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The impact of different kinematics on crack formation in root dentin after endodontic instrumentation

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Abstract*— *Endodontic instrumentation systems can cause dentinal cracks. These defects may propagate a vertical root fracture to the teeth and extraction will be necessary. The purpose of this study was to compare the formation of root crack caused by the rotatory and reciprocating system. Forty-five extracted human mandibular molars were selected for this study. The mesial roots have been removed and randomly divided into 3 groups according to instrumentation technique: GWG- waveOne Gold primary, GRP: reciproc Blue R25 and GPN – Protaper Next X2. The roots were standardized at 16mm in length and only the mesio buccal canals were prepared by the respective instruments. The mesio-lingual root canal served as control of the research. After root canal instrumentation the roots were the horizontally sectioned at 3, 6 and 9mm from the apex with low-speed saw under water-cooling. The slices were analyzed at X12 magnification with operative microscopy to determine the presence of dentinal cracks. The Friedman test was used to analyze the data. The control did not exhibit and dentinal defects however, all the evaluated systems promoted crack rates. There was no difference among the groups in crack frequency. According to he results, root canal instrumentation with rotatory or reciprocanting files can result in some microcracks in root dentin.

Keywords*— *Cracks, dentinal defect, endodontics, reciprocation motion, rotary systems.

I. INTRODUCTION

Conventional endodontic treatment consists of several stages, but they are interconnected, and whose final objective is to clean, disinfect and effectively fill the root canal system, to promote the return of normality or the preservation of tissue health. apical and periapical, as well as returning function to the tooth in the dental arch [1, 2, 3, 4].

One of the extremely important stages that has undergone major technological advances is the chemical-mechanical preparation of the root canal system, since new techniques and instruments have been used with different proposals, always aiming at more conservative treatments and with greater preservation of root dental structure [5, 6, 7, 8, 9].

Currently, with a crown-down preparation philosophy, there is the possibility of using automated techniques, which can be used under rotational or reciprocating kinematics, with nickel-titanium instruments with or without heat treatment, different tapers and specific motors [10, 11]. Such systems promote faster endodontic

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treatments and, also, with improvements in the quality of the preparation [12, 13, 14, 15].

The possibility of formation of cracks in the dental structure is something important and must be taken into account in the case of the mechanical part of the endodontic preparation [6, 10, 12, 16, 17, 18]. The kinematics and other characteristics of automated instruments are still a recurring question in the works regarding their influence on the formation of apical cracks resulting from the preparation [4, 9].

Several current studies have been published in order to analyze the formation of root cracks in teeth after endodontic instrumentation, so it is always advisable to carry out comparison studies as new instruments are developed and commercialized [19, 20, 21, 22]. The aim of the present study was to evaluate the formation of dentinal cracks after preparation with different kinematics of endodontic instrumentation: WaveOne Gold and Reciproc Blue reciprocating systems and Protaper Next rotary system in curved mesial root canals of mandibular molars.

II. MATERIALS AND METHODS

The Human Research Ethics Committee of the Pontifical Catholic University of Campinas approved this study. This *ex vivo* experimental study was performed on 45 extracted human permanent mandibular molars. To select only moderately curved mesial roots, radiographs of each tooth were taken, digitalized and the angle of curvature were measured using Schneider's method. Only those roots with angles of curvature between 10º and 20º (moderate curvatures) were selected. All teeth were de-coronated perpendicular to the long axis of the tooth, standardizing roots segments of 13 mm in length. An evaluation under microscopy to analyze possible existing cracks was performed.

Another analysis criterion observed was the need for two independent root canals in the mesial roots, and this was confirmed with K # 10 files and standardization of the apical foramen with a # 15 file.

All specimens were embedded in auto-polymerizing acrylic resin, and periodontal ligament simulation was performed using hydrophilic vinil plysiloxane impression material (3M ESP, Seefeld, Germany) as described in the literature previously [6].

The samples were randomly divided into three experimental groups using a computer algorithm (www.random.org). Each group represented an endodontic instrumentation system:

Group GWG – a WaveOne gold primary file (25.07) was used in reciprocating motion in a crow-down technique. Three in-and-out movements (pecks) with a stroke amplitude of 3 mm were performed in each third of the canal (cervical, middle, and apical) until the working length was reached (1 mm short of the apical foramen).

Group GRB – an R25 blue (VDW, Ballaigues, Switzerland) file was used in a manner similar to that described for the RCB group.

Group GPN - An X1 (17.04) Protaper next file (Dentsply Maillefer, Ballaigues, Switzerland) was used in rotary motion (300 rpm, 2 N·cm). Three in-and-out movements (pecks), with stroke amplitude of 3 mm, were performed in each third of the canal (cervical, middle, and apical) until the working lenth was reached (1 mm short of the apical foramen). The exact same sequence was then followed with an X2 (25.06) instrument.

The same operator performed all preparations. Instrumentation of the respective experimental groups was performed with the aid of an X-Smart Plus motor (Dentsply Maillefer, Ballaigues, Switzerland), adjusted for each system. Regardless of system, each file was used only once, for the preparation of only one canal, and later discarded. The specimens were irrigated with 3 mL of double-distilled water per root third, through a 30G NaviTip needle (Ultradent Products Inc, South Jordan, UT) throughout instrumentation. In all groups, after each cycle of instrumentation and irrigation, foramen patency was controlled with a #10 K-file advanced 1 mm beyond the foramen. At the end of the instrumentation, a final irrigation with 1 mL of the same irrigant used throughout was performed, never exceeding the total amount of irrigant standardized for all specimens (10 mL). Canals were evacuated with the aid of capillary tips (Ultradent, South Jordan, UT) and further dried with the paper points provided with the respective systems.

