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Research paper

Comparison of incidence of dentinal defects after root canal preparation with continuous rotation and reciprocating instrumentation

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ABSTRACT

Biomechanical preparation is one of the most important steps in endodontic therapy. Rotary instrumentation has facilitated this step. Nowadays the market is flooded with different types of rotary instruments. The present study compared the root dentinal crack formation with continuous rotating versus reciprocating root canal preparation methods. One hundred and fifty freshly extracted teeth were used for the study. They were divided into 5 groups with 30 teeth in each group. Thirty teeth were kept under control group A and no root canal preparation was done for this group. Another 30 teeth were prepared with hand files which were kept under control group B. In the experimental groups (sample size, $n=30$ each) root canals were prepared with ProTaper, K3XF rotary system and WaveOne. Sectioning of these teeth was done at 3, 6 and 9 mm from the apex and were evaluated for the presence of any defects. Root dentinal cracks were produced with each type of rotary instruments. Statistical analysis showed no significant difference in root dentinal crack formation between control groups and WaveOne system. There was statistically significant difference in root dentinal crack formation when the canals were prepared with ProTaper and K3XF rotary system. So it was concluded, that continuous rotating instruments could produce dentinal crack formation. Root canal instruments with reciprocating movement appear to be a better option than continuous rotation movement.

Introduction

The main goal of cleaning and shaping the root canal system is to prepare the root canal, thus creating adequate space for copious irrigation and three dimensional obturation [1,2]. Use of inflexible stainless steel instruments in curved canals can cause iatrogenic damage to the original shape of the root canal [3]. This damage can be in the form of canal

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transportation, ledge formation or perforation [4]. To avoid this damage, nickel titanium (NiTi) instruments with shape memory and superelasticity were developed [5]. But NiTi instruments carry inherent risk of instrument fracture and root dentinal crack formation [6,7]. These root dentinal cracks can further progress to root fractures resulting in failure of root canal treatment [8].

Most commonly NiTi instruments are used with two types of movement: first is continuous rotating full sequence and second is reciprocating. Torsion and flexion occur with continuous rotating NiTi instruments while preparing root canals, which can lead to instrument fracture. To avoid this, reciprocating movement was proposed [9]. This movement minimizes the stresses on instrument by counterclockwise (cutting action) and clockwise (release of instrument) movements [10]. Reciprocating movement claims to mimic manual movement and reduces various risks associated with continuous rotating file systems. But reciprocating systems with small and equal Clockwise (CW)/Counterclockwise (CCM) angles have decreased cutting efficiency, thus making progression into canal more laborious [11].

WaveOne (Dentsply Maillefer, Ballaigues, Switzerland) is a single instrument NiTi file system to shape the root canal completely from start to finish. These specially designed NiTi files work in a reverse 'balanced force' action using a preprogrammed motor to move the files in a back and forth reciprocal motion. As WaveOne utilizes CCW (counterclockwise) movement greater than CW (clockwise) movement, it is claimed that it requires less apical pressure for its advancement into the canal [12]. It was also thought that reciprocation might decrease the incidence of dentinal cracks formation. But this speculation is not supported by literature.

Thus, the present study was taken up to compare the incidence of generation of dentinal defects after canal preparations with continuous rotating instruments (ProTaper and K3XF system) and WaveOne (reciprocating motion).

Materials and method

One hundred and fifty freshly extracted human mandibular premolars were selected for the study. Mature root apices and single straight root canals with single apical foramen were main considerations for the sample selection. Single rooted premolars were verified by taking their buccal and proximal radiographs. The coronal portions of all the teeth were removed with diamond disks, (Jiangyin Rongmai international trading Co. Ltd., China) leaving roots 16 mm in length. All roots were observed under a stereomicroscope (12x magnification, Trinocular Stereo Zoom Microscope Nikon SMZ- 745T) to exclude the presence of any cracks. Access cavity was prepared for each tooth and patency of canal was checked with ISO No. 10 K file (Dentsply Maillefer Ballaigues, Switzerland). Working length was measured with ISO No. 15 K file (Dentsply Maillefer Ballaigues, Switzerland) keeping it 1 mm short of the apical foramen.

