



ROTARY VERSUS RECIPROCATING FILE SYSTEM: AN INVITRO STEREOMICROSCOPIC EVALUATION OF RADICULAR DENTINAL CRACKS FORMATION AT VARIOUS ROOT LEVELS

Dental Science

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ABSTRACT

Aim: This invitro study is designed to evaluate and compare the radicular dentinal cracks at various root levels formed by rotary and reciprocating file systems

Methodology: The study was carried out on 50 mandibular premolars with single canal which were divided among 3 groups of 15 each as test samples and 1 group served as negative control group consisted of 5 teeth. Access opening of the teeth was done using diamond burs and high speed contra- angle hand piece. Canal length was measured by inserting a size 10 k-file into canal terminus and subtracting 1 mm from this measurement. A glide path preparation was done using 15 k-type files. Apical preparation was completed with size 25 instrument of each system. Bio-mechanical preparation was done using Pro-Taper universal (rotary endomotor) (n=15), Pro-Taper Gold (rotary endomotor) (n=15) and WaveOne Gold (reciprocating handpiece) (n=15) in Group A, Group B and Group C respectively. Teeth in Group D were not instrumented (negative control group) (n=5). Irrigation was carried out using 3% sodium hypochlorite and 9% saline using 27 guage syringe. Teeth were sectioned at 3mm, 6mm and 9mm from the apical end and were observed under the stereomicroscope for dentinal cracks.

Results: Statistical analysis was performed using (SPSS) version 16 for windows (SPSS Inc, Chicago, IL). Data normality was checked by Shapiro-wilk test. Intergroup comparison of means between 4 groups i.e. Cracks measurements of different groups were done with the help of ANOVA test. Intergroup pair wise comparison was done using Tukeys post hoc test.

Conclusion: ProTaper universal and protaper gold rotary files have tendency to cause more dentinal cracks when compared with Waveone reciprocating system which showed the least number of dentinal cracks at all the levels of root. Both rotary as well as reciprocating file systems tend to generate more stress and thus more dentinal cracks at the apical third in comparison to middle and coronal third

KEYWORDS

dentinal cracks, Protaper file, Reciprocating file, Stereomicroscope, Wave One Gold file

INTRODUCTION

The main objective of chemomechanical root canal preparations involves preservation of the course of canals and efficiently cleaning of the entire root canal system. 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. The increased flexibility & superelasticity of the NiTi alloy & specific geometric design of Rotary NiTi instruments have an advantage over the traditional hand files as they produce fewer ledge, zip formations, canal transportations & perforations¹.

However, the success rate of root canal treatment is challenged when the teeth are instrumented with with rotary NiTi instruments having active cutting edges & 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}.

Further, The use of high concentrations of sodium hypochlorite, loss of tissue, dehydration of dentin, tooth anatomy, placement of prosthetic posts and different obturation techniques worsens the strength of root dentin⁶. Kim et al (2010) stated that file design affects strain concentration and the apical stress during root canal instrumentation. Whether it is hand files or rotary instruments, they are anticipated to cause restricted frictional forces within the canal, thus generating radicular dentinal defects.⁷

Rotary files like ProTaper Universal files (Dentsply Maillefer, Ballaigues, Switzerland) are the gold standard NiTi were compared in its tendency to induce dentinal damage in form of root microcracks and were reported to create more dentinal damage because of larger taper and convex triangular cross-section leading to increased dentin removal than other files.

Reciprocating files uses reciprocating motion which is similar to

balanced force technique minimizes torsional and flexural stresses are being tried these days to minimize the deleterious effects caused by continuous rotary motion of rotary Ni Ti files on root canal dentin⁸. Wave One gold (Dentsply Maillefer, Ballaigues, Switzerland) is recently introduced single-file engine-driven reciprocating file system. The file is made of M-Wire NiTi alloy, which enhances flexibility while maintains cutting ability. Due to the reciprocal motion, pattern of stress applied to the root canal walls is expected to be different from that of conventional rotary systems This invitro study was designed to evaluate and compare the radicular dentinal cracks at various root levels formed by rotary (protaper universal, protaper Gold) and reciprocating file (Waveone Gold) systems with the null hypothesis that there is no significant change in the dentin crack formation with both rotary as well as reciprocating file systems.

Methodology

The sample size was calculated with a total of 50 which was further divided into 3 groups, 15 for each group and 5 teeth for negative control group keeping the Level of significance at 5% and power of study at 80% Teeth which were Free of caries, restorations, cracks or other structural defects were included and teeth with developmental anomalies, trauma dehydration (brittle), calcified canals and teeth which had more than one root (fused or separate) were excluded from the study.

