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Original Article

Prevalence of Dentinal Defects after Root Canal Preparations in Molars with Reciproc and WaveOne Systems

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Abstract

Objective: To evaluate the prevalence of dentin defects, including partial and complete cracks and fractures, after root canal preparation in molars with Reciproc and WaveOne reciprocating instruments. **Material and Methods:** Fifty mandibular first and second molars with mature apices were selected to endodontic in vitro instrumentation. Ten teeth were unprepared and served as the control, and the remaining forty teeth were divided into two groups, being twenty corresponding to each reciprocating system. Reciproc and WaveOne systems were used in a reciprocating working motion, under the same conditions, to prepare the two mesial canals. Roots were then sectioned 2, 4 and 6 mm from the apex, and the cut surface was observed under a microscope using 20-fold magnification and checked for the presence of fractures and incomplete cracks. **Results:** none of the evaluated groups presented fractures, and the control group showed no incomplete cracks. Overall evaluation showed statistical differences between these two groups and the control group ($p=0.017$) for the prevalence of incomplete cracks, but no significant differences were obtained between Reciproc and WaveOne groups ($p>0.05$). Reciproc group presented more incomplete cracks on 4-mm sections compared with the control group on the same section ($p=0.0326$). **Conclusion:** Root canal preparation with both reciprocating instruments resulted in incomplete cracks, but not fractures. At the level of 4 mm from the apex of the canals, the Reciproc system produced significantly more incomplete cracks. Considering both systems, WaveOne utilization resulted in lesser structural alterations on dentin considering the middle portion of the roots.

Keywords: Dentin; Instrumentation; Endodontics.

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 [1]. Vertical root fracture and crack formation can be seen in root dentin during and after endodontic procedures, and is thus a complication of root canal treatment, often leading to tooth extraction [2-5].

In the last decades, many new nickel-titanium (NiTi) rotary instruments have been developed and introduced by various manufacturers, including the recently introduced single-file nickel-titanium systems Reciproc (VDW, Munich, Germany) and WaveOne (Dentsply Maillefer, Ballaigues, Switzerland). They are able to prepare canals with only one instrument, requiring less time than rotary full-sequence systems [6-9].

It might be speculated that when using only one instrument for complete preparation, more stress will be generated during mechanical instrumentation compared with canal instrumentation by using full-sequence systems leading to dentin defects [10]. Currently, there are few data available in this regard. One study found that the alloy from which the instrument is manufactured was a more important factor in determining the damaging potential of single-file instruments than the motion of instrumentation [11]. Another analysis showed that the Reciproc system caused fewer root cracks than full-sequence rotary systems [12]. It was also noted that root canal preparation with both rotary and reciprocating instruments resulted in dentin defects. At the apical level of the canals, reciprocating files produced significantly more incomplete dentinal cracks than full-sequence rotary systems [10].

These studies worked with premolars with a single oval canal and lower incisors [10-12], but there have been no studies using molars. The aim of this study was to compare the prevalence of dentin defects in roots of molars after preparation of the canal system with Reciproc and WaveOne reciprocating instruments.

Material and Methods

This study was performed after approval by the ethics committee on research with human subjects.

Fifty mandibular first and second molars with mature apices and indications for extraction were selected and stored in purified filtered water [13]. Teeth with severely curved mesial roots (>25°) were excluded from the study [14]. The coronal portions and distal roots of all teeth were removed by using a diamond-coated bur with water-cooling. All roots were inspected with a stereomicroscope (Leica M205C, Leica Microsystems, Wetzlar, Germany) under 20x magnification to detect any pre-existing craze lines or cracks. Teeth with such findings were excluded from the study and replaced by similar teeth. An acrylic emulsion (Vedacit/Otto Baumgart, Brazil) was used for coating the cement surface of roots to simulate the periodontal ligament space. All roots were

embedded in acrylic blocks. Ten teeth were left unprepared and served as the control, and the remaining forty teeth were subjected to the procedures described below.

Canal patency was established with a #10 K-File (Dentsply Maillefer, Ballaigues, Switzerland) in both mesiobuccal and mesiolingual canals and the working length was obtained by measuring the length of the initial instrument at the apical foramen minus 1 mm. For each file, the individual torque limit and rotational speed programmed in the file library of the motor were used, whereas Reciproc and WaveOne were used in a reciprocating working motion generated by the system (VDW Silver Reciproc, VDW, Munique, Germany). In the group Reciproc, a R25 Reciproc file with size 25 at the tip and taper of 0.08 over the first 3 mm was used in a reciprocating, slow in-and-out pecking motion. In the group WaveOne, a primary WaveOne file with size 25 and taper of 0.08 was used in a reciprocating, slow in-and-out pecking motion. After three pecks using the reciprocating files, 2 mL of 2.5% NaOCl was used as irrigant for each canal, patency was established with a #10 K-File and the flutes of the instrument were cleaned. The irrigation was performed with a 5-ml syringe and needle (NaviTip 29-gauge needle; 25 mm; Ultradent, South Jordan, UT). This procedure was repeated until reaching the working length. Instruments were used to prepare four canals only.

The teeth were horizontally sectioned at 2, 4 and 6 mm from the apex with double-sided disc diamond cutting (4" x 0.012" x 0.5"; Extec, USA) under water-cooling in a cutting machine (Minitom, Struers, Denmark). To avoid any artefacts by dehydration, the teeth were kept moist in purified filtered water throughout all experimental procedures [13]. The specimens underwent 20 minutes in an ultrasonic tank to improve their cleanliness. To improve the visualization of defects, the specimens were immersed in 1% methylene blue (Dilecta, Joao Pessoa, PB, Brazil) for 2 hours, and then washed by immersing in water for 2 hours three times.

All slices were observed under a digital stereomicroscope (Leica M205C) at 20X magnification using a cold light source, and pictures were taken using a DFC 295 camera (Leica Microsystems) and software Leica Application Suite v.4.2 (Leica Microsystems). The images were observed by a blinded and calibrated observer. The dentine was inspected and defects were noted. Defects were categorized as: "no defect", "fracture" and "incomplete cracks". "No defect" was defined as root dentine devoid of any lines or cracks where both the external surface of the root and the internal root canal wall had no defects. "Fracture" was defined as a line extending from the root canal space to the outer surface of the root. "Incomplete cracks" were defined as all other lines observed that did not extend from the root canal to the outer root surface [15].

The results are expressed as the number and percentage of sections in each group. Binomial (two proportions) and Fisher exact test (one-sided) were used for statistical analysis of differences between and within the groups ($p<0.05$).

Results

None of evaluated groups presented fractures despite treatment and evaluated sections and the control group showed no defected roots. Twenty incomplete cracks were noted and distributed in 10 samples for each evaluated group (Reciproc and WaveOne). Overall evaluation showed statistical differences between these two groups and the control group (p=0.017) when the prevalence of incomplete cracks was considered, but no significant differences were obtained between Reciproc and WaveOne groups (P>0.05).

The prevalence of incomplete cracks per sections is shown in Table 1 by intergroup and intragroup evaluation. Only the Reciproc group presented more incomplete cracks on 4-mm sections compared with the control group on same section (p=0.0326). The difference between a sound section in the control group and the Reciproc and WaveOne groups is shown in Figure 1. Intragroup evaluation revealed differences only within the Reciproc group between 2 mm and 4 mm (p=0.0218), with more defects in this latter group of sections.

Table 1. Prevalence of "incomplete cracks" observed in evaluated groups considering different sections (number of sections per evaluated group = 60; number of sections of control group = 30; number of overall sections = 150).

Group/Section	2mm	4mm	6mm	Total
Control	0(0%)$^{a, A}$	0(0%)$^{b, A}$	0(0%) $^{d, A}$	0(0%)
Reciproc	1(5%) $^{a, A}$	7(35%) $^{c, B}$	2(10%) $^{d, AB}$	10 (16.6%)
WaveOne	3(15%) $^{a, A}$	4(20%) $^{bc, A}$	3(15%) $^{d, A}$	10(16.6%)

The percentage is attributed to the ratio between defects (one per section) and total sections inside the groups or overall. Different capital letters were associated with statistical relevance following horizontal evaluation (same group in different sections) and different non capital letters with vertical evaluation (different groups in the same section).; Values with the same superscript letter were not statistically different at p=0.05.

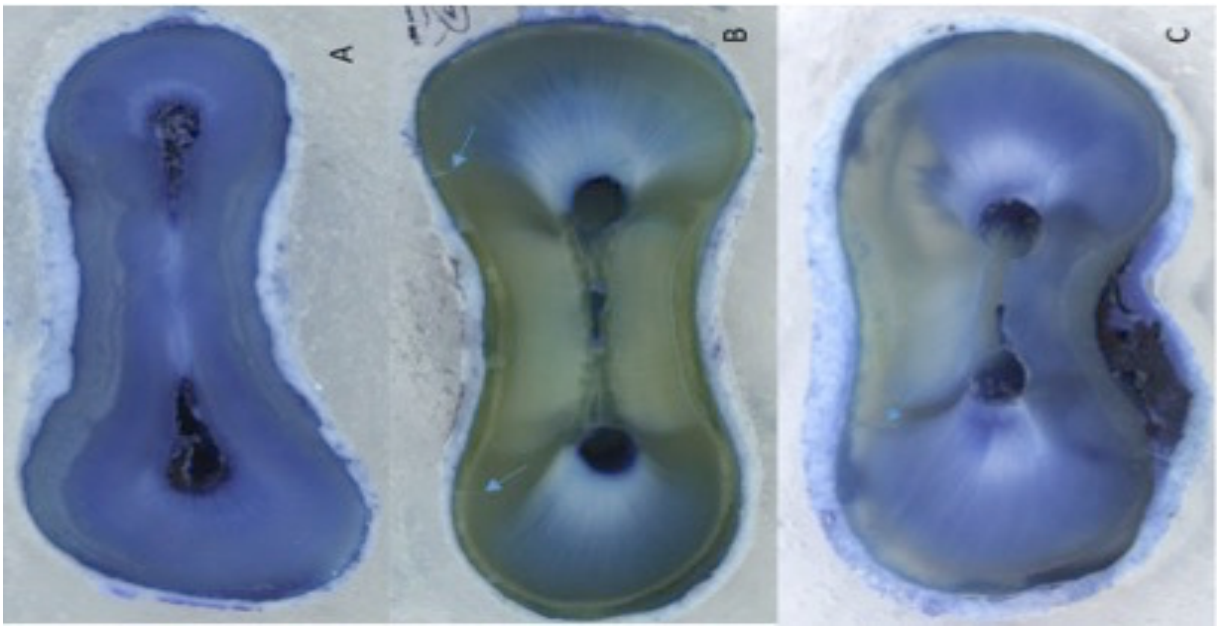

Figure 1. Sound section from Control group (A), and incomplete cracks in the Reciproc group (B), and in the WaveOne group (C). 20X magnification.

Discussion

None of evaluated groups presented fractures despite treatment, which may be attributed to the reciprocating movement minimizing torsional and flexural stresses [16-21]. However, a previous study found that the alloy from which the instrument is manufactured was a more important factor in determining the damaging potential of single-file instruments than the motion of the instrument. In fact, ProTaper instruments, whether in rotation or reciprocation motion, produce significantly more cracks than WaveOne files and no significant difference existed when ProTaper files were used in reciprocation or a rotation motion. Furthermore, significantly more force is needed to fracture the roots when WaveOne files are used [11]. Therefore, it is possible that fractures are more related to the alloy from which the instrument is manufactured than the motion of the instrument, with an M-wire alloy being less damaging.

Additionally, in a previous study using mandibular central incisors, the instrumentation with Reciproc files was associated with significantly more complete cracks compared with full-sequence rotary systems Mtwo and ProTaper [10]. Fractures were also seen after use of full-sequence rotary systems in mandibular premolars [22]. In our study using mandibular first and second molars, no complete fractures were observed in any of the samples, similar to a previous study in which mandibular premolars were used [23]. In another study, using mandibular first molars, only a single case of complete fracture was observed in the ProTaper system [1]. This may indicate that mandibular molars are more resistant to fracture compared to incisors and premolars, justifying the absence of fractures in this paper.

This study revealed that dentinal defects occurred independently of the type of reciprocating instruments used. Incomplete cracks appeared in ten sections the Reciproc and WaveOne groups, as observed in other studies in which root canal preparation with reciprocating instruments resulted in dentin defects [10,12]. This suggests that the two instruments have the same potential for damage to dentin tissues due to their many similarities, such as the tip diameter, taper and protocol use. Reciproc and WaveOne are able to prepare canals with only one instrument, and it has been speculated by other authors that when using only one instrument, more stress will be generated during mechanical instrumentation. Thus, it might be assumed that the incidence of dentinal defects would be increased compared with preparations using full-sequence rotary systems [6-10].

The instruments with Reciproc and WaveOne files were associated with significantly more incomplete cracks than the control group, which were defined as all lines observed that did not extend from the root canal to the outer root surface [15]. It is as yet unclear whether craze lines and incomplete cracks may propagate into complete cracks and fractures after completion of the root canal treatment. In addition, following treatment procedures such as post-space preparation or retreatment are discussed as cofactors for the development of dentinal defects or fractures [1,23-25]. Thus, even with the formation of only cracks, it can trigger a fracture that leads to tooth extraction.

Twenty incomplete cracks were noted, which were distributed in ten for each evaluated group, at 2 mm in four teeth, at 4 mm in eleven teeth, and at 6 mm in five teeth. The 4-mm section in the overall evaluation was the most affected, in agreement with a previous study [12]. However,

when comparing each group, it was observed that there was a homogeneous distribution in the WaveOne group between sections and no difference between this group and the control and Reciproc groups, suggesting that this instrument works the same way across different regions of the root canal. The Reciproc group presented statistically significantly more incomplete cracks on 4-mm sections compared with the control group, which disagrees with a study in the apical section, where Reciproc and WaveOne produced significantly more incomplete cracks than Mtwo and ProTaper [10]. This increased incidence of cracks at 4 mm suggests that, in this region, the instrument works more aggressively in the root canal, unlike WaveOne, which is more homogeneous.

In the present study, craze lines were not observed in unprepared teeth, in agreement with previous studies [1,11,12,22,23], but when craze lines were also observed in unprepared teeth, it was assumed that they may be a result of forces induced during extraction procedures.

Conclusion

Reciproc and WaveOne systems created incomplete cracks in the root dentin, but not in fractures. Considering both systems, WaveOne utilization resulted in lesser structural alterations on dentin considering the middle portion of the roots. Further studies are required to evaluate the effects of reciprocal root canal instruments to evaluate their risks on treatment outcome.

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