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Comparative Evaluation Of Dentin Crack Formation After Root Canal Preparation Using 3 Different Rotary Files - Invitro Study

Research Article

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Abstract

Introduction : The aim of the present study was to evaluate the dentinal cracks after root canal preparation with rotary files: ProTaper Gold, TruNatomy and ProFit S3 at different instrumentation lengths. The aim was to evaluate and compare the incidence of dentinal crack formation after root canal preparation with ProTaper Gold, TruNatomy and ProFit S3 files.
Methodology: Forty Five extracted single-rooted premolars with straight, single root canals were selected for the study. The specimens were randomly assigned to three groups, with 15 samples in each group. The root canal preparation for the three groups was done with ProTaper Gold, TruNatomy and ProFit S3, respectively, following which the specimens were horizontally sectioned at 3, 6, and 9 mm from the apex. Sectioned samples were viewed under a stereomicroscope to determine the presence or absence of dentinal cracks. The data were analyzed using one-way ANOVA and Chi-square tests.
Results: TruNatomy and ProFit S3 files produced lesser number of cracks than ProTaper Gold. However, there was no statistically significant difference among the three groups at 3 mm,6 mm and 9mm ($P > 0.05$). It was evident that all files produced dentin cracks but it was not statistically significant.
Conclusions: ProTaper Gold, TruNatomy and ProFit S3 rotary files may cause dentinal cracks. ProTaper Gold, ProFit S3 files tend to produce more dentinal cracks than TruNatomy files.

Keywords: Dentin crack; ProFit S3; ProTaper Gold; Rotary files; TruNatomy.

Introduction

Endodontic diseases are associated with multiple bacterial infections. Root canal preparation is one of the most important steps in successful root canal treatment [1].

The main objective of root canal treatment is to eliminate inflamed and necrosed pulp tissue from the radicular portion, shape the dentinal walls to ease irrigation and to fill it with an inert material, maintaining the anatomy of the root canal system, and keep sound dentin for a prolonged period [2]. However, the complex canal anatomy causes instrumentation challenges, which may prevent adequate disinfection of the root canal system or cause procedural errors such as instrument separation, transportation, ledges, or perforations [2,3].

In recent times, rotary nickel-titanium (NiTi) instruments have completely changed the way root canal preparations are carried out, there are several nickel-titanium (NiTi) file systems used within the field of dentistry. NiTi rotary file systems have good flexibility which reduces the incidence of iatrogenic errors in the danger zone, ledge formation, perforation, and transportation of canals. Thus contributing to the better efficiency and safety of the root canal preparation [2-4]. Several approaches have been developed by the manufacturer to improve the flexibility and resistance to fracture of NiTi rotary endodontic instruments [2-6]. These

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approaches include modification of the instrument's cross-sectional design, decreasing the taper all over the length of the cutting blade, and enhancement of the manufacturing process by use of new alloys that provides improved mechanical properties[2-5]. NiTi rotary instruments have the advantages of increased flexibility and shortened working time, while instrument separation and dentinal crack formation are their major disadvantages[2-7].

Root canal preparation procedures can damage the root canal dentin causing dentinal cracