

Comparative evaluation of dentinal cracks and detachments after instrumentation with hand and rotary files at various instrumentation lengths: An *in vitro* study

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ABSTRACT

To compare the incidence of dentinal cracks and detachments after instrumentation using different types of NiTi files in rotary motion. 36 human extracted mandibular central incisors were taken and divided into four groups (n=9 per group). Group 1 - Hand instrumentation, Group 2 - ProTaper Universal, Group 3 - Protaper Next, and Group 4 - M-two files in rotary motion. Specimens were then sectioned horizontally and viewed under dental operating microscope. Roots prepared with hand files shows the lowest percentage of dentinal cracks and detachments (7%); whereas in roots prepared with ProTaper Universal, ProTaper Next, and M-two was 66, 20, and 13%, respectively. There was no significant difference between ProTaper Next and M-two group ($P < 0.05$). Apical cracks developed in 2 of 27 teeth with rotary file systems. Apical dentinal detachments developed in 1 of 27 teeth with rotary file systems. No crack was resultant from instrumentation with rotary files terminating 1mm short of apical foramina. Only in cases when instrumentation with rotary files terminated short of the apex, less cracks and detachments occurred. More apical cracks appeared in teeth with deviated apex.

Keywords: Dentinal defects, rotary file systems, nickel titanium, instrumentation, apical foramina

Introduction

The objective of chemomechanical preparation is complete removal of microorganisms, pulp tissue, debris, and enlarging the canal to receive three-dimensional obturation.^[1,2] At times, during biomechanical preparation of the canal, we tend to damage the root dentin, thereby creating a gateway to dentinal cracks and minute fractures formation or even vertical root fractures, leading to treatment failure.^[3,4] Complexities in canal preparation are attributed to variation of cutting instruments' design, taper, and composition of its material.^[5]

In the past few decades, NiTi rotary instruments have transfigured root canal treatment by reducing operator fatigue, by reducing preparation time and has intended to reduce the procedural errors as compared with hand instrumentation.^[6-9] However, rotary with their large tapers tends to cause more complete and incomplete dentinal cracks.^[10,11]

The debate with regard to the best motion of action for NiTi rotary continues. Comparison of the incidence of dentinal microcracks of ProTaper, ProTaper Next, and M two files has not been done so far. In this study, after cleaning and shaping, the teeth were analyzed for cracks under dental microscope.

Materials and Methods

Thirty-six human extracted mandibular central incisors were selected and kept in distilled water [Figure 1]. Radiographs were taken from buccolingual and mesiodistal angles. Specimens with single root and single canal were included in this study. Teeth with root fractures, cracks, open apices, canals, multiple roots, caries or restorations, severe anatomic variations, and calcified canals were excluded. To ensure standardization, decolonization was done under water

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cooling with a low-speed straight handpiece using carborundum disc maintaining 16 mm from the apex [Figure 2].

Through the reserach, specimens were wrapped in 4 × 4 gauze and kept moist and for coating the surface of roots to simulate periodontal ligament space, a silicon impression material was used.

Through inserting a size #10 K file (Dentsply Maillefer, Ballaigues, Switzerland) into the root canal terminus and subtracting 1 mm from this measurement, the working length of the canals was determined. Making use of a size #15 K file (Dentsply Maillefer, Ballaigues, Switzerland), a glide path was performed. Instrumentation of the teeth was sone at three various instrumentation lengths including 1 mm short of apical foramen, at the apical foramen and 1 mm beyond apical foramen [Table 1].

After each instrument change, the irrigation of the root canals with 1% sodium hypochlorite solution was carried out. After preparing four canals, each instrument was changed. A total of 10 mL 1% sodium hypochlorite was used in each canal. After preparation, the specimens from the prepared groups were rinsed with 10 mL distilled water.



Figure 1: 36 extracted human mandibular incisors



Figure 2: Sectioning of teeth

The specimens were divided into four groups (n = 9). All instruments were set in rotation motion through X-Smart (Dentsply Maillefer, Ballaigues, Switzerland) and in accordance to the instructions of the manufacturer, the speed and torque were programmed and each instrument was cleaned through making use of gauge after three pecking motions.

Group 1 - Hand instrumentation, Group 2 - ProTaper Universal, Group 3 - Protaper Next, and Group 4- M-two files in rotary motion. Canals were prepared using Protaper rotary (Dentsply Maillefer, Ballaigues, Switzerland) mounted in a 6:1 reducing handpiece and X-Smart motor (Dentsply Maillefer, Ballaigues, Switzerland) and was set in rotary speed program (300 rpm). The ProTaper shaping SX will be used in coronal Enlargement, then S1, S2, F1, and F2 will be sequentially used to the working length. The same was followed for ProTaper Next and M two rotary files.

All the specimens were sectioned perpendicular to the long axis at 3, 6, and 9 mm from the apex using a low-speed carborundum discs under water cooling. Slices were observed under a dental operating microscope.

To define crack formation, two different categories were made (“no crack” and “crack”). The description of root cracks is divided into two categories:

- No crack - Root dentin without cracks or craze lines either on the internal or the external surface of the root canal.
- Crack- Crack lines observed from the root canal lumen to the outer surface or from the outer surface into the root dentin.^[12]

Statistical analysis

The results were expressed as the number and percentage of dentinal cracks and detachments in each group. Chi-square test was used for the statistical analysis of the groups. The level of significance was set at P = 0.05 using statistical analysis SPSS software 20.0.