For continuous rotating instrumentation – Protaper (Dentsply Maillefer, Ballaigues, Switzerland) and K3XF systems (SybronEndo 1717 West Collins Avenue, Orange, CA 92867) were used. For reciprocating instrumentation a WaveOne (Dentsply Maillefer, Ballaigues, Switzerland) system was used. For ProTaper and WaveOne 6:1 reduction handpiece (X-smart plus, Dentsply Maillefer Ballaigues, Switzerland) with individual torque limit and rotational speed programmed in the file library of the motor was used. For a K3XF system torque limit and rotation speed as specified by manufacturer was used.

After each continuously rotating instrument or after 3 pecks while using the reciprocating files, irrigation was done with 5 ml of 3% sodium hypochlorite solution (Septodont) using 27 gauge needle (Romsons Juniors India Unit-II C-1, Foundary Nagar, Agra).

Sample size of 150 teeth was randomly divided into five groups with 30 teeth in each group.

Control group A: Teeth left unprepared.

Control group B: Hand instrumentation was done using a step back technique. After coronal enlargement with Gates Glidden burs, apical preparation to the desired master apical file ISO size 40 was commenced with K files to working length. Then the working length was progressively decreased by (modified step back technique) 1 mm to create a tapered

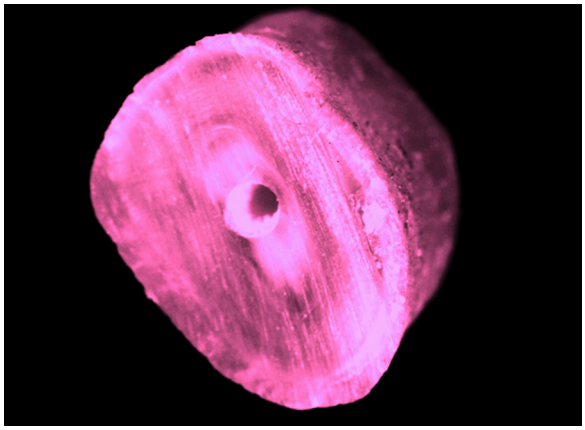

Fig. 1 – Craze line i.e. line extending from outer surface into dentin but does not reach the canal lumen.

Fig. 2 – Partial crack i.e. line extending from canal walls into dentin without reaching outer surface.

shape. After each step recapitulation was done with a smaller number K-file.

Group C: A ProTaper rotary system (Dentsply Maillefer, Ballaigues, Switzerland) using a crown down technique was used to prepare samples of this group. The instrument sequence used was SX instrument at two third of the working length, S1 and S2 at working length minus 1 mm. Further F1 (20/.07), F2 (25/.08), F3 (30/.09) and F4 (40/.06) were used at working length.

Group D: Samples were prepared using the K3XF rotary system (SybronEndo 1717, West Collins Avenue, Orange, CA 92867) using a crown-down technique. Canal preparation was done with the K3XF technique with file No. 40/.06 at working length.

Group E: WaveOne file was used in a reciprocating working motion generated by torque control motor using a WaveOne technique. A reciprocating WaveOne file No. 40/.08 was used in a reciprocating slow in and out pecking motion till working length.

One examiner completed all root canal preparations and cross sectioned all samples. These cross sectioned samples were examined by another two experienced examiners having minimum of five years post PG experience, who were not given any information about the specimens they were examining. This was to rule out any operator bias. Sectioning of prepared teeth was done at 3, 6 and 9 mm from the apex using 0.1 mm low speed diamond disc (Jiangyin Rongmai international trading Co. Ltd., China). Water was used as coolant during this process to avoid any artefacts because of dehydration. Teeth were kept moist in distilled water throughout the study. Digital stereomicroscope (Nikon Model SMZ- 745T) with cold light source was used to observe the sectioned samples and digital photographs were taken. Results from the two examiners were compiled and statistically evaluated.

