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Incidence of dentinal crack formation after root canal preparation using different rotary files

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Abstract

Purpose: the purpose of this study is to investigate the incidence of dentinal crack formation after root canal preparation using ProTaper Next, ProTaper Gold and TruNatomy rotary files.

Material and methods: ninety five extracted human lower first molars were collected. Teeth were divided into 1 control group consisting of 5 teeth and 3 experimental with 30 samples in each experimental group. Root canal preparation was done with ProTaper Next, ProTaper Gold and TruNatomy files in the mesio-buccal canal. Then mesial roots were sectioned at 3mm, 6mm, and 9mm from the apex and examined under a stereomicroscope. The data were analyzed using Chi-Square test.

Results: No cracks were observed in the control group. TruNatomy file produced less crack in compare to ProTaper Gold and ProTaper Next. Dentinal cracks occurred more in the middle and apical thirds in compare to coronal third.

Conclusion: ProTaper Next tends to produce more crack in compare to ProTaper Gold and TruNatomy files.

Keywords: Cracks, ProTaper Next, ProTaper Gold, TruNatomy

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Introduction

Successful root canal treatment depends on proper diagnosis, biomechanical preparation and proper obturation of the root canal. Mechanical preparation is very important and is done by removing organic tissue, debris, microorganisms and enlarging the canal space.(1)

Root canal preparation is fulfilled using endodontic instruments and irrigating solutions under aseptic working conditions. NiTi rotary instruments became now one of the mostly used instruments for mechanical enlargement of the root canal space.(2)

NiTi rotary files had several advantages such as increase flexibility and short working time needed to prepare the canal. Increasing flexibility of rotary files would decrease iatrogenic errors and increase the efficiency and safety of the root canal treatment.(3)

ProTaper Next is made by M- wire technology. This system has an off center rectangular cross section. It has a progressive and regressive taper. Off centered rectangular shape provides the file a swaggering motion (snake-like), which minimizes the contact between the file and the dentinal wall, thus reducing the screwing effect.(4)

Later, ProTaper Gold has a convex triangular cross section with a progressive taper. According to the manufacturer ProTaper Gold is considered as a twin to ProTaper Universal as it has the same geometry, but high austenite finish temperature and thermal treatment provides greater flexibility and resistance to cyclic fatigue. (5)

Recently, TruNatomy instruments has been developed. It was manufactured using special NiTi heat treated wire in order to increase flexibility. TruNatomy files are off-centred parallelogram cross-section. TruNatomy consist of three files: small

(size 020 .04 taper), prime (size 026 .04 taper) and medium (size 036 .03 taper).(6)

Root canal preparation can damage the root dentin, that might result in dentinal crack formation that have the ability to develop to vertical root fracture.(7)

Studies has shown that distinctive root canal preparation systems damage the root canal wall to different degrees. Different types of dentinal wall defects may happen such as craze lines, micro-cracks or vertical root fracture. (8)

Some authors define “crack tooth syndrome” as incomplete fracture of posterior teeth these teeth are vital, fracture extend to dentin and could reach the pulp.(9)

Other authors reported that if the crack involves enamel only so this is a nonstructural “craze line” and in this case no treatment is required, But if the crack extend to the dentin so this is a structural crack and in this case treatment is required.(10) (11)

The aim of this study is to compare the incidence of dentinal crack formation after root canal preparation using ProTaper Next ProTaper Gold and TruNatomy files.

Materials and Methods:

A total of 95 freshly extracted human lower first molars were collected for this in vitro study from the Oral Surgery department faculty of dentistry Ain Shams University. Teeth were extracted for periodontal, restorative or orthodontic reasons not related to this study. The teeth were stored in purified filtered water.

Teeth were randomly distributed into four groups, one control group (5 teeth, 10 canals) and teeth were left unprepared (normal control). Three experimental groups (90 teeth, 90 canals). In the experimental groups only the mesio-buccal canals were prepared while the mesio-lingual canals were left unprepared to act as negative control.

