

Evaluation of Root Dentin Cracks Caused by Three Single File Systems Versus Pro Taper System – An In Vitro Study

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ABSTRACT

Introduction: Biomechanical preparation of root canals is one of the main steps in achieving endodontic success due to enabling bacterial elimination, removal of debris, and facilitating obturation. The aim of this study was to compare the incidence of dentinal cracks observed in the canal wall after canal instrumentation with 3 single-file systems and the ProTaper system (Dentsply Maillefer, Switzerland).

Material and Methods: Eighty mandibular premolars with single root canal were selected. Teeth were decoronated and mounted in resin blocks with simulated periodontal ligaments. They were divided into 4 experimental groups (n = 20); then instrumented to the full working length with the ProTaper, OneShape (MicroMega, Besancon, France), Reciproc (VDW, Munich, Germany), and WaveOne Gold (Dentsply Maillefer) was performed. The roots were sectioned perpendicular to the long axis at 3, 6, and 9 mm from the apex and were observed under a stereomicroscope. The presence of cracks was noted. The chi-square test was performed to compare the appearance of cracked roots between the experimental groups.

Results: Cracks found after canal instrumentation with the ProTaper, OneShape, and Reciproc and WaveOne Gold files, were 46.6%, 23.3%, 13.6%, 11.6% respectively. The difference between the experimental groups was statistically significant (P < .001).

Conclusion: Nickel-titanium instruments cause cracks in root surface or in the canal wall; Reciproc and WaveOne Gold files caused less cracks than the ProTaper and OneShape files.

Keywords: ProTaper, OneShape, Reciproc, WaveOne Gold, M Wire NiTi Alloy

INTRODUCTION

Many NiTi rotary and reciprocating instruments have been introduced over few decades with the objective of performing root canal therapy in easier, faster and better way.¹ Rotary NiTi instruments having active cutting edges and larger taper as they tend to cause microcracks at the entire root canal dentin followed by root fracture, thus deteriorating the root integrity and reducing long term prognosis of endodontically treated teeth.²⁻⁵ Vertical root fracture is one of the frustrating complications of root canal treatment, which often results in tooth extraction.⁶

Over the last decades, technological advancements in rotary NiTi instruments have led to new design concepts and easier, faster, and better root canal shaping.⁷

ProTaper rotary files (Dentsply Maillefer, Switzerland) are popular instruments that are characterized by an increasing taper design that facilitates active cutting motion and removes relatively more dentin coronally compared with

other systems.⁸

Reciproc files (VDW, Munich, Germany), are one of the single file systems made of M-Wire NiTi alloy subjected to an innovative thermal treatment process to increase flexibility of the instrument. The Reciproc files have an S-shaped cross-section, 2 cutting blades, and a continuous taper over the first 3 mm of their working part followed by a decreasing taper until the shaft. Reciproc files are used in a reciprocating motion, which reduces the risk of cyclic fatigue caused by tension and compression.⁹⁻¹¹

Another single file system, OneShape files (Micro-Mega, Besancon, Cedex, France) are used in a traditional continuous rotation motion. They have a triangle cutting edge in the apical part, 2 cutting edges in the coronal part, and a cross-section that progressively changes from 3 to 2 cutting edges between the apical and coronal parts; this design offers an optimal cutting action.

WaveOne Gold (Dentsply, Maillefer) instruments are manufactured utilising a new proprietary thermal process, producing a super-elastic NiTi file. The gold process is a post manufacturing procedure in which the ground NiTi files are heat-treated and slowly cooled. WaveOne Gold files are designed with a reverse cutting helix, engage and cut dentine in a 150-degree counterclockwise (CCW) direction and then, before the instrument has a chance to taper lock, disengages 30 degrees in a clockwise (CW) direction. The net file movement is a cutting cycle of 120 degrees and therefore after three cycles the file will have made a reverse rotation of 360 degrees.¹²

Therefore, the aim of this study was to evaluate the incidence of dentinal cracks in root canal caused by three single file systems i.e; Reciproc, OneShape and WaveOne Gold versus multi file system i.e; ProTaper Next.

