

Comparative evaluation of the incidence of root microcracks observed within the canal wall after canal preparation using different rotary and reciprocating instruments

Rohit Kochhar¹, Ruchika Dewan², Manju Kumari^{3,*}, Ramsa Khan⁴, Danish Khan⁵

¹Professor & HOD, ^{2,3}Professor, ^{4,5}PG Student, Dept. of Conservative Dentistry and Endodontics, I. T. S. Dental College and Hospital, Knowledge park III, Greater Noida, Uttar Pradesh, India

***Corresponding Author:**

Email: docmanjukmr@gmail.com

Abstract

Introduction: Root microcracks may occur as a result of use of rotary cleaning and shaping instruments. It may be affected by the type and design of the rotary file system used to shape the root canal system.

Aim: The aim of this study was to compare the incidence of root microcracks observed within the canal wall after canal preparation using different rotary and reciprocating instruments.

Materials and Method: Fifty extracted single rooted anterior teeth were randomly assigned to 5 groups (N=10 teeth per group). The root canal preparation was done using TF Adaptive systems in Group 2, ProTaper Next in Group 3, WaveOne in Group 4 and Reciproc in Group 5. No instrumentation was done in Group 1. All the roots were horizontally sectioned 3, 6, and 9 mm from the apex and then viewed through a stereomicroscope at x25 magnification.

Results: The control group had no cracks, and the difference between the control group and the experimental groups was statistically significant ($p < 0.05$) at all the levels. At 3 mm level, Group 2 & 3 samples were found to have significantly less number of cracks than Group 4 & 5. At 6 mm level, there was no statistically significant difference among groups. At 9 mm level, Group 4 was found to have significantly lower number of cracks than Group 2.

Conclusion: All tested groups caused significantly more dentinal defect compared to the unprepared groups.

Keywords: Dentinal cracks, ProTaper Next, TF Adaptive systems, Reciproc, WaveOne.

Introduction

Biomechanical procedure with rotary instruments can possibly lead to root micro cracks which can possibly lead to root fracture.¹ Various studies have reported that root microcracks can occur from use of Nickel-Titanium files in root dentin.²⁻⁴ Technological advancements in the design and shape of Niti instruments are responsible for better faster and easier root canal shaping procedure.⁵ ProTaper Next (Dentsply Maillefer) instruments made from M wire technology has introduced an off-centered rectangular design and progressive and regressive percentage taper. This design results in decrease of dangerous taper lock, the screw effect, and reducing torque on any file by decreasing the contact between the dentin and file.⁶

Recently, a new system called twisted file adaptive has been introduced. When it is exposed to minimal or no applied load it uses continuous rotation on the other hand when it engages dentin and a load is applied, it changes its mode from continuous to reciprocation mode with specific clockwise and counterclockwise angles varying from 600°-0° upto 370°- 50°.⁷ Another new single file systems, Reciproc (VDW, Munich, Germany) and WaveOne (Dentsply, Maillefer) made from M wire technology⁸ have been introduced and uses only 1 file to prepare the canal and thereby requiring less time than other file system.⁹ The design feature such as core diameter, rake angle, flute depth and cross-sectional shape may affect the behaviour of the file.¹⁰

Therefore, the aim of this study was to compare incidence microcracks within the root canal wall after canal preparation using different reciprocating files and NiTi rotary systems. The null hypothesis was that there would be no difference in crack formation at different root level among the groups.

Material and Method

Fifty extracted single rooted anterior teeth with straight canals were selected and stored in distilled water. All teeth were sectioned under water with low speed disc at 16mm from the apex. The roots were then covered with a single layer of aluminium foil and embedded in acrylic resin. To stimulate the periodontal ligament, silicone light body-based material was applied over the covered root.

Access opening was done with a diamond bur (TR#2). Number 10k-k file was used to determine the working length. Then the file was inserted till the root apex and 0.5 mm was subtracted from this measurement. Number 15-k file type was used to prepare the glide path and then enlarged upto size 20K file. The specimens were then divided 1 control and 4 experimental groups of 10 teeth each (n=10) where biomechanical preparation (BMP) was done using following protocol:

Group 1: Negative control group wherein no BMP was performed

Group 2: Twisted File Adaptive system were used for BMP upto number 25/08

Group 3: ProTaper Next Rotary instrument were used for BMP upto number 25/06

Group 4: WaveOne reciprocating system were used for BMP upto number 25/08

Group 5: Reciproc Rotary System was used for BMP upto number 25/08

All samples were prepared apically to size # 25. During the biomechanical preparation, frequent irrigation was done using 3% sodium hypochlorite 0.5 ml of distilled water was used to rinse the specimen of the prepared group. Sectioning of all the roots was done perpendicular to the long axis of the tooth at three different level (3, 6 and 9mm) using a diamond saw followed by stereomicroscopic evaluation at X20 magnification. Two different criteria were used to define the crack formation.

Root dentin devoid of cracks or micro cracks either at the internal or the external surface of the root canal surface was defined as "No defect". Any microcracks, fracture or craze lines if present in root dentin or extending to outer root surface was defined as "Defect".

The results were expressed as the number and

percentage of cracked roots in each group. The data was analyzed with a Fischer exact test (with 95% confidence level, $p \leq 0.05$ statically significant). Statistical Package for Social Sciences software, 17.0 Version (SPSS, Chicago, Illinois, USA) was used for statistical analysis.

Results

The percentage and number of cracks in the study groups are shown in Table 1. No cracks were noticed in the control group and a statistically significant difference was observed between the control and experimental group ($p \leq 0.05$) at all the levels i.e., 3, 6 and 9mm.

At 3mm level, Group 2 & 3 samples were found to have significantly less number of cracks as compared to Group 4 & 5. At 6 mm level, comparison between four experimental groups showed that there was no statistically significant difference. At 9 mm level, Group 4 was found to have significantly lower number of cracks as compared to Group 2.

Table 1: Percentage and number of cracks in study groups group

Group		Apical	Middle	Coronal	Total
Group 1 (Control)	Count	0	0	0	0
	% within GR	0.0% ^c	0.0% ^c	0.0% ^c	0.0%
Group 2 (TF Adaptive)	Count	1	5	6	12
	% within GR	10.0% ^a	50.0% ^a	60.0% ^{a,b}	
Group 3 (ProTaper Next)	Count	2	6	5	13
	% within GR	20.0% ^a	60.0% ^a	50.0% ^a	
Group 4 (WaveOne)	Count	6	4	3	13
	% within GR	60.0% ^b	40.0% ^a	30.0% ^{a,d}	
Group 5 (Reciproc)	Count	5	5	4	14
	% within GR	50.0% ^b	50.0% ^a	40.0% ^a	

Same superscripts along the columns indicate non-significant difference

Discussion

In the present study, there was significant difference in crack formation at different root level among the groups; therefore the null hypothesis was rejected. Both TF Adaptive and ProTaper Next resulted in significantly less number of dentin cracks as compared to Wave one and Reciproc Rotary System at the apical third region. Samples within the control group showed no cracks on the external surface when observed under stereomicroscope before and after sectioning procedure. This shows that sectioning method used did not induce any cracks, therefore, cracks observed in the study groups were definitely due to the technique of root canal preparation.

The least amount of cracks observed in TFA could be attributed to the new adaptive reciprocating motion. This system when exposed to a minimal or no load uses continuous rotation and when it engages dentin and load is applied, it uses reciprocal motion.¹¹ This

adaptive movement might have decreased the stress concentration on the root canal wall resulting in less crack formation at the apical level

Kim et al.¹² suggested that file design increases the apical stress and strain during instrumentation. ProTaper Next files have different cross-section design which could be the reason for the reduced dentinal cracks at the apical section in this study. According to Ruddle et al.,⁶ decreased incidence of cracks in the tooth when ProTaper Next files were used may be due swagging motion generated by the off- centered rectangular design of the file. This motion could decrease the screw effect, dangerous taper lock and torque on any given file by reducing the contact between the dentin and file.⁶

Burklein and others¹³ in their study found both Wave one and Reciproc to produce significantly more cracks than Protaper similar to the results of the present study. In their study more defects was created by

reciprocating single file than Mtwo and Protaper files used in full rotary sequence. According to the authors in reciprocating system since single file is used till working length there is more chances of stresses on canal wall. In a study by Gergi et al.⁷ it was observed that both Reciproc and WaveOne produce significantly more cracks than TF Adaptive in the apical third of the root and correlated it with the cross-sectional design of the instrument. The WaveOne has a convex triangular cross section in the middle and coronal portion of the instrument with a modified triangular cross section with radial lands at the tip leading to reduced cutting efficiency and smaller chip space when compared to Reciproc having S-shaped geometry with a double cutting edge; however the difference was statistically insignificant.

Contrary to our findings, Berutti and others⁹ found that the Reciproc and wave one produced significantly less dentinal cracks than Protaper Next. According to the authors the Protaper next produces active rotating movement which causes high level of stress concentration in the walls of root canal that may have resulted in higher incidence of formation of cracks. Liu and others¹⁴ in their study reported only 5% of cracks when Reciproc was used in reciprocating motion whereas 50% cracks when ProTaper universal files was used in full sequence rotary motion. Roane et al.¹⁵ and Mavani et al.⁵ found that incidence of root cracks was less when reciprocating wave one file was compared to multiple file system. According to the authors, reciprocating motion is similar to balanced force technique which could have minimized stresses both torsional and flexural. They also added WaveOne instrument is made from M-wire, which is a more flexible variant of the NiTi alloy.

Conclusion

In the present study, Reciproc showed maximum number of cracks followed by WaveOne and ProTaper Next showing similar number of cracks and least by TF Adaptive system. Therefore, it can be concluded that rotary & reciprocating file system tested in the present study caused significantly more dentinal defect compared to the unprepared groups.

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