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Effects of 3 Single-File System (Protaper Universal, Protaper Next, Protaper Gold) on crack formation in dentin after root canal preparation - An In-vitro study

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Abstract: ***Introduction:*** *The aim of the present study was to investigate the incidence of cracks in root dentin after root canal preparation with Protaper Universal (Dentsply Maillefer), ProTaper Next (Dentsply Maillefer, Ballaigues, Switzerland) and Protaper Gold (Dentsply Maillefer, Ballaigues, Switzerland) rotary instruments.*
Materials and Methods: *A total of 30 extracted mandibular premolars were selected. The root canals were instrumented using Protaper Universal, Protaper Next and Protaper Gold rotary files. All roots were horizontally sectioned at 3, 6, and 9 mm from apex with slow speed saw under water cooling. The sections were observed under a stereomicroscope at ×25 to determine the absence or presence of crack. Data were analyzed using post hoc test and one way ANOVA.*
Results: *Protaper Next and Protaper Gold produced significantly less cracks than Protaper Universal .*
Conclusion: *Within the limitation of this in vitro study, it can be concluded that nickel–titanium instruments may cause cracks on the root surface. Protaper Next and Protaper Gold tend to produce less number of cracks as compared to Protaper Universal.*

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I. Introduction

The primary aim of chemo mechanical preparation is to completely remove the microorganisms, pulp tissue and debris and enlarging the canal diameter to receive an obturating material.[1] Complexities in canal preparation may be attributed to variation in the design of the cutting instrument, taper and composition of the material from which it is made.[16] In the last decades, the emergence of NiTi rotary instrumentation has transfigured the root canal treatment by reducing the operator fatigue, time required to complete the preparation and minimized the procedural errors as compared with hand instrumentation.[17] However, rotary files with large tapers may cause significantly more complete and incomplete dentinal cracks. [18]

Crack is defined as a defect with complete crack lines extending from inner root canal space up to the outer surface of the root.[2] Dentinal cracks or root fracture occur when the tensile stress in the root canal wall exceeds the tensile stress of dentin. Rotary NiTi files with large tapers can produce increased friction and stresses on the canal wall and cause dentinal cracks in root dentin.[7]

Protaper Universal rotary files (Dentsply Maillefer, Ballaigues, Switzerland), which have been used for years, have a convex triangular cross-sectional design and various percentage tapers that enable an active cutting motion and the removal of relatively more dentin coronally. ProTaper Universal rotary files are made from a conventional superelastic NiTi wire. In previous studies, the ProTaper Universal system was associated with more cracks than other rotary NiTi instruments.[3]

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, which is made from M-Wire technology. Having an off centered rectangular design decreases the screw effect, dangerous taper lock, and torque on any given file by minimizing the contact between the file and the dentin.[14]

A new system has been introduced called ProTaper Gold (PTG) (Dentsply Maillefer, Baillagues,Switzerland). PTG provides more than twice the resistance to cyclic fatigue as PTU and PTG's advanced metallurgy creates an increase in flexibility. The PTG instruments have been developed with proprietary advanced metallurgy. According to Hieawy et al. (2015), the metallurgical characteristics of PTG files not only had a 2-stage specific transformation behaviour but also had high Af temperatures, similar to

controlled memory wire (Shen et al. 2011). The PTG instruments include three shaping (Sx, S1 and S2) and five finishing (F1, F2, F3, F4 and F5) files.[4]

II. Material And Methods

A total of 30 extracted human mandibular premolars with mature apices and straight root canals (<5°) were selected and kept in distilled water. The root surfaces were examined under stereomicroscope to exclude external defects and cracks. Then, the teeth were decoronated with a slow speed saw under water coolant to obtain a standardized root length of 16 mm. As suggested previously, a single layer of aluminum foil was used to cover the roots of the teeth, and each root was embedded into acrylic resin set in an acrylic tube. Root was removed, from tube, and the aluminum foil was removed from the root.