MATERIAL AND METHODS

Eighty extracted human mandibular premolars with single root canals were selected. Teeth with fracture lines, open apices, dental caries or resorption defects were excluded.

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Radiographs were taken in buccolingual direction to verify the presence of a single canal. The external root surfaces were inspected at 10X magnification under a stereomicroscope (Olympus, Japan) to exclude the possibility of any external defects or cracks. To ensure standardization, the teeth were sectioned at 15mm from the apex using a diamond disc (Horico, Germany) under water coolant. The roots were covered with a single layer of aluminum foil and inserted in acrylic resin (DPI, India) set in an acrylic tube. The root was then removed from the acrylic tube, and the aluminum foil suspended from the root surface. A light body silicon-based material (Fxeceed, GC, Japan) was used to fill the space created by the foil and to simulate the periodontal ligament, and the root was positioned into the acrylic tube.^{13,14} Teeth were assigned to four root canal shaping groups. The working length of the canals was determined by inserting a size 10 K-type file into the root canal till it was visible at the apex and subtracting 1 mm from this measurement. A glide path was performed till #20 K type file. The root canal shaping procedures were performed according to the manufacturers' instructions using endomotor X SMART PLUS (Dentsply) for each instrument system as follows:

Group 1: Instrumentation with the ProTaper as follows: SX, S1, S2, F1, F2, F3, and F4. The first 3 shaping files were used with a brushing motion away from the root concavities before light resistance was encountered, and the last 4 finishing files were used until the working length was reached at a rotational speed of 300 rpm and 2 Ncm torque.

Group 2: In the OneShape group, root canal preparation was performed with rotary file #25.06 at a constant speed of 400 rpm in pecking motions as recommended by the manufacturer.

Group 3: In the Reciproc group, a Reciproc file #25/.08 (VDW) was used in a reciprocating motion till the working length using the "reciproc all" mode.

Group 4: In the WaveOne Gold group, canals were prepared with WaveOne Gold file #25.07 using an in-and-out motion. After 3 movements of at most 3-mm amplitude, the instrument was removed and cleaned with gauze.

Each canal was irrigated with 2 mL 2% sodium hypochlorite between each instrument use by using a luer lock syringe (Hindustan Unolock) with needle placed at 1 mm from WL.

Sectioning and Microscopic Examination

All of the roots were sectioned perpendicular to the long axis at 3, 6 and 9mm from the apex using a diamond disc (Horico, Germany) under water coolant. A total of 60 slices per group were evaluated for cracks. The coronal aspect of each slice was observed at 25X magnification under a stereomicroscope (Olympus, Japan). A chi-square test was performed to compare the appearance of cracked roots between experimental groups.

To define crack formation, 2 different categories were made (ie, "no crack" and "crack"). "No crack" was defined as root dentin without cracks or craze lines either at the internal surface of the root canal wall or the external surface of the

root. "Crack" was defined as all lines observed on the slice that either extended from the root canal lumen to the dentin or from the outer root surface into the dentin.⁵

RESULTS

The Reciproc, WaveOne Gold and OneShape instruments caused less cracks than the ProTaper files and the results were statistically significant ($P < .001$). Reciproc and WaveOne Gold files also resulted in lesser cracks than OneSape file system. There was no statistically significant difference between Reciproc and WaveOne Gold groups.

| Group | Number of slices with crack | %age of roots with crack |
|--------------|-----------------------------|--------------------------|
| ProTaper | 28 | 46.6 |
| OneShape | 14 | 23.3 |
| Reciproc | 8 | 13.6 |
| WaveOne Gold | 7 | 11.6 |

DISCUSSION

The two file systems used in this study which work in continuous rotation motion were OneShape and ProTaper files. The cracks caused by OneShape and ProTaper were 23.3% and 46.6%, respectively. The dentinal cracks caused by Reciproc and WaveOne GOLD were 13.6% and 11.6% respectively.

