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Research Article

Effect of Four Reciprocating Single-File System on Dentinal Crack Formation: An *In Vitro* Study

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Abstract

Introduction: The purpose of this study was to compare the formation of microcracks after canal preparation performed with four different reciprocating single-file systems: Reciproc (VDW, Munich, Germany), Wave One (Dentsply Maillefer, Ballaigues, Switzerland), Reciproc Blue (VDW, Munich, Germany) and Wave One Gold (Dentsply Maillefer).

Methods: Eighty extracted mandibular first premolars were selected and divided into 4 experimental groups (n = 16 teeth) and a control group (unprepared teeth, n = 16); Control, Reciproc (group 1), Reciproc Blue (group 2) Wave One (group 3) and Wave One Gold (group 4). Roots were then sectioned at 3, 6 and 9 mm from the apex, and the surface was observed under a stereomicroscope. Data were analyzed using logistic regression ($P < .05$).

Results: No cracks were observed in the control group. All the systems tested caused cracks, mainly in the apical section (3 mm). Wave One Gold (50.0%) and Reciproc Blue (62.5%) showed fewer microcracks than other experimental groups ($P < .05$). There was no significant difference among Reciproc and Wave One experimental groups ($P > .05$).

Conclusion: All the instruments tested created dentinal cracks. Within the limitations of this study, the flexibility of nickel-titanium instruments because of heat treatment seems to have a significant influence on dentinal crack formation. Wave One Gold caused less microcracks than the other instruments tested.

Keywords: *Micro Cracks; Single-File System; Wave One Gold; Reciproc Blue*

Introduction

During biomechanical preparation, a canal is shaped by the contact between instruments and dentin walls. These contacts create many momentary stress concentrations in dentin. Such stress concentrations may induce dentinal defects and craze lines or microcracks [1]. Thus root canal shaping procedures have the potential to induce crack formation, which can extend to complete fractures under functional load and these vertical root fracture become frustrating complications of root canal treatment as they often result in tooth extraction [2]. Most of the nickel-titanium file systems used multiple files to shape the canal. Review of literature reveals, more dentinal defects with full-sequence rotary files. Recently a new concept proposes use of "single use, single file system to shape the canal completely from start to finish" thus requiring less time than full sequence rotary systems [3]. The use of reciprocating motion has been shown to extend the lifespan of NiTi instruments, hence increasing fatigue resistance, compared with conventional continuous motion.

Different heat treatments, design features, such as NiTi core diameter, cross-sectional shape, taper, rake angle, type of alloy affect the behaviour of these single file systems and therefore, may influence the generation of cracks.

Currently single file systems used in reciprocating motion are: Reciproc and Reciproc Blue (VDW GmbH, Munich, Germany) [4] and Wave One and Wave one Gold (WOG, Dentsply Maillefer) [5]. Reciproc and wave One made of M wire Niti alloy subjected to innovative thermal treatment to increase flexibility. Reciproc Blue has a S-shaped cross section, 2 cutting edges, 8% taper and a noncutting tip made of special NiTi alloy with innovative heat treatment. Wave One has apical cross section which is modified convex triangular and coronal cross section is convex triangular and has fixed taper 8%. Wave One Gold metallurgy was changed from M-wire to a gold alloy. The cross section of the file was modified to a offcentered parallelogram, having 2 cutting edges and variable taper of 7%.

Materials and Methods

Freshly extracted mandibular first premolars from the Department of Oral and Maxillofacial Surgery GDC Srinagar were used as the study samples. The total number of extracted teeth used for the study were 80 and stored in distill water. Proximal radiographs were taken and only single rooted teeth with single canal were included in study. To standardise canal instrumentation, teeth were decoronated by diamond disc with water cooling, establishing a standardised root length of 14 mm.