In group 1, (normal control group) neither access cavity nor root canal preparation were performed in this group.

In group 2, (ProTaper Next) the mesio buccal canal was prepared by manual files size 15 and 20 (2% taper) to the working length. Coronal enlargement was performed using orifice opener (ProTaper Next XA). ProTaper Next files were used with an electric motor at 300 rpm and 4-5.2 N/cm torque in up and down motion until reaching the working length. This operation was done for X1, X2, X3 and X4 files.

In group 3, (ProTaper Gold) the mesio buccal canal was prepared by manual files size 15 and 20 (2% taper) to the working length. Coronal enlargement was performed using orifice opener (ProTaper Gold SX). ProTaper Gold instruments were implemented using an electric motor, S1 and S2 files were used in the coronal 2/3 of the canal, F1 and F2 files were used to the full working length. SX and S1 were used at 300 rpm and 2 N/cm torque, while S2, F1 and F2 were used at 300 rpm and 1.5 N/cm torque. All files were used in up and down motion.

In group 4, (TruNatomy) the mesio buccal canal was prepared by manual files size 15 and 20 (2% taper) to the working length. Coronal enlargement was performed using orifice opener (TruNatomy Orifice Modifier). TruNatomy instruments were used with an electric motor at 500 rpm at 1.5 N/cm torque was in up and down motion until reaching the working length. This operation was done for SMALL, PRIME and MEDIUM files.

After root canal preparation, roots were sectioned horizontally at 3mm, 6mm and 9mm from the apex with a carbide disc using isomet 3000 electric micromotor and low speed straight hand piece.

Sections of prepared teeth (mesial canals) were examined under a stereomicroscope under 20X magnification. Each sample was examined precisely for the presence or

absence of crack. Images were taken with digital camera under 20X magnification.

Results:

All samples of the normal control group were free of any crack. Mesio-lingual canals (negative control group) were also free from any crack.

The highest percentage of samples with **cracks** was observed in ProTaper Next (74%), followed by ProTaper Gold (50%), while the lowest percentage was found in TruNatomy samples (20%). (figures 1, 2 and 3)

Chi-square test, fisher's exact tests were used to analyze the data using SPSS software 15.0 with level of significance kept as $P < 0.05$

Furthermore, Fisher's exact test was performed to identify the presence of any statistically significant difference among different groups at each level apical, middle and coronal. The percentage of absence of cracks for group 4 & negative control; were the highest percentage followed by group 3 then group 2 at 6 mm among subgroup A. Those differences; were statistically significant. There were no statistically significant differences; between negative control, group 2, 3 & 4 groups regards cracks at 3 mm & 9 mm among subgroup A. (Table 1)7

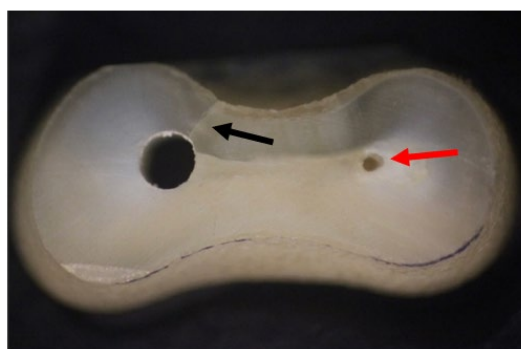


Fig. 1: Photograph showing complete crack in the middle section of the prepared mesio-buccal canal black arrow. Note absence of crack in the unprepared mesio-lingual canal red arrow. (ProTaper Next, X20)

