems were introduced, such as the M4 (SybronEndo Corporation, Orange, CA, USA),[21] the Endo-Eze AET (Ultradent Products Inc., South Jordan, UT, USA), and the Endo-Express (Essential Dental Systems, South Hackensack, NJ, USA).[22]

The first study experimenting with an alternating movement was that of Yared in 2008, which used the ProTaper F2 instrument (Dentsply Maillefer, Ballaigues, Switzerland) in a reciprocating movement.[23-25] The interest in reciprocation was renewed and in 2010 Dentsply introduced two single-file (rotational) reciprocating systems, Reciproc[26] (VDW, Munich, Germany) and WaveOne[27] (Dentsply/Maillefer) based on the concept developed by Yared. The study showed great promise for the reduction in the number of instruments required in the cleaning and shaping sequence; in minimizing possible contamination; and alleviating operator anxiety of the possibility of instrument failure. Apart from these benefits, preparation time was shown to be faster than when using the same instrument in full rotation.

These findings were confirmed by Burklein and Schäfer[28] in 2012 when they compared Reciproc (VDW) and WaveOne (Dentsply/Maillefer) functioning in reciprocating motion to Mtwo (VDW) and "ProTaper" universal "(Dentsply/maillefer)" in conventional use.

Advantages of alternating (reciprocation) NiTi instruments over continuous rotation are as follows:

- Binding of the instruments into the root canal dentin walls is less frequent, reducing torsional stress
- The reduction in the number of cycles within the root canal during preparation results in less flexural stress on the instrument.
- There is decreased risk of instrument fracture.[29]

ENDODONTIC INSTRUMENTS UTILIZING RECIPROCATING MOTION

WaveOne

The WaveOne NiTi file system (Dentsply/Maillefer) was introduced to the dental market in 2010. It is a single-use system that is designed to shape root canal systems to a continuously tapering morphology.[30,31] Instead of a rotary motion, the files work in a reverse "balanced force" cutting motion and are driven by a pre-programmed motor (X-Smart Plus motor fitted with 6:1 reducing hand piece) (Dentsply/Maillefer) that is capable of turning the files in a back and forth "reciprocating" motion (Table 1 and Figs 1 to 4).[32-34]

Table 1: WaveOne specifications

	Motion		*Sizes*
Cross section	*Counterclockwise movement (CCW)*	*Clockwise movement (CW)*	*In lengths of 21, 25, and 31 mm (Fig. 1)*
Different cross sectional Designs over the entire length of the working part of the instruments Tip – modified triangular/ convex cross section with radial lands Middle/near the shaft – neutral rake angle with a triangular/ convex cross section[32] (Figs 2 and 3) and the variable pitch flutes along the length of the instrument considerably improve safety (Fig. 4)[33]	170° is capable of advancing the instrument apically as the dentin on the root canal wall is engaged and cut Three sequential reciprocating cycles will complete one complete reverse CCW rotation and the repeated cutting and release process allows the instrument to advance apically into the root canal.[34] 170–50° = 120° (one reciprocating cycle resultant angle) 120° × 3 = 360° (one complete reverse CCW rotation)	50° 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	WaveOne small file – tip of the file is size ISO 21 and the shaft has a continuous taper of 6% WaveOne primary file – tip of the file is size ISO 25 and the shaft has a continuously decreasing taper of 8% from its tip to its shaft (0.8, 0.65, 0.6, 0.55) WaveOne large file – tip of the file is ISO 40 and the shaft has a continuously decreasing taper of 8% from its tip to its shaft (0.8, 0.65, 0.6, 0.55)

Fig. 1: WaveOne instruments: Small 21/06 (yellow ring); primary 25/08 (red ring); large 40/08 (black ring)