The 3 single-file systems used ie, the Reciproc, OneShape and WaveOne Gold caused less damage than the ProTaper system when 7 files were sequentially used. This is in accordance with a study by Shemesh et al¹⁵ which states that more manipulations in the canal could cause the accumulation of damage. The ProTaper F2 has a .08 taper in the apical portion.¹⁶ This might be the reason of more dentinal cracks in the group instrumented with ProTaper system. This is in accordance with the previous studies.^{17,18}

According to a study by Bier et al¹⁷, cracks were observed in the horizontal sections of 16% of the roots instrumented with the ProTaper system. Liu et al¹⁸ also observed cracks at the apical root surface in 25% of the roots instrumented with the ProTaper instruments.

In this study, the Reciproc file with an apical size of #25 .08 caused significantly less cracks than the OneShape file with an apical size of #25 .06. Despite the difference in cross-sectional design, it may be that the reciprocating motion caused less dentinal damage than the continuous rotation motion.

Reciproc and WaveOne Gold files are single file systems and work in a reciprocating movement similar to the balanced force technique.¹⁹ There are various advantages of using reciprocating file systems. The reciprocating movement minimizes torsional and flexural stresses⁹ and reduces canal transportation.^{20,19,21} Furthermore, the files working in reciprocating motion shows significantly higher resistance to cyclic fatigue.^{16,22}

Previous studies have reported the WaveOne Primary reciprocating instrument showed fewer dentinal defects when compared with the NiTi rotary ProTaper system.^{23,24}

The heat treatment of NiTi has led to instruments that are

claimed to be more flexible and fatigue resistant.²⁵ Abou El Nasr and Abd El Kader²⁶ have shown the WaveOne instrument used in a reciprocating motion presented fewer defects than the F2 file used in the same motion; their study concluded that the heat-treated alloy had a significant impact in decreasing dentinal defect creation. Other studies evaluating heat treated rotary instruments have also shown fewer defects than a traditional NiTi rotary instrument.^{27,24} The cross-section of WaveOne GOLD is a parallelogram with two 85-degree cutting edges in contact with the canal wall, alternating with off-centred crosssection where only one cutting edge is in contact with the canal wall. Decreasing the contact area between the file and the canal wall reduces binding (taper lock) and, in conjunction with a constant helical angle of 24 degrees along the active length of the instrument, ensures little or no screwing in. The additional space around the instrument also ensures additional space for improved debris removal.¹²

CONCLUSION

Under the limitations conditions in this study, it can be concluded that the single reciprocating file systems: Reciproc and WaveOne Gold caused less root cracks than the ProTaper and OneShape files. OneShape file system also has lesser tendency to cause dentinal cracks than ProTaper system.