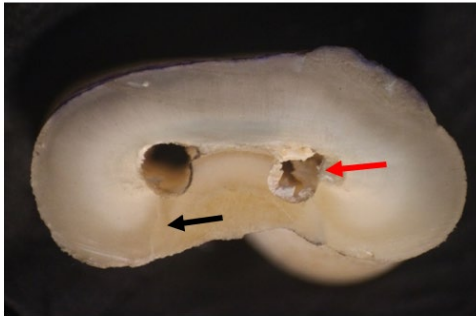


Fig. 2: Photograph showing complete crack in the middle section of the prepared mesio-buccal canal black arrow. Note absence of crack in the unprepared mesio-lingual canal red arrow. (ProTaper Gold, X20)

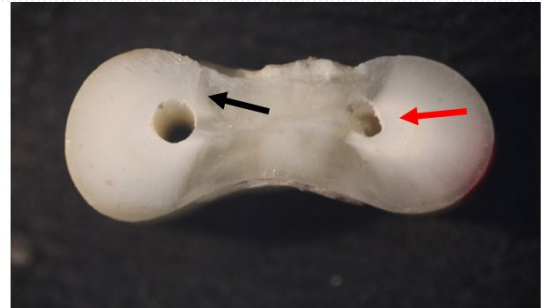


Fig. 3: Photograph showing complete crack in the middle section of the prepared mesio-buccal canal black arrow. Note absence of crack in the unprepared mesio-lingual canal red arrow. (TruNatomy, X20)

Table 1: Comparison between groups regards cracks

		Negative Control (n=15)	Group 2 (n=15)	Group 3 (n=15)	Group 4 (n=15)	Total (n=60)	X ²	P Value	Sig.
3mm	Absence of cracks	15(100%)	11(73.3%)	14(93.3%)	14(93.3%)	54(90%)	6.38	0.168	NS
	Incomplete cracks	0	2(13.3%)	0	1(6.7%)	3(5%)			
	Complete cracks	0	2(13.3%)	1(6.7%)	0	3(5%)			
6 mm	Absence of cracks	15(100%)	11(73.3%)	12(80%)	15(100%)	53(88.3%)	8.90	0.038	S
	Incomplete cracks	0	2(13.3%)	0	0	2(3.3%)			
	Complete cracks	0	2(13.3%)	3(20%)	0	5(8.3%)			
9mm	Absence of cracks	15(100%)	14(93.3%)	15(100%)	15(100%)	59(98.3%)	2.85	0.384	NS
	Incomplete cracks	0	1(6.7%)	0	0	1(1.7%)			
	Complete cracks	0	0	0	0	0			

Discussion:

Root canal preparation using NiTi instruments may weaken the tooth structure and lead to dentinal defects in the form of cracks. These cracks act as areas of stress concentration, with repeated occlusal forces these cracks propagate and might lead to vertical root fracture.(7)

Mesio buccal canals of mandibular first molars were chosen in this study due to their narrow mesio-distal diameter in compare to bucco-lingual. Their small dimensions and thin walls made them more prone to stress during root canal preparation. This was in accordance to (12) and (13) but in contrary to the choice of (14) and (15) who selected mandibular premolars in their study. Teeth and cut sections were stored in purified filtered water during the experimental period, since storage medium may affect the mechanical properties of the dentinal walls. That's why water was used in this study to decrease the chance of any artifact that could happen due to dehydration. Purified filtered water was recommended by (16) as a storage medium for researches on extracted teeth because, it causes least amount of changes in dentin over time.

Root sectioning was performed at 3mm, 6mm and 9mm from the apex, to study the effect of the files on the narrow apical portion of the root, the area at which root curvature begin and the wide coronal portion of the root. Although root sectioning might be a direct cause of crack formation, sectioning was performed by a diamond disc under a constant coolant to reduce this possibility . However, the use of mesio-lingual canal as a negative control in which no dentinal crack was observed, this imply that the sectioning technique used in this study did not induce dentinal crack.

stereomicroscope was used to examine the sections and evaluate the type of crack if present. The stereomicroscope was chosen because of its simplicity and availability, also it had a wide range of magnification which allows proper visualization of the root section. The use of 20X magnification was to allow the visualization of the entire root section while, 30X allows proper identification of the crack extent.

Manufactures recommend the change of the file after several uses in root canals to avoid file fracture. The rotary instruments used in this study were recommended for single use by the manufacturers.(17) Therefore, during root canal preparation a new set of file was used every three canals.

In the present study examination of samples of the control group reviled no cracks. This imply that neither the extraction technique nor the sectioning method were a factor that might induced crack formation. For that reason it could be believed that any crack observed in the dentinal wall was due to the preparation procedure. These results were in agreement with the findings of previous studies performed by (18) and (19) On the other hand these results of the control group were in contradiction with the results of (20) and (21) as they reported the presence of cracks in the unprepared canals (control group). These contradiction results could be due to difference in sectioning technique or age of the patients from which the teeth were collected. In addition, they prepared both mesio-buccal and mesio-lingual canals of the same tooth and they compared them with other unprepared teeth.

Results showed that out of 30 teeth 22 exhibited cracks in group 2 ProTaper Next (74%), while in group 3 ProTaper Gold the incidence of crack formation was 15 teeth out

of 30 (50%). TruNatomy was the least file causing crack formation 6 out of 30 teeth with a percent of (20%).

The high percent of cracks demonstrated in group 2 could be attributed to the offset mass of rotation of the ProTaper Next file which leads to a mechanical wave of motion similar to the oscillation. This causes cutting off a bigger envelope of motion compared to other files with the same size but having a symmetrical mass and axis of rotation. An explanation reported by (22)

While teeth in group 3 reviled less number of cracks when compared to group 2 15 teeth out of 30. This could be explained by the fact that ProTaper Gold is more flexible and have the most recent metallurgic characteristics compared to ProTaper Next.

The least number of cracks was seen in teeth prepared with TruNatomy files (group 4) a finding that could be related to the taper of this file which is different and smaller than ProTaper Next and ProTaper Gold files.

These results of the incidence of crack formation during root canal preparation were in agreement with those of (22) who reported that the highest percentage of crack formation was related to ProTaper Next followed by ProTaper Gold while the least percentage was in TruNatomy group. In another study (23) stated that ProTaper Next caused the highest percentage of crack formation.

In the present study the roots were sectioned at 3, 6 and 9mm from the apex. This allows studying the effect of the three rotary files in the apical narrow area, the middle portion of the root and the wide coronal part.

The results of the present study revealed that the incidence of crack formation in the apical section of teeth mechanically prepared with ProTaper Next was 33.3% (10 out of 30). This percentage of crack formation decreased to 20% (6 out of

30) in ProTaper Gold, while in TruNatomy decreased to 10% (3 out of 30).

These results in ProTaper Gold group could be due to their high austenite finish temperature and also ProTaper Gold had two stage specific transformation behavior which give the file greater flexibility.(24) While TruNatomy files are less destructive for the root canal wall due to the regressive taper and heat treatment of the alloy.(17)

Regarding the high percentage of crack formation in ProTaper Next this finding could be explained that ProTaper Next instruments have a higher torque of 4 - 5.2 Ncm compared to other rotary files in this study from 1.5 to 2 Ncm. An explanation reported by (13) This high torque used in ProTaper Next could induce greater stress on the dentinal walls and lead to increase incidence of crack formation in this group compared to ProTaper Gold and TruNatomy groups.

Collectively, from the results it is recommended to further investigate the shaping ability and the effect of TruNatomy rotary file on the dentinal wall as only few papers were available in the literature.

Conclusion

Based on the results of this study it could be concluded that:

- 1) ProTaper Next, ProTaper Gold and TruNatomy may cause dentinal cracks.
- 2) ProTaper Next and ProTaper Gold rotatry files tend to produce more cracks than TruNatomy file.
- 3) Highest percentage of cracks was in middle section followed by apical, while the lowest percentage was in coronal section.

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