Fig. 2: WaveOne apical cross-section, modified convex triangular

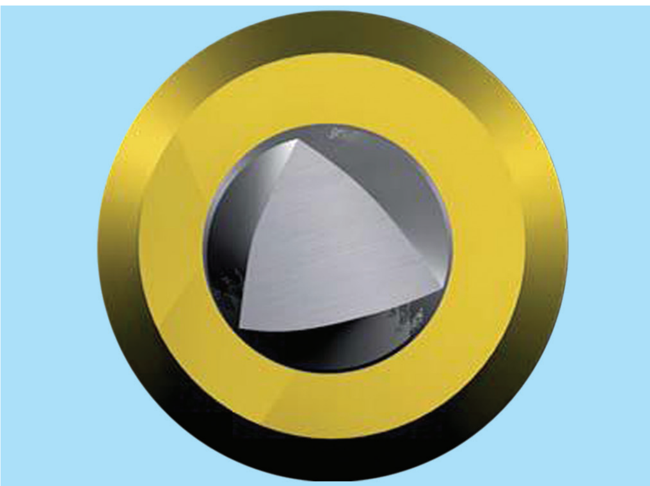

Fig. 3: WaveOne coronal cross-section, convex triangular

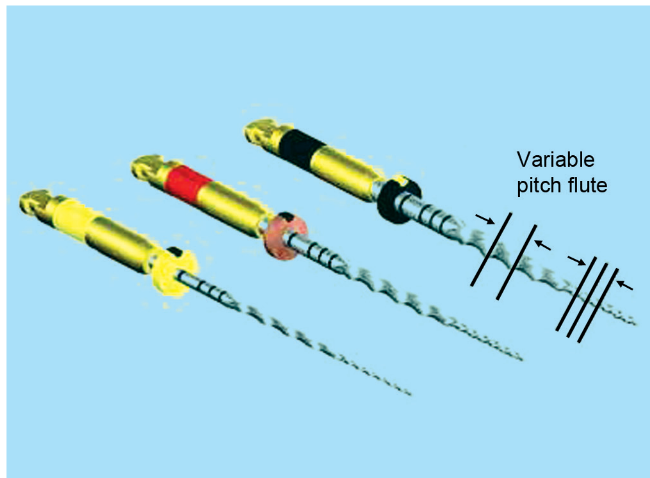

Fig. 4: The variable pitch that flutes along the length of the instrument considerably improves safety

Reciproc System (Table 2 and Figs 5 and 6).

The Reciproc system also includes three instruments (R25, R40, and R50) (Fig. 5) and is driven by the VDW Silver Reciproc Motor (VDW) or the X-Smart Plus motor (Dentsply/Maillefer).

WaveOne and Reciproc are manufactured from M-Wire technology to improve the fracture resistance of the instruments. M-Wire is a new NiTi alloy that is prepared by a special thermal process, claimed to increase flexibility and resistance to cyclic fatigue.[37,38] It is reported that instruments made from M-Wire with a ProFile (Dentsply/Maillefer) design exhibit nearly 400% more resistance to cyclic fatigue than do super elastic wire instruments of the same size.[39]

Table 2: Reciproc specifications

Cross section	*Motion*	*Sizes*
The instruments have an S-shaped cross section and demonstrate a progressive taper (Fig. 6)	Counter clockwise movement (CCW) Clockwise movement (CW) In reciprocation, the instrument is driven first in a cutting direction and then reverses to release the instrument. 150° 30° The angle in cutting direction (CCW) is greater than the angle in reverse direction (CW), so that the instrument continuously progresses toward the apex One complete rotation of 360° is completed in three reciprocating movements.[36] 150–30° = 120°(one reciprocating cycle resultant angle) 120° × 3 = 360° (one complete reverse CCW rotation)	In lengths of 21, 25, and 31 mm (Fig. 5) The Reciproc R25 instrument has a diameter of 0.25 mm at the tip and an 8% taper over the first 3 mm from the tip. The diameter at 16 mm from the tip (D16) is 1.05 mm The Reciproc R40 has a diameter of 0.40 mm at the tip, 6% taper over the first 3 mm from the tip and at D16 a diameter of 1.10 mm R50 has a diameter of 0.50 mm at the tip, a 5% taper over the first 3 mm from the tip and at D16 a diameter of 1.17 mm[35]

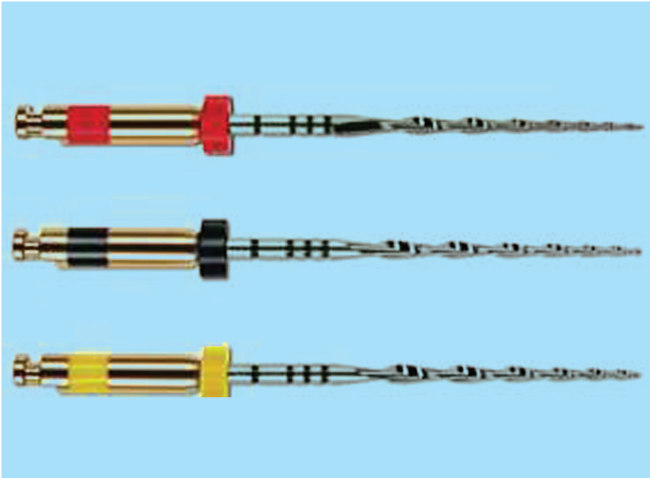

Fig. 5: Reciproc instruments: R25 (red ring); R40 (black ring); R50 (yellow ring)