Results

The results were expressed as number and percentage of cracked roots in each group. ProTaper Universal produced more cracks when compared to ProTaper Next and M two NiTi files in rotary motion [Figures 3 and 4].

Discussion

In the present study, dentinal cracks were observed in only one group, which is indicator of the point that the sectioning method did not induce damage; accordingly, it may be concluded that the cracks were the result of the preparation procedures and currently there is no method being able to avoid such cracks totally.

Table 1: Various Instrumentation lengths in relation to the apical foramen

Files	AF+1 mm	AF	AF-1mm
Hand file	3	3	3
ProTaper Universal	3	3	3
ProTaper Next	3	3	3
M two	3	3	3

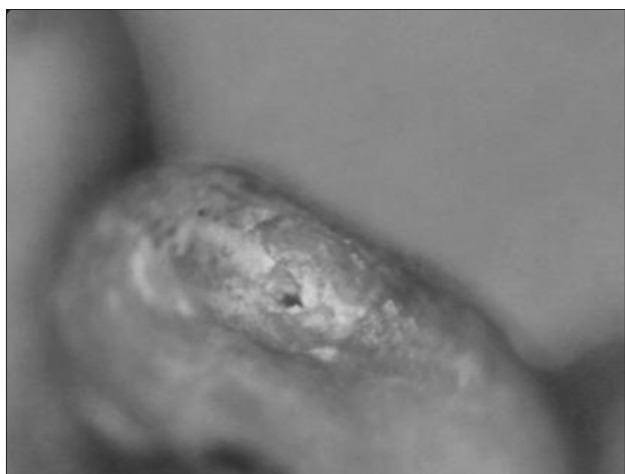


Figure 3: Dentinal detachment observed in middle third after rotary instrumentation using ProTaper Universal

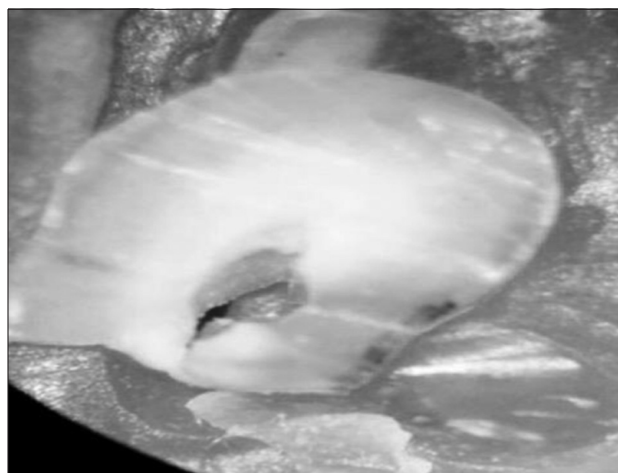


Figure 4: Dentinal crack observed in apical aspect after rotary instrumentation using ProTaper Universal

This study is in accordance with the previous studies which compared the incidence of dentinal defects of manual Flexo Files with different rotary systems: ProTaper (Dentsply-Maillefer, Ballaigues, Switzerland), ProFile (Dentsply-Maillefer), System GT (Dentsply-Maillefer), or S-ApeX (FKG Dentaire, La Chaux-de-Fonds, Switzerland). They concluded that no defects were found in the unprepared roots and those prepared with hand files and S-ApeX. ProTaper, ProFile, and GT preparations resulted in dentinal defects in 16%, 8%, and 4% of teeth, respectively.^[10,12]

Hand instrumentation did not cause much damage to the root canal, which could be because of its less aggressive movements in the canal when compared with engine operated.^[13,14] In this study, although cracks were observed in all groups, cracks in the coronal region were more compared to cracks in the apical region which is in accordance with the previous studies done.^[15,16] Least amount of cracks were observed in the canals instrumented with ProTaper Next in rotary motion, and more cracks were observed in canals instrumented with ProTaper Universal in rotary motion. Cracks are formed because of high level of stress concentrated in the root

canal walls and also the taper (F1, F2, F3 0.07, 0.08, and 0.09, respectively) which is greater than ProTaper Next (X1, X2, and X3; 0.04, 0.06, and 0.07, respectively) which could explain the incidence of cracks observed.^[17] The reason for less cracks in ProTaper Next file system is due to its off-centered rectangular design which generates a swagging motion, which decreases the screw effect, dangerous taper lock and torque on any given by minimizing the contact between the file and the dentin.^[18] In addition, ProTaper Next files are made of M-wire alloy which shows more flexibility than those made from conventional NiTi wire.^[19-22] Furthermore, sectioning method was used which allowed the evaluation of the effect of root canal treatment procedures on the root dentin by direct inspection of the roots.^[23]

Conclusion

Least defects were observed in canals with hand instrumentation. Apical cracks developed in 2 of 27 teeth with ProTaper Universal rotary file systems. Apical dentinal detachments developed in 1 of 27 teeth with ProTaper Universal rotary file systems. No crack was caused by instrumentation via rotary files terminating 1mm short of apical foramina and with regard to instrumentation with rotary files terminated short of the apex, less cracks and detachments occurred. More apical cracks appeared in teeth with deviated apex.

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