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# Original Research

## Cyclic Fatigue and Torsional Resistance of Reciproc versus Waveone Used in Reciprocation Motion: A Comparative Study

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***ABSTRACT*:**

**Aim:** The aim of this study was to evaluate cyclic fatigue and torsional resistance of instruments between two reciprocating systems (Reciproc and Wave-One) **Methodology:** Cyclic fatigue test with a simultaneous pecking motion was performed with the instrument. (n = 15 each) operating in the recommended reciprocation motion until fracture for the Reciproc R25 and Wave-One Primary files. ProTaper F2 was tested in continuous rotation to serve as a control for comparison. The number of cycles to fracture (NCF) was determined by measuring the time to fracture. The length of the fragment was measured and the fracture surface was examined by using scanning electron microscopy. Torsional strength was measured by using a torsiometer after fixing the apical 5 mm of the instrument rigidly. Statistical analysis was performed by using one-way analysis of variance. **Results:** The results showed that Reciproc had a higher NCF and Wave-One had a higher torsional resistance than the others. Both reciprocating files demonstrated significantly higher cyclic fatigue and torsional resistances than Pro-Taper ($P < .05$). **Conclusion:**Operating files in reciprocating motion enhances their cyclic fatigue resistance. Wave-One files showed maximum resistance to cyclic fatigue and torsional failure due to their cross-sectional diameter coupled M-Wire technology.

**Keywords:** Cyclic fatigue; reciprocation; torsional failure; Wave-One, Reciproc.

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### INTRODUCTION

Development of nickel-titanium (NiTi) endodontic instruments started a revolution in biomechanical preparation of root canal systems.[1] These instruments have a lower elasticity modulus than conventional stainless-steel files and are therefore more flexible. This greater flexibility, combined with other favorable mechanical properties and high cutting efficiency, increases the safety and effectiveness of instrumentation of curved canals without causing deviation in the final preparation shape. [2] Despite the ease of use and clinical efficiency of NiTi files, this

type of instrumentation system can result in complications and accidents. Unexpected fracture of instruments in the absence of visible signs of cutting blade deformation has been reported. [3] Fracture of NiTi instruments used in continuous rotary motion can be caused by torsion or cyclic fatigue. Torsional fracture occurs when the tip or another part of the instrument is locked in the canal while the other parts continue to rotate.[4] The instrument tip fractures when torque exceeds the elastic limit of the metal. [5] When the instrument is used for instrumentation in curved canals, compression force and tensile stress are alternately generated on each part of the instrument. [6] Continuous repetition of these forces can cause instrument fracture. Cyclic fatigue refers to the number of cycles an instrument can support; a good instrumentation system must be able to withstand stress fracture at more than 1,000 cycles. [7] To increase the fracture resistance of instruments, new fabrication processes have been developed in the production of NiTi alloys. [8] M-Wire alloy is prepared using a differential thermal process that can substantially increase the flexibility and mechanical strength of NiTi instruments. [9] In addition to new alloys, NiTi instruments with different kinematics, such as reciprocating motion, have longer life spans and greater cyclic fatigue resistance. [10] Recently, M-Wire alloy was used in the development of two new instrumentation systems that are specifically designed to be used with reciprocating motion: the Reciproc (VDW GmbH, Munich, Germany) and Wave- One (Dentsply/Maillefer, Ballaigues, Switzerland). [11] Both these systems comprise three instruments: the R25, R40, and R50 (the Small, Primary, and Large Files, respectively). The main difference between the instruments in these systems is the gradual increase in the diameter of the active tip. [12] These single-use instruments are designed to prevent fracture from prolonged use. However, single-use instruments are used in one tooth, even if the tooth has three or four root canals, as in the case of molars, and are suitable for curved and atretic canals. [12] Studies suggest that a disadvantage of single-use instruments is excessive tensile and compression forces on the instrument, which occur with instruments in continuous rotary systems and can cause fracture. [13] Failure due to the torsional overload is one of the most frequent cause of fracture of NiTi rotary files, and this occurs due to repeated stressing at levels below its yield point. When a torque-controlled motor is used, clinically it is possible that repeated locking (and release) of rotary instruments would occur. The probability that rotary instruments are subjected to such repetitive loads is much higher in narrow canals than in wider canals.[14]

**AIM OF THE STUDY**

The aim of this study was to evaluate cyclic fatigue and torsional resistance of instruments between two reciprocating systems (Reciproc and Wave- One)