REFERENCES

- Schilder H. Cleaning and shaping the root canal. *Dent Clin North Am* 1974; 18: 269-296.
- Liu R, Hou BX, Wesselink PR, et al. The incidence of root microcracks caused by 3 different single – file systems versus the protaper system. *J Endod* 2013;39:1054-6.
- Barreto MS, Moraes Rdo A, Rosa RA, et al. vertical root fractures and dentin defects: effects of root canal preparation, filling and mechanical cycling. *J Endod* 2012;38:232-5.
- Adorno CG, Yoshioka T, Suda H. The effect of working length and root canal preparation technique on crack development in the apical root canal wall. *Int Endod J* 2010;43:321-7
- Shemesh H, Bier CAS, Wu MK, et al. The effects of canal preparation and filling on the incidence of dentinal defects. *Int Endod J* 2009;42:208-13
- Tsisis I, Rosen E, Tamse A, Taschieri S, Kfir A. Diagnosis of vertical root fractures in endodontically treated teeth based on clinical and radiographic indices: a systematic review. *J Endod* 2010;36:1455-8.
- Gambarini G. The K3 rotary Nickel titanium instrument system. *Endod Top* 2005;10: 179–82
- Bergmans L, Van Cleynenbreugel J, Beullens M, et al. Smooth flexible versus active tapered shaft design using NiTi rotary instruments. *Int Endod J* 2002;35: 820–8.
- Blum JY, Machtou P, Esber S, et al. Analysis of forces developed during root canal preparation with the balanced force technique. *Int Endod J* 1997;30:386–96.
- Varela-Patiño P, Ibañez-Parraga A, Rivas-Mundiño B, et al. Alternating versus continuous rotation: a comparative study of the effect on instrument life. *J Endod* 2010;36: 157–9.
- De-Deus G, Brandão MC, Barino B, et al. Assessment of apically extruded debris produced by the single-file ProTaper F2 technique under reciprocating movement. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2010;110:390–4
- Julian Weber. Shaping canals with confidence: WaveOne GOLD single-file reciprocating system. vol. 6, no. International Dentistry – African edition.
- Adorno CG, Yoshioka T, Suda H. Crack initiation on the apical root surface caused by three different nickel-titanium rotary files at different working lengths. *J Endod* 2011;37:522–5.
- Liu R, Kaiwar A, Shemesh H, et al. The incidence of apical root cracks and apical dentinal detachments after canal preparation with hand and rotary files at different instrumentation lengths. *J Endod* 2013;39:129–32.
- Shemesh H, Roeleveld AC, Wesselink PR, et al. Damage to root dentin during retreatment procedures. *J Endodontics* 2011;37:63–6.
- De-Deus G, Moreira EJJ, Lopes HP, et al. Extended cyclic fatigue life of F2 ProTaper instruments used in reciprocating movement. *Int Endod J* 2010;43:1063–8
- Bier CAS, Shemesh H, Tanomaru-Filho M, et al. The ability of different nickeltitanium rotary instruments to induce dentinal damage during canal preparation. *J Endod* 2009;35:236–8
- Liu R, Kaiwar A, Shemesh H, et al. The incidence of apical root cracks and apical dentinal detachments after canal preparation with hand and rotary files at different instrumentation lengths. *J Endod* 2013;39:129–32.
- Roane JB, Sabala CL, Duncanson MG Jr. The “balanced force” concept for instrumentation of curved canals. *J Endod* 1985;11:203–11
- Varela-Patiño P, Ibañez-Parraga A, Rivas-Mundiño B, et al. Alternating versus continuous rotation: a comparative study of the effect on instrument life. *J Endod* 2010;36: 157–9
- Franco V, Fabiani C, Taschieri S, et al. Investigation on the shaping ability of nickeltitanium files when used with a reciprocating motion. *J Endod* 2011;37:1398–401
- Kim H-C, Kwak S-W, Cheung GS-P, et al. Cyclic fatigue and torsional resistance of two new nickel-titanium instruments used in reciprocation motion: Reciproc versus WaveOne. *J Endod* 2012;38:541–4.
- Kansal R, Rajput A, Talwar S, et al. Assessment of dentinal damage during canal preparation using reciprocating and rotary files. *J Endod* 2014;40:1443–6.
- Li SH, Lu Y, Song D, et al. Occurrence of dentinal microcracks in severely curved root canals with ProTaper Universal, WaveOne, and ProTaper Next File Systems. *J Endod* 2015;41:1875–9.
- Hieawy A, Haapasalo M, Zhou H, et al. Phase transformation behavior and resistance to bending and cyclic fatigue of ProTaper Gold and ProTaper Universal instruments. *J Endod* 2015;41:1134–8.
- Abou El Nasr HM, Abd El Kader KG. Dentinal damage and fracture resistance of oval roots prepared with single-file systems using different kinematics. *J Endod* 2014;40: 849–51
- Capar ID, Arslan H, Akcay M, Uysal B. Effects of ProTaper Universal, ProTaper Next, and HyFlex instruments on crack formation in dentin. *J Endod* 2014;40:1482–4.

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