A light body silicon based material was used to replace space created by aluminium foil and simulate periodontal ligament, and the root was immediately inserted into impression material. Apical 3 mm of root was exposed and immersed in water during instrumentation to prevent dehydration. Ten teeth were divided into three groups of 10 teeth each. Canal length was measured by inserting a size 10 k file into canal terminus and subtracting 1 mm from this measurement. A glide path preparation was done by 15k type files. Apical preparation was completed with size 25 instrument of each system. 1% sodium hypochlorite solution was used as an irrigant during instrumentation.

After preparation the specimens from the prepared groups were rinsed with 5 mL distilled water. The root canal shaping procedures were performed according to the manufacturers' instructions for each instrument system as follows:

1. Group 1 : For each ProTaper Universal file, the individual rotational speed (250 rpm) and the torque limit programmed in the file library of the motor were used. The sequence was as follows: SX, S1, S2, F1, F2, F3, and F4. The first 3 shaping files were used with a brushing motion away from the root concavities before light resistance was encountered, and the last 4 finishing files were used until the working length was reached.
2. Group 2: The ProTaper Next files were used in the sequence Pro-Taper Universal SX and then ProTaper Next X1, X2, X3, and X4 at a rotational speed of 300 rpm and 200 g/cm torque. Each file was used with a brushing motion similar to that used with the Pro-Taper Universal files.
3. ProTaper Gold The root canals were instrumented using PTG instruments with a torque-controlled endodontic motor (X-Smart, Dentsply Maillefer). The following sequence was used: Sx file (1/2 of the WL), S1 and S2 files (2/3 of the WL), F1 file (size 20, 0.07 taper) and F2 (size 25, 0.08 taper) file (full WL). All the PTG instruments were used at 300 rpm with a torque of 3 Ncm for Sx and S1 instruments, 1.5 Ncm for F1 instruments and 2 Ncm for F2 instruments

Sectioning and microscopic examination

Roots were sectioned perpendicular to long axis at 3, 6, and 9 mm from the apex using a low speed saw under water cooling. Digital images of each section were captured at ×25 magnification using a digital camera attached to a stereomicroscope. Each specimen was checked by two operators for the presence of dentinal defects. No crack was defined as root dentin devoid of any microcracks or craze lines either at the external surface of root or at the internal surface of root canal wall. Crack was defined as any lines, microcracks, or fracture observed on the slice that either extended from root canal lumen to the dentin or from outer root surface into the dentin. Data were analyzed by SPSS version 15 Software (IBM, Chicago, IL, USA)

Definition of dentinal microcracks: To define crack formation, 2 different categories were made (''no crack'' and ''crack'') [Table/Fig- 1a,b]. To avoid the confusing description of root cracks they were divided in to two categories: No crack- No crack was defined as root dentin without cracks or craze lines either at the internal surface of the root canal wall or the external surface of the root. Crack- Crack was defined as all lines observed on the slice that either extended from the root canal lumen to the outer surface or from the outer root surface into the dentin .

Statistical analysis

The data were analysed with a chi-square test. All statistical analyses were performed using IBM SPSS Statistics 20 software (IBM SPSS Inc, Chicago, USA) at a 95% confidence level (P = 0.05).

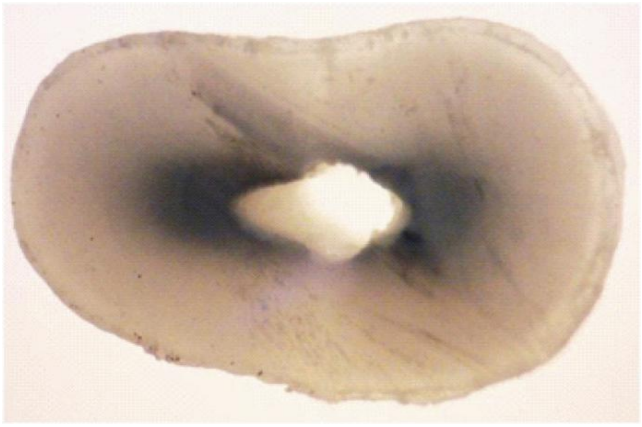

Figure 1 Representative image of the slice without a dentinal crack.

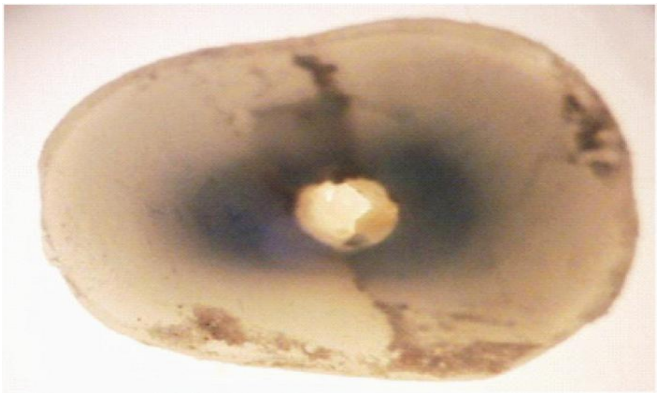

Figure 2 Representative image of the slice with a dentinal crack.

III. Results

As shown in Table 1 ProTaper Next and Protaper Gold produced significantly less cracks than Protaper Universal. Between ProTaper Next group and Protaper Gold group the difference is statistically insignificant.

Table 1: Dentin crack for different instrumentation

Experiment	Protaper Universal	Protaper Next	Protaper Gold
3 mm	8	2	1
6 mm	6	2	2
9 mm	5	3	1

IV. Discussion

The primary aim of chemomechanical root canal preparation includes the preservation of original course of the canal and cleaning of the entire root canal system. One common complication associated with mechanical canal preparation is vertical root fracture (VRF), which usually leads to tooth loss.[10] Various NiTi instruments with different design have been introduced, but all of them result in incomplete cracks or even VRF. Hence, such defects should be prevented. Bier *et al*. suggested that craze lines occurred in 4% to 16% which may develop into fractures during retreatment or after long‑term functional stresses such as chewing. This proves that root canal preparation with NiTi rotary systems and every following additional procedure in endodontics as obturation and retreatment with rotary system can create fractures or craze lines.[2]

In the present study, dentinal cracks were observed in all groups except group 1 which implies that the sectioning method did not induce damage, so it may be concluded that the cracks were a result of the preparation procedures and currently no method is able to avoid completely such cracks.[1]

The design of file may affect shaping forces on root dentin; these forces may cause root fracture.

ProTaper Next has a rectangular cross‑section design, increased and decreased tapering over entire length. Off centered rectangular design of ProTaper Next may have contributed to less number of cracks than OneShape. This design generates a swaggering motion, which decreases screw effect, dangerous taper lock, and torque on the file.OneShape has asymmetrical cross‑section over entire length and variable pitch, noncutting safety tip.[2]

Previously, a finite element analysis study showed that tapered files cause increased stress on the canal walls . Bier et al stated that the taper of the files could be a contributing factor in dentinal crack formation. In the apical portion, the ProTaper Universal finishing files (F1, F2, and F3) have more taper (0.07, 0.08, and 0.09, respectively) than the ProTaper Next (X1, X2, and X3; 0.04, 0.06, and 0.07, respectively) Yoldas et al claimed that the tip design of rotary instruments, cross-sectional geometry, constant or variable pitch and taper, and flute form could be related to crack formation.[3]

PTG and PTU instruments have the same cross-sectional geometry, taper and tip design. Moreover, in the PTG and PTU groups, the same number of files (five files for each group: Sx, S1, S2, F1 and F2) were used at the same rotational speed for each file for the preparation of the root canals. However, according to the manufacturer, the PTG instruments have greater flexibility than the PTU instruments. The greater flexibility of PTG instruments might have led to fewer cracks than that caused by PTU instruments at the apical section.[4]

According to our study, incidence of crack observed in root dentin was greater after instrumentation with Protaper Universal as compared to Protaper Next and Protaper Gold. One of the limitations of this study was application of elastomeric material to simulate the periodontal ligament. Adorno et al. suggested that elastomeric material may collapse and permit direct tooth to acrylic contact; moreover, clinical situation is more complex because the presence of periodontal ligament influences the distribution of stresses.[2]

V. Conclusion

Within the limitation of this *in vitro* study, it can be concluded that NiTi instruments may cause cracks on the root surface. Protaper Next and Protaper gold tend to produce less number of cracks as compared to Protaper universal.

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