Sixty extracted human mature single canal mandibular premolar teeth without any defects were selected. Cleaning and removal of tissue remnants on the root surfaces were carried out using curettes and ultrasonic tips. The teeth were stored in distilled water until use. The selected teeth were randomly divided into group A,B and C with protaper universal, protaper gold and wave one gold respectively of 15 teeth each (n=15) and a negative control group of 5 teeth(n=5)

As suggested previously⁹, a single layer of aluminum foil was used to cover the roots of the teeth, and each root was embedded into acrylic

resin set in an acrylic tube. Root was removed from tube, and the aluminum foil was removed from the root. A light-body silicon-based material was used to replace space created by aluminum foil and simulate periodontal ligament, and the root was immediately inserted into impression material. Apical 3 mm of root was exposed and immersed in water during instrumentation to prevent dehydration. Access opening of the teeth was done using diamond burs and high speed contra-angle hand piece. Canal length was measured by inserting a size 10 k-file into canal terminus and subtracting 1 mm from this measurement. A glide path preparation was done by 15 k-type files. Apical preparation was completed with size 25 instrument of each system using ethylene diamine tetraacetic acid (EDTA) gels with intermittent irrigation with Sodium Hypochlorite (NaOCl) and saline irrigating solution.

In the ProTaper Universal and Protaper Gold group, the following sequence was used for canal preparation at 300 rpm and recommended torque values for each file using a crown down technique. Sx file was used for coronal enlargement and S1, S2, F1 and F2 corresponding to apical size 25 used at working length.

In WaveOne Gold (WOG) group, the root canals were prepared with a WOG primary single file(25/0.07) in a reciprocating movement. The preparation was performed with in-and-out pecking movements of the instrument with 3 mm of amplitude until the WL was reached with a brush motion on the buccolingual extension. Speed and torque was maintained at 350 rpm and 5 N/cm2 of torque respectively Bio-mechanical preparation was done for all groups according to manufacturer's instructions.

Irrigation was carried out using 3% sodium hypochlorite and normal saline using syringe. Teeth were sectioned at 3mm, 6mm and 9mm from the apical end using slow speed micromotor under water coolant and diamond disc and were observed under the stereomicroscope for dentinal cracks and images were captured by digital camera attached to stereomicroscope.

Each specimen was checked by two operators for the presence of dentinal defects.

Defects were classified using Wilcox et al¹⁰ classification as no defect, fracture and all other defects.

"No defect" was root dentine without any lines or cracks, neither the external surface nor the internal root canal wall had no defects. "Fracture" was the teeth with crack that was extending from the root canal space to the outer root surface. "Other defects" were other cracks that did not extend from the root canal to the outer root surface. This includes the internal and external craze lines and partial cracks. "Internal craze lines" included cracks extending from the canal lumen wall into the dentin without reaching the root surface; however, "external craze lines" were defined as cracks extending from the root surface into dentin without reaching the canal lumen

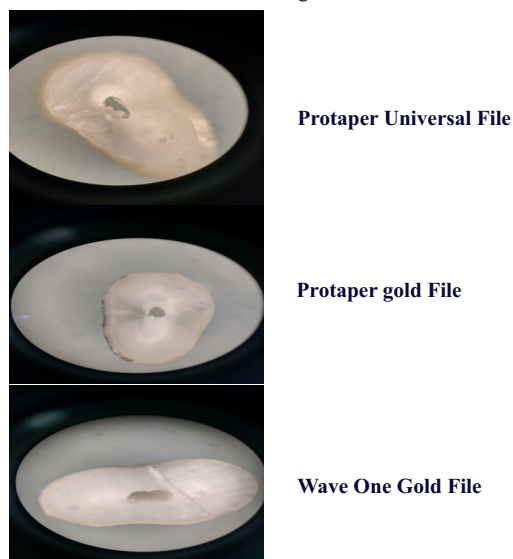


Fig 1: Stereomicroscopic images of dentinal cracks

RESULTS

Statistical analysis were performed using Statistical Package for Social Sciences(SPSS)version 16 for Windows(SPSS INC, Chicago, IL).Descriptive data was expressed in proportions(percentages).Chi square test was used to compare percentage/proportion of cracks among four groups at various levels of root dentin. Confidence interval was set at 95% and probability of alpha error set at 5%.Power of the study set at 80%

At the apical third(3mm from apex), protaper universal file(40%) showed maximum number of dentinal cracks followed by protaper gold(20%) and reciprocating wave one gold(13.33%) which was statistically significant($P=0.039$)(Table 1)

Table 1: Comparison of frequency of cracks at 3mm level

Groups – 3MM Level	Present n (%)	Chi-square	p value, Significance
Control	0/15 (0%)	Chi = 8.349	p = 0.039 , significant difference
Protaper Universal	6/15 (40%)		
Protaper Gold	3/15 (20%)		
Wave One	2/15 (13.33%)		

Table 2: Comparison of frequency of cracks at 6 mm level

Groups – 6 MM Level	Present N (%)	Chi-square	p value, Significance
Control	0/15 (0%)	Chi = 4.320	p = 0.229 (no significant difference)
Protaper Universal	4 /15 (26.6 %)		
Protaper Gold	3/15 (20%)		
Wave One	3 /15 (20 %)		