Finished the preparation, all roots were removed from the resin apparatus and stored in distilled water for hydration.

Roots were horizontally sectioned at 3, 6 e 9mm from the radicular apex using a diamond-coated saw (Isomet 1000- Buehler, Lake Bluff, Il, USA) under a continuous water stream. The samples were then stained with 1% methylene blue and after inspected under an operatory microscope at 16X for detection of dentinal cracks. Roots slices with any type of crack line were accounted.

Statistical tests were performed using SPSS (Version 9.0, SPSS Inc., Chicago, Ill, USA). The normally of data was tested with D'Agostino test and after Friedman test. The level of statistical significance was set as 5%.

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III. RESULTS

It was found that, regardless of the instrument used and the analysis of the root third, structural cracks were observed in all groups (Fig. 1-3).

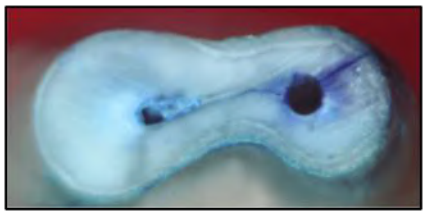

Fig. 1: Crack line observed in specimen of GWG

Fig. 2: Crack line observed in specimen of GRB

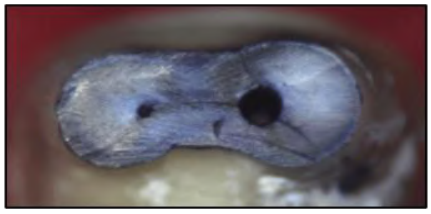

Fig. 3: Crack line observed in specimen of GPN

After microscopic evaluation, no cracks lines were observed in the mesio-lingual root canals considered as negative control.

No significant difference was noted among the groups (P.>.05) (Table 1), independent of the root third evaluated (Table 2).

Table.1: Occurrence of dentinal cracks in different groups

	GWG	GRB	GPN	p-Value
Median (IQD)	0.00 (0.50)[a]	0.00 (0.50)[a]	0.00 (1.00)[a]	= 0.8187

Abbreviations: IQD, interquartile deviation.

Table.2: Occurrence of dentinal cracks in different thirds

Group	Data	3mm	6mm	9mm	p-Value
GWG	MD (IQD)	0.00 (0.00)a	0.00 (0.00)a	0.00 (0.00)a	=0.9512
	MA (SD)	0.13 (0.35)a	0.06 (0.25)a	0.06 (0.25)a	
GRB	MD (IQD)	0.00 (0.00)a	0.00 (0.00)a	0.00 (0.00)a	=0.9512
	MA (SD)	0.13 (0.35)a	0.06 (0.25)a	0.06 (0.25)a	
GPN	MD (IQD)	0.00 (0.00)a	0.00 (0.00)a	0.00 (0.00)a	=0.8607
	MA (SD)	0.20 (0.41)a	0.06 (0.25)a	0.13 (0.35)a	

Abbreviations: MD, Median; IQD, interquartile deviation; MA, Mean; SD,

standard deviation.

IV. DISCUSSION

Many previous studies confirm micro cracks or some dentinal defects after root canal preparation with different endodontic files [13, 19, 20, 21, 23, 24]. The current study assessed the effect of endodontics files using different kinematic motions (rotatory and reciprocating movements) on the formation of dentinal cracks. The presence the defects like microcracks in dentinal root can compromise the success of endodontic treatment [9, 17, 20].

During root canal preparation, the root canal diameter is enlarged on account of the contact between dentin walls and endodontic file. A possible cause of dentinal micro cracks would be excessive dentin removal during instrumentation, and it is important to emphasize that resistance to tooth fracture is an important aim in endodontics as they may decrease the long-term survival rate [7, 25, 26].

In the present study, no dentinal defect was observed in the non-instrumented root canals of the same mesial root, which confirms a possible influence of endodontic instrumentation on the stress caused in the prepared roots [9]. The use of curved mesial root canals in the study aimed to simulate a condition similar to in vivo [24].

Studies reveal conflicting results on dentinal cracks after the use multifile (Protaper Next) or single files (WaveOne and Reciproc) systems [9, 14, 27, 28]. However

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in the experimental groups it was observed that independent of the kinematics evaluated in the study, no significant difference was observed in the formation of root cracks.

Endodontics instruments with higher tapers tend to generate more stresses into the radicular dentine and promote an increase in the incidence of root cracks [15, 29, 30]. The instrument used in the present study in the Protaper Next system for the apical preparation was the X2 which has # 25 and taper .06. On the other hand, the WaveOne gold primary and Reciproc Blue R25 reciprocating instruments feature a taper of .07 and .08 respectively. However, this factor was also not relevant since all the instruments tested showed a similar index of root cracks in accordance with some studies [25, 30, 31, 32].

The cross-sectional design presents itself differently as the files tested, Reciproc exhibit a S-shaped with a double cutting edge while, WaveOne gold has an offset parallelogram-shaped cross-section and Protaper Next an off-centred rectangular cross section. As much as this difference could impact greater stress on dentin, this fact did not cause differences in the root crack index [30]. The staggered preparation by root thirds, regardless of the system employed, shaping the root canal in a more conservative way, probably allowing a lesser impact on dentin.

Regardless of the endodontic instrumentation system, the clinician or specialist must be aware of the importance of training prior to clinical use in order to obtain better efficiency and success in their endodontic treatments.

Further studies are needed to understand the effect of different root canals preparation systems on dentinal crack formation.

V. CONCLUSION

Under the limitation of this study, rotatory and reciprocating instrumentation can be associated with the microcracks formation in radicular dentine, regardless of the root third analyzed.

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