Each specimen was examined with dental operating microscope (DOM) (micro vision Dental Microscope) to exclude cracked samples for excluding teeth with any external defects. Teeth with such findings were excluded and replaced by similar teeth in the study. Determination of sample size with a α-error of 5% and power of 80% it was estimated that 16 teeth would be needed in each group (n = 16). In all teeth, the canal width near the apex was compatible with a size 10 K-file (Dentsply Maillefer). The buccolingual and mesiodistal widths of the canals were measured at 9 mm from the apex on radiographs. Roots with comparable canal widths were finally selected. Sixteen teeth were left unprepared as the control group. The working length was established by subtracting 1 mm from the length of a size 10 K-file inserted into the canal until the tip of the file became visible at the apical foramen. The periodontal ligament was simulated using addition silicone impression and fixing the teeth in blood sample collecting tubes with it. A working jig (Figure 1) was constructed to hold the tubes containing teeth to standardize the instrumentation.

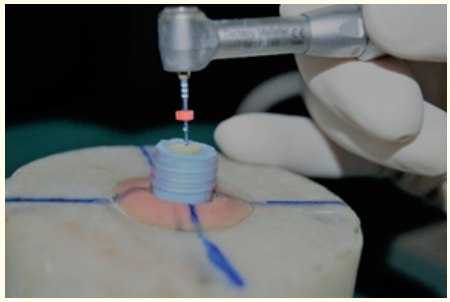

Figure 1: Simulation of periodontal ligament by silicone impression (blue arrow) material and customized jig for standardization of instrumentation (white arrow).

Root canal preparation

Teeth in control group were left unprepared and stored in distill water. All instruments were activated using programmed reciprocating motion generated by X smart plus motor (Dentsply Maillefer).New file were used to shape each canal. The Reciproc and reciproc blue files were used in RECIPROC ALL mode (tip size 25 and an 8% taper over the first 3 mm from the tip). Wave one (tip size 25, 0.08 taper from d1-d3) and Wave one Gold (tip size 25, 0.07 taper from d1-d3) primary files were used in WAVEONE ALL mode. All the files were used in slow in-and-out pecking motion, no more than three to four times with minimum apical pressure.

After each instrument insertion, the teeth were irrigated with 2 mL 3% sodium hypochlorite using a syringe and a 30-G Endo Irrigation Needle single side vent placed 1 mm from the working length. After completion of the procedure, canals were rinsed with 2 mL distilled water. To avoid any artifact by dehydration, all roots were kept moist in distilled water throughout all the experimental procedures.

Sectioning and microscopic observation

All the roots were horizontally sectioned at 3, 6 and 9 mm from the apex with diamond disc at low-speed under water cooling. The

slices were then analyzed using a stereomicroscope (Kyowa Getner, Japan). The samples were photographed with a reflex camera (Nikon D90; Nikon Tokyo, Japan) attached to the stereomicroscope at a magnification of 24x and 80x to determine the presence of micro cracks (Figure 2).

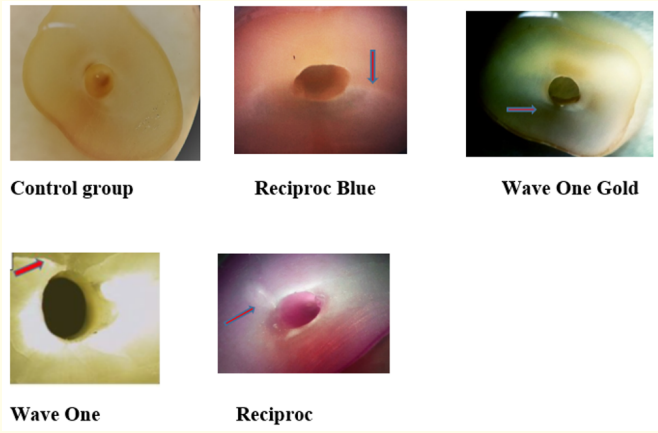

Figure 2: Microscopic cross sections from each experimental group at the 3-mm level.

Definition of defects (scoring of Defects)

The dentin surface was inspected and dentinal defects observed were categorized as follows:

- 0 = No defect - root dentin devoid of any craze lines, microcracks and fractures.
- 1 = other defects - incomplete cracks: a craze line- a line extending from the outer surface into the dentin, without reaching the canal lumen, or a partial crack - a line extending from the canal walls into the dentin without reaching the outer surface.
- 2 = Fracture - a line extending from the root canal space all the way to the outer surface of the root.

Roots were classified as cracked if at least 1 of the 3 sections obtained from each root showed even 1 defect.