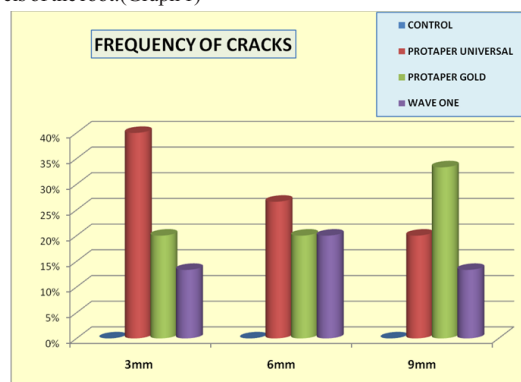
At the middle third(6mm from apex), protaper universal file(26.6%) showed maximum number of dentinal cracks followed by protaper gold(20%) and reciprocating wave one gold(20%) which was statistically insignificant($P=0.229$)(Table 2)

At the cervical third(9mm from apex), protaper universal file(20.0%) showed maximum number of dentinal cracks followed by protaper gold(33.3%) and reciprocating wave one gold(13.33%) which was statistically insignificant($P=0.229$)(Table 3)

Table 3: Comparison of frequency of cracks at 9 mm level

Groups – 9MM Level	Present N (%)	Chi-square	p value, Significance
Control	0/15 (0%)	Chi = 6.240	p = 0.100, no significant difference
Protaper Universal	3/15 (20%)		
Protaper Gold	5 /15 (33.3%)		
Wave One	2/15 (13.33%)		

None of the control group specimen showed dentinal cracks at any levels of the root.(Graph 1)



Graph 1: Frequency Of cracks

DISCUSSION

In this invitro study all the teeth were examined thoroughly under microscope and periapical radiographs were taken to rule out any possible surface cracks or internal cracks. None of the teeth presented cracks indicating the cracks produced were solely due to instrumentation with rotary as well as reciprocating files.

ProTaper universal files (40%) and Protaper Gold (20%) caused significantly more cracks than WaveOne files (13.33%) at 3mm level

from apex of tooth $p=0.039$ (Table 1). These results are in agreement with previous study by Capar et al.¹¹ (2004) who showed the rotary NiTi instruments caused more dentinal cracks at apical third of root dentine. PTU files have larger taper and show active cutting action in rotation producing maximum stress along the root dentin¹²

At 6mm and 9mm protaper universal showed more cracks (26.6% and 20% respectively) than protaper gold and waveone but the results were not significant (Table 2 and Table 3). The file sx is large and cuts the coronal dentin aggressively producing more dentinal cracks. Progressively increasing taper, smaller pitch, more number of files producing more rotations, triangular convex cross section are the other contributing factors in developing dentinal microcracks¹³

In the present study, reciprocating WaveOne gold file created lesser incidence of root cracks as compared to multiple rotary files system. Reciprocating motion is similar to balanced force technique which minimizes torsional and flexural stresses.¹⁴ Alternating engaging and disengaging of canal walls in reciprocating motion might have lead to lesser stress concentration on canal walls and caused least incidence of root microcracks compared to other groups in the study. The results of this study is in agreement with previous study by Liu et al.² found that when Reciproc was used in reciprocating motion less cracks (5%) were found as compared to ProTaper universal files (50%) used in full sequence rotary motion

Moreover, WaveOne instrument is manufactured with M-wire, which is a more flexible variant of the NiTi alloy. Kansal et al.¹⁵ conducted a similar study and found that when ProTaper F2 and WaveOne files were used in reciprocating motion induced lesser dentinal damage as compared to ProTaper F2 file used in rotary motion

The WAVEONE GOLD file covers a wider range of canal morphologies due to enhanced flexibility in the GOLD-Wire. All files now have a reduced taper to support the clinician to achieve minimally invasive dentistry. Improved protection to the patient due to the file having a higher cyclic fatigue resistance and reduced screwing effect compared to standard rotary systems. Shorter shaping time due to having a higher cutting efficiency. Like previous studies Microcracks were observed under stereomicroscope¹ after sectioning the roots at various levels which has disadvantage of deleterious effect of sectioning procedure but none of the control group showed microcracks indicating the sectioning procedure did not induce microcracks in the tested samples and were mainly due to the instrumentation of the root canals with NiTi rotary as well as reciprocating files.

Many studies have used micro computed tomography imaging which is non destructive to investigate microcracks by rotary instrumentation¹⁶ but there are high chances of these imaging procedures developing heat leading to dehydration of samples inducing cracks which might affect the results of the studies¹⁷.

However, further studies using other methods such as optical coherence tomography or infrared thermography should help in minimizing the apparent disadvantages of the mentioned techniques to achieve predictable results.

Files used in this study were used at varying recommended speed and torque which cannot be standardized for all files. The use of different speed and torque setting for each file system could be a limitation of the present study. Also it was difficult to standardize the downward force used during instrumentation. Furthermore, teeth with only straight root canals were selected without anatomic complexities which did not reproduce true clinical presentation

CONCLUSION

Within the limitation of the present invitro study, rotary and ciproccating files used in the present study showed dentinal cracks at all the levels of root.

ProTaper universal and protaper gold rotary files have tendency to cause more dentinal cracks when compared with Waveone gold reciprocating system which showed the least number of dentinal cracks at all the levels of root.

Both rotary as well as reciprocating file systems tend to generate more

stress and thus more dentinal cracks at the apical third in comparison to middle and coronal third

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