**METHODOLOGY**

Cyclic fatigue test with a simultaneous pecking motion was performed with the instrument (n = 15 each) operating in the recommended reciprocation motion until fracture for the Reciproc R25 and Wave-One Primary files. Pro-Taper F2 was tested in continuous rotation to serve as a control for comparison. The Reciproc R25 instrument and Wave-One Primary file, both of which had an ISO size 25 at the tip and a taper of .08 in the apical 3 mm, were selected. The cyclic fatigue test was conducted in a custom-made device that allowed a reproducible simulation of an instrument confined in a curved canal. An artificial canal block was made of tempered steel with 0.6-mm apical diameter, 6.06-mm radius, and 45-degree angle of curvature, measured according to the method of Schneider,[15] was incorporated into the blocks. A continuous up-and-down (4 mm in each direction at 0.5 second) pecking movement was incorporated to simulate the pecking motion in a real clinical situation. The instrument was allowed to rotate/reciprocate with spontaneous pecking movement until fracture. Timing was stopped as fracture was detected visually and/or audibly. The number of cycles to fracture (NCF) was determined by measuring the time to fracture. The length of the fragment was measured and the fracture surface was examined by using scanning electron microscopy. Torsional strength was measured by using a torsiometer after fixing the apical 5 mm of the instrument rigidly. Statistical analysis was performed by using one-way analysis of variance.

**RESULTS**

Reciproc had the best fatigue resistance between groups ($P < .05$), and Wave-One had significantly higher NCF than Pro- Taper ($P < .05$). The mean lengths of the fracture fragment of 3 brands showed no difference statistically ($P > .05$). The ultimate torsional strength was the highest for Wave-One, followed by Reciproc and Pro-Taper in that order (Table 1). The differences were significant between groups ($P < .05$). SEM of the fracture surface showed similar and typical features of cyclic fatigue and torsional failure for the 3 brands. Crack initiation area and overload fast fracture zone for cyclic fatigue fractures**.**

**Table 1- Cyclic Fatigue and Torsional Resistance Test Results (mean value)**

| | Reciproc | Wave-One | ProTaper |
|---|---|---|---|
| Number of cycles before fatigue | 2346 | 1568 | 683 |
| Length of broken instrument | 3.09 mm | 4.66 mm | 4.8 mm |
| Torsional strength | 2.99 N.cm | 3.78 N.cm | 2.02 N.cm |

## DISCUSSION

The new concept of reciprocating instrument and the use of only one instrument to enlarge the canal, regardless of the pre-existing canal condition (such as dimension and curvature), into a final size and taper seems to go against the current instrumentation protocol that requires the gradual enlargement of the canal with a series of instruments until the desired shape is obtained. However, this new concept of using a single (reciprocating) instrument is cost-effective and can shorten the learning curve for practitioners to adopt the new technique.[16] It was reported that the larger cross-sectional area would have a higher flexural and torsional stiffness, and thus the file design (cross-sectional shape, diameters of core, etc) would have a significant influence on the torsional and bending (hence, fatigue) resistance.[17] From our experimental results, Reciproc showed higher cyclic fatigue but lower torsional resistance than Wave-One. It implies that Reciproc possesses lower flexural stiffness and smaller polar moment of inertia than Wave-One. In other words, Wave-One had a higher torsional stiffness than Reciproc. The SEM analysis showed typical fractographic appearances of cyclic fatigue and torsional fractures. After the cyclic fatigue test those instruments showed the presence of crack initiation areas and overload fast fracture zones.[18]

Many testing conditions and methodologies have been used to compare the cyclic fatigue resistance of rotary endodontic instruments. The use of reciprocating motion can improve the mechanical properties of instruments and increase fatigue resistance, compared to continuous

rotation. However, because of the differences amongst the various reciprocating motions (different speeds and angles), further studies are needed to determine the most suitable motions for root canal treatment. An important point to consider is that the mean time to fracture is not directly proportional to the increase in the number of reciprocations required to complete a full 360 degrees rotation, probably because the resulting speeds are not directly proportional. This should be considered in future studies concerning the definition and measurement of reciprocating motion speed.[19]On the basis of the results in this study, the 2 types of NiTi reciprocating instrument should be recommended for selective applications, according to the canal conditions. For instance, Reciproc might be more suited for preparing canals with more abrupt curvature because of its good fatigue resistance and Wave-One for the constricted canal that might induce higher torsional stresses. Further researches, ex vivo or clinical, are highly recommended to verify the clinical efficacy of these instruments for shaping the root canal and for ways to minimize the risk of fracture. Reciproc outclassed Wave-One in cyclic fatigue resistance, but vice versa for torsional strength.

## CONCLUSION

Operating files in reciprocating motion enhance their cyclic fatigue resistance. Wave-One files showed maximum resistance to cyclic fatigue and torsional failure due to their cross-sectional diameter coupled M-Wire technology.

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