Statistical analysis

The recorded data was compiled and entered in a spreadsheet (Microsoft Excel) and then exported to data editor of SPSS Version 20.0 (SPSS Inc., Chicago, Illinois, USA). Data were summarized as frequencies and percentages. A logistic regression was used to ascertain the effects of canal preparation by four different file system on likelihood of crack formation.

Results

No complete fracture was observed in any samples examined. No defect was observed in the control group. All single files tested caused dentinal cracks. The distribution of other defects per group and section level as well as total cracked roots and their relative percentage was evaluated.

The apical section (3 mm) showed major number of microcracks. WOG showed statistically fewer roots with microcracks compared with other experimental groups ($p < .05$). WOG and Reciproc Blue showed statistically significant difference with other experimental groups (Wave One and Reciproc) at 3,6 and 9 mm level ($p < .05$).

Number of other defects at different Levels				Number and percentage of roots with other defects per groups
Group	3 mm	6 mm	9 mm	
	No.	No.	No.	
Control	0	0	0	0.0
Reciproc	13	7	7	12 (80.0%)
Reciproc Blue	7	3	3	10 (62.5%)
Wave One	14	8	7	13 (81.3)
Wave One Gold	5	2	2	8 (50.0%)

Table

Discussion

Root canal preparation procedures can damage the root dentin, resulting in dentinal microcracks, crazelines and fractures. Single file systems used in reciprocating motion such as Reciproc Blue and Wave One Gold are recently introduced into market and it is claimed that the alloy and different heat treatments used in these systems enables high flexibility, fatigue resistance and superior adaptation of these files to the root canal walls [6]. The results of the present study showed dentinal microcracks caused by all 4 single-

file systems which is in agreement with other *in vitro* root canal instrumentation studies that have persistently shown such results [7,8]. The final apical diameter achieved with these four file system was similar (size 25) and this standardization improved reliability of the results. The methodology used was adapted from previous studies [9-12]. To enable better stress distribution during the shaping procedures, PDL simulation was done with silicon impression material because it acts as a major stress absorber [12,13]. The roots were distributed among the groups equally according to their root canal diameter at the 9-mm level. Standardization was achieved in the groups by including only teeth with a canal width near the apex compatible with a size 10 K-file and leaving all the roots approximately 14 mm in length. In this study teeth were sectioned at different levels. The sectioning method has a significant disadvantage related to its destructive nature and possible microcracks induced by the sectioning [14,15]. However, in the present study control group revealed no defects and this implies that the methodology adopted did not induce dentinal damage [12].

All the files used in present study were single file systems and it might be speculated that instrument design, taper, method of manufacturing and the type of the alloy influence dentinal microcrack formation. A series of studies have found that changes in the transformation behavior via heat treatment were effective in increasing the flexibility of NiTi endodontic instruments [16-19]. Heat-induced or heat-altering manipulations were used to influence or alter the properties of NiTi endodontic instruments. NiTi Blue alloy as in Reciproc Blue showed enhanced mechanical properties compared with M-Wire NiTi [20]. The Gold technology as in WaveOne Gold showed enhanced flexibility, fatigue resistance and controlled memory effect compared to conventional and M-wire NiTi instruments (25/0.08). The regressive taper of both files preserves the dentin in coronal 2/3 of root canal. It might be speculated that shaping with novel, gold, heat-treated Wave One Gold file and Reciproc Blue's novel heat treatment would result in a lesser number of dentinal microcrack [21,22].

Regarding kinematics, some studies suggest motion of a shaping technique could influence microcracks. However, the results in this study suggest that shaping motion has limited and unpredictable role on dentinal microcrack formation, as WOG produced less microcracks than Wave One even if same reciprocating motion was used to activate them. In this study major number of microcracks were observed in the apical section (3 mm) for all tested file systems, which is in agreement with previous studies [23]. The variable taper of Reciproc, WO, Reciproc Blue and WOG may explain the reduced number of microcracks in the middle and coronal teeth sections.

Conclusion

Within the limitations of this study, it could be concluded that multiple factors cause dentinal cracks, but the flexibility of NiTi instruments because of heat treatment seems to influence the incidence of microcracks more than other factors. In particular, WOG caused less microcracks than other single file systems.

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