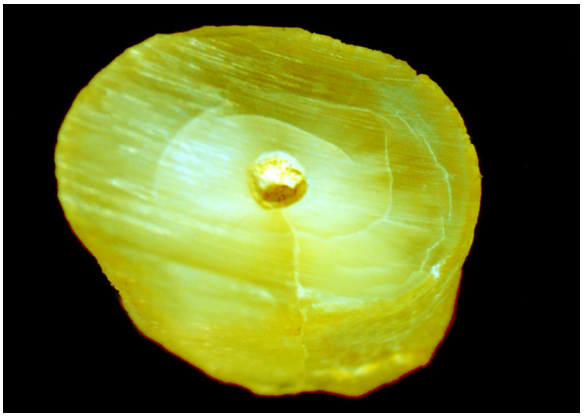

Fig. 3 – Fracture: line extending from root canal space all the way to outer surface of root.

A scoring system used according to the type of defects present [13]

No Defect (Score 0): Root dentin devoid of any lines or cracks where both external surface of root and internal root canal wall does not present any evident defects.

Craze line (Score 1): Line extending from outer surface into dentin but does not reach the canal lumen (Fig. 1).

Partial crack (Score 2): Line extending from canal walls into dentin without reaching outer surface (Fig. 2).

Fracture (Score 3): Line extending from root canal space all the way to outer surface of root (Fig. 3).

The incidences of root dentinal defects among various groups were compared by using a Chi square test.

Results

Roots were classified as 'defective' if at least one of three sections showed either a craze line, partial crack or a fracture. Results were expressed as number and percentage of defective roots in each group (Table 1). A complete crack was present in only one (3.3%) sample prepared with the ProTaper rotary system.

The data collected was statistically analyzed to compare the presence of defective roots between various experimental groups. Each group was compared with control groups and it

Table 1 – Comparison of number and percentage of teeth showing defects between various groups at coronal, middle and apical third.

Dentinal damage	Control group (A)	Control group (B)	Protaper rotary	K3XF rotary	WaveOne	Total
At coronal third						
Score 0	30 (100%)	30 (100%)	22 (73.3%)	25 (83.3%)	28 (93.3%)	135
Score 1	–	–	6 (20%)	3 (10%)	2 (6.7%)	11
Score 2	–	–	1 (3.3%)	2 (6.7%)	–	3
Score 3	–	–	1 (3.3.%)	–	–	1
At middle third						
Score 0	30 (100%)	30 (100%)	24 (80%)	29 (96.7%)	27 (90%)	140
Score 1	–	–	3 (10%)	1 (3.3%)	2 (6.7%)	6
Score 2	–	–	2 (6.7%)	–	1 (3.3%)	3
Score 3	–	–	1 (3.3%)	–	–	1
At apical third						
Score 0	30 (100%)	30(100%)	30 (100%)	30 (100%)	30 (100%)	150
Score 1	–	–	–	–	–	–
Score 2	–	–	–	–	–	–
Score 3	–	–	–	–	–	–
Total	30	30	30	30	30	30

was found that WaveOne did not produce any significant dentinal cracks. ProTaper and K3XF rotary systems produced significant dentinal cracks as compared to control groups but when were compared with each other no significant difference was found (Tables 2 and 3).

Discussion

Rotary endodontics was developed with the aim of reducing the treatment time, increasing efficiency and accuracy of root canal preparation. Currently, there are many different NiTi rotary systems available in the market. Root canal preparation with different rotary NiTi endodontic instruments may cause stress and strain which can lead to micro cracks or craze line formation in root dentin [14]. Tip design, cross-sectional geometry, taper, pitch and flute form of NiTi instruments may contribute to the extent of these defects [15].