COMPARISON BETWEEN ROTARY AND RECIPROCATING FILES

Cyclic Fatigue

De-Deus et al,[40] Gambarini et al,[41] and Plotino et al[42] evaluated the cyclic fatigue resistance of instruments in reciprocating motion compared with continuous rotation. The results demonstrate that the reciprocating movement induced less cyclic fatigue and promoted an extended life of the instrument in comparison with conventional rotation. However, there is no agreement in the literature regarding the influence of instrument design on the behavior of instruments under cyclic fatigue.[43-47]

Testarelli et al[48] compared cyclic fatigue resistance of instrument used with continuous rotation and the new motion (TF Adaptive rotating reciprocation). The results showed a significant increase of cyclic fatigue resistance of instruments used with the TFA motion. This can be explained by the alternance of engaging/disengaging movements, since the motion can be defined as a noncontinuous rotation, which reduces the number of cycles of the instrument and therefore reduces the cyclic fatigue on the instrument, while the traditional continuous rotation movement continuously engages and stresses the instruments.

Debris Removal

A study by Bürklein et al compared the efficacy of instruments functioning in a conventional rotating action with instruments functioning in reciprocating motion.[29,49] The results demonstrated that, in general, the use of Mtwo, Reciproc, and WaveOne instruments used in reciprocation resulted in less residual debris compared with canal shaping performed with ProTaper instruments used in rotating motion.

Debris Extrusion

Bürklein and Schäfer,[28] Myers and Montgomery[50] compared the debris extrusion associated with the larger reciprocating files to that recorded in the full sequences of rotary files. The results demonstrated that the full sequence rotary instrumentation systems were associated with less debris extrusion compared with the reciprocating single-file systems, one of which, Reciproc, produced significantly more debris compared with all the other systems. This can be explained by the absence of physiological back pressure provided by periapical tissues that may influence debris extrusion in the experimental studies.[51]

Bacterial Reduction

The rotary systems, ProTaper Universal and Mtwo, have been shown to provide adequate geometry[52] and substantial bacterial reduction in the root canal.[53] A recent study compared the influence of the reciprocating single-file technique with conventional rotary instrumentation on the bacterial reduction in infected root canals.[54-56] The conclusion of the study was that reciprocating systems resulted in similar bacterial reductions to those obtained with rotary systems or with the manual instrumentation technique.

Maintenance of Root Canal Anatomy

Berutti et al,[57,58] Yoo and Cho[32] compared canal shaping efficacy between reciprocating files and rotary files. The studies concluded that canal modifications were reduced and the original canal contour in curved canals was better maintained when the reciprocating file system was used compared with rotary instruments.[59,60]

Dentinal Defects/Cracks

A recent study compared the incidence of dentinal defects after root canal preparation with reciprocating and with rotary instrumentation on extracted human central lower incisors.[61] The study concluded that all four systems caused dentinal defects. Reciproc was associated with more complete cracks compared with the full sequence rotary systems. Cracks appeared more often in sections 2, 4, and 6 mm from the apex than on the apical root surface.[62,63]

Clinical Efficiency

A recent study by Park et al[64] compared the efficiency of reciprocating instruments by measuring the working time required to complete canal shaping. According to the authors with the study the difference can be attributed to the fact that WaveOne instruments have three cutting blades and might have better cutting efficacy than the two-bladed Reciproc instruments.

Fig. 6: Reciproc S-shaped crosssection

As the number of files used increased, the efficiency decreased. Only a few or no microcracks were detected after reusing files for five canals. The authors concluded that reciprocating files might be able to be reused up to five times with no critical changes in the metallurgical properties of the instruments.

Removal of Filling Material during Retreatment

Ruddle suggested that retreatment could improve root canal disinfection and debridement before a new homogenous root canal obturation is placed.[65,66] Recent studies compared the efficacy of reciprocating and rotary techniques for removing filling material during retreatment.[67-69]

The results of the study demonstrated that:

- Remaining endodontic filling material was observed on the canal walls of all the specimens regardless of the technique used;
- The reciprocating technique was the most rapid method for removing gutta percha and sealer.
- More apically extruded material in reciprocating system compared with retreatment rotary system.[69]

CONCLUSION

The field of endodontics has undergone tremendous changes from the use of SS files to NiTi and also in the manner in which these endodontic instruments are driven, i.e., in rotary and reciprocating motion. Endodontic instrument used in reciprocation is not a new concept, but in recent past it has gained more popularity because of change in design shape and metallurgy of NiTi instruments which can be used in reciprocating motion. This reciprocation has got many advantages over rotation, thus the reciprocating system has got a promising result over rotary system.

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