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Incidence of Dentinal Cracks Caused by ProTaper Universal, ProTaper Next, Hyflex, and Mtwo System

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Abstract **Original Research Article**

The aim of this study was to investigate the incidence of dentinal cracks after root canal preparation with ProTaper Universal (Dentsply Maillefer), ProTaper Next (Dentsply Maillefer, Ballaigues, Switzerland), HyFlex (ColteneWhaledent, Switzerland), and Mtwo(VDW, Munich, Germany) rotary instruments. Methods: One-hundred mandibular premolars were selected and divided into 4 experimental groups of 25 specimen each. The experimental groups were instrumented with ProTaper Universal, ProTaper Next, Hyflex and Mtwo systems. After root canal preparation, roots were sectioned perpendicular to their long axis at 2, 4 and 6mm from the apex, and the sections were then observed under a stereomicroscope. The presence of cracks was recorded, and the data was analyzed with a chi-square test. The significance level was set at P = .05. Results: Vertical root fractures were not observed in any of the groups. The ProTaper Next, HyFlex and Mtwo instruments caused fewer cracks than the ProTaper Universal instrument (P < .05). However, there were no significant differences in crack formation between the ProTaper Next, HyFlex and Mtwo groups (P > .05). Conclusions: Within the limitations of this in vitro study, all of the instrumentation systems resulted in cracks in the root dentin. The ProTaper Next, HyFlex and Mtwo instruments tended to cause fewer dentinal cracks compared with the ProTaper Universal instrument.

Keywords: Cracks, rotary nickel-titanium instruments,controlled memory, M-wire technology, ProTaper Next, ProTaper Universal, Hyflex, Mtwo.

INTRODUCTION

Instrumentation with rotary nickel-titanium (NiTi) instruments could potentially cause dentinal cracks [1-9], which may have the potential to develop into fractures [10, 11]. Cracks after canal instrumentation are detected either in horizontal sections cut at different levels along roots [1-5] or at the apical root surface [6-9].

Recently, ProTaper Next (Dentsply Maillefer) instruments have been introduced that have an off-centered rectangular design and progressive and regressive percentage tapers on a single file and is made from M-Wire technology. Having an off-centered rectangular design decreases the screwing effect and dangerous taper lock [12].

HyFlex rotary instruments (Coltene-Whaledent, Switzerland) are another type of novel NiTi system. Hyflex instruments are manufactured using a unique process in which the crystallographic phase transition from austenite to martensite occurs at room temperature in contrast to conventional NiTi files, making the files extremely flexible and fracture resistant.

The Mtwo rotary system (VDW, Munich, Germany) have an S- shaped cross sectional design with a non-cutting tip. The two cutting edges have a positive rake angle to cut dentine effectively. Moreover the pitch length increases from tip to the shaft. This design is claimed to eliminate threading and binding in continuous rotation. Mtwo was selected because of its ability to maintain curvatures [13], and favorable cyclic fatigue resistance [14].

Thus the aim of this study was to observe the incidence of cracks in root dentin after root canal shaping procedures performed by ProTaper Universal, PproTaper Next, Hyflex and Mtwo rotary systems.

MATERIALS AND METHODS

One hundred extracted human mandibular premolars with straight roots were selected and divided

into 4 groups. Teeth with fracture lines, open apices, dental caries or resorption defects were excluded. Radiographs were taken to verify the presence of a single canal. The ProTaper Universal, ProTaper Next, Hyflex, Mtwo, were used in 4 experimental groups (n=25). The teeth were decoronated at the level of cementoenamel junction by a diamond disc (Horico, Germany) under water coolant. Working length was determined by inserting a size 10 K file (Dentsply Maillefer) into the canal until the tip of the file was just visible at the apical foramen. Each root was wrapped with a single layer of aluminum foil and embedded in acrylic resin (DPI, India) set in an acrylic tube. The roots were then removed from the tube, and the aluminum foil peeled off. A rubber base impression material (Flexceed, GC Japan) replaced the space created by the foil which represented a simulated periodontal ligament, and the root was immediately repositioned. The coronal part of each canal was flared with #2 Gates-Glidden drills (Dentsply Maillefer). Glide path was created with a # 15 K (Dentsply, Maillefer) hand file. The root canal shaping procedures were performed using endodontic motor (NSK, Japan) according to the manufacturers' instructions for each instrument system as follows:

Group 1: The ProTaper Universal files were used in the following sequence; SX, S1, S2, F1, F2, F3 and F4 at a speed of 250 rpm. The first 3 shaping files were used with a brushing motion till light resistance was encountered and the last 4 finishing files were used until the working length was reached.

Group 2: The ProTaper Next files were used in the sequence X1, X2, X3, and X4 at a rotational speed of 300 rpm and 2 Ncm torque. Each file was used with a brushing motion similar to that used with the ProTaper Universal files.

Group 3: The HyFlex files were used in a gentle in-and-out motion with a rotational speed of 500 rpm and 2.5 Ncm torque. The HyFlex files were used in the sequence of 25/0.08 (two thirds of the working length), 25/0.06, 30/0.06, and 40/0.04 (the full working length).

Group 4: Mtwo rotary instruments were used, with a sequence of 10/.04, 15/.05, 20/.06, 25/.06, 30/.05, and 35/.04 up to master apical file 40/.04. One set of instruments was used for the preparation of 4 root canals. Each canal was irrigated with 2 mL 2% sodium hypochlorite between each instrument by using a syringe and a 29-gauge needle (NaviTip; Ultradent, South Jordan, UT) placed at 1 mm from WL. A total of 16 mL NaOCl was used for each root.

All roots were horizontally sectioned at 2, 4, and 6 mm from the apex with a diamond disc (Horico, Germany) under water coolant. Slices were then viewed through a stereomicroscope (Olympus, Japan) at 20X magnification. The data were analyzed with a chi square test. The testing was performed at the 95% confidence level (P = .05).

RESULTS

Vertical root fractures were not observed in any group. The ProTaper Next (26%), HyFlex (26%) and Mtwo (23%) instruments caused fewer cracks than the ProTaper Universal instrument (54%) ($P < .05$). Mtwo instruments caused least amount of cracks. There were no significant difference in crack formation between the ProTaper Next, HyFlex and Mtwo groups ($P > .05$).

DISCUSSION

The incidence of cracks observed in root dentin after root canal shaping procedure by ProTaper Univeral, ProTaper Next, Hyflex and Mtwo files was 54%, 26%, 26% and 23%, respectively. This is in accordance with a study by Liu et al (15) which reported dentinal cracks in 50% of the roots instrumented with the ProTaper Universal system.

The taper of preparation can be a contributing factor in the generation of dentin defects. The ProTaper Universal finishing files (F1, F2, and F3) have more taper in the apical portion (0.07, 0.08, and 0.09, respectively) than the ProTaper Next (X1, X2, and X3; 0.04, 0.06, and 0.07, respectively) and HyFlex instruments (25/0.06, 30/0.06, and 40/0.04), this may explain the higher incidence of cracks observed in the ProTaper Universal group, which is also in accordance with the previous studies [16-18].

As more root dentin is removed, greater is the risk of initiating root fracture [19]. In a previous study, S-Apex (FKG Dentaire, La Chaux-de-Fonds, Switzerland), a nontapered instrument, showed no damaging effects on the root canal wall [20]. ProTaper F3 reaches a large taper of 0.09, which could explain its higher incidence of dentinal cracks than the Mtwo instruments which has a small taper (up to 0.06).

The design of the file could affect the forces acting on root dentin [21]. The forces generated during instrumentation have been linked to an increased risk of root fracture [22]. The off-centered rectangular design of the ProTaper Next instrument may have contributed to the relatively smaller number of cracks in this study. This design generates a swaggering motion, which decreases the screw effect, dangerous taper lock on any given file by minimizing the contact between the file and the dentin [12].

ProTaper Next and HyFlex are manufactured with M-wire alloy and controlled memory NiTi wire and have relatively high flexibility. This may have contributed to the small number of cracks in this study. In addition, the crack formation could be related to the greater cutting efficacy of the instruments.

Moreover, increased rotational speed is associated with increased cutting efficiency. The cutting efficacy of the HyFlex instrument is greater than that of the ProTaper Universal instrument [23]. Because of its extended fatigue resistance [24], the recommended speed of the HyFlex instrument (500 rpm) is higher than that of the other instruments tested in the present study. Consequently, the smaller number of cracks in the HyFlex and ProTaper Next groups compared with the ProTaper Universal group might be related to their relatively higher cutting efficacy.

CONCLUSION

Within the limitations of this in vitro study, it can be concluded that the root canal instrumentation with Mtwo system causes least amount of dentinal cracks followed by ProTaper Next, Hyflex and ProTaper Universal instruments. There was no significant difference between Mtwo, ProTaper Next and Hyflex groups. Mtwo, Hyflex and ProTaper Next instruments result in significantly less dentinal cracks than ProTaper Universal instruments.

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