The total volume of dentin removed from root canals is significantly greater with NiTi engine driven systems when compared to hand filing, this may contribute for the formation of the defects. These small defects can extend to the external surface thus breaching the intact root dentin. Also defects shown in one section might communicate with defects in another section [16].

Control group A samples showed no cracks on external surface when observed under stereomicroscope before sectioning. Even after sectioning no cracks were found. This means that the sectioning method used in the study did not induce any cracks. So cracks if present in other groups should be due to the technique of root canal preparation.

Control group B samples also showed no crack formation, even after using Gates Glidden burs for coronal flaring as their use was limited to coronal one-third only. This was in accordance with the earlier studies which concluded that use of Gates Glidden burs for coronal flaring does not induce cracks in the root dentinal wall [17]. Less crack formation with hand filing can be because of the slower speed, better tactile sensation and less stress generated as compared to rotary instruments. However, this must be balanced against the better efficiency of motor driven systems in cleaning and shaping the root canal.

Group C samples prepared with ProTaper files showed the most root dentinal crack formation among all the groups, in 33.3% of samples. This could be attributed to continuous rotating motion and design of the file having triangular or modified triangular cross section resulting in less space for collection of dentine chips, thus generating stresses on the root dentinal wall. Its 7–9% taper of various files from F1 to F3 can also cause more stresses. Bier et al. also found cracks in horizontal section of 16% of roots instrumented with the ProTaper system [18]. Liu et al. observed cracks at apical root surface in 25% of roots instrumented with the ProTaper system [19].

Group D samples prepared with K3XF files showed crack formation in 16.7% of samples. Decrease in incidence of crack formation with this continuous rotating system could be due to its peripheral blade relief design of the file which claimed to reduce friction, facilitating its smoother operation. This feature controlled the depth of cut which prevented the files from over-engagement thus, protecting the root dentin from getting more damaged [20].

Present study found that WaveOne file produced significantly less cracks i.e. only 10% of group E samples. It was found that the single file (WaveOne) system caused less damage as compared to multiple files used by the ProTaper or K3XF system. This might be due to the reciprocating motion, the difference in file design in this single file system and shorter root canal preparation time.

The present study showed more crack generation at coronal third as compared to middle or apical third. Versluis et al. also concluded that the stresses generated at 1 mm short of the apical foramen were one third of stresses at more coronal levels. This may be due to increase in taper of various files towards the coronal third [21].

Other reasons that can contribute to the root dentinal crack formation beside different type of systems are operator skill, storage conditions and the absence of periodontal cushioning in prepared samples. Clinical procedures that can further lead to propagation of these cracks are stresses induced by obturation methods or postspace preparation techniques [22, 23]. In addition, simple masticatory forces, parafunctional habits like bruxism and occlusal loading can also contribute to progression of incomplete cracks to complete fracture of root.

One main shortcoming of this study was that we could not match the roots for root dentine thickness amongst all groups. Although we have used only mandibular premolars in all groups, there would still be differences in dentine thickness. Thickness variation would give rise to significant changes in strength and hence its response to stresses during instrumentation, we must interpret the results of this study with some caution.

Table 2 – Comparison of number and percentage of teeth showing defects between control and experimental groups.

Defect	Control group (A)	Control group (B)	Protaper rotary	K3XF rotary	WaveOne
Absent	30 (100%)	30 (100%)	20 (66.7%)	25	27 (90%)
Present	–	–	10 (33.3%)	5	3 (10%)
Total	30	30	30	30	30

Table 3 – Basic statistical values and level of significance of comparison between control and experimental groups.

Group comparison	Chi square value χ^2	Degree of freedom (df)	'p' Value	Level of significance
Control groups Vs Protaper	12	1	0.001	Significant
Control groups Vs K3X rotary	5.455	1	0.020	Significant
Control groups Vs WaveOne	0.00	1	1.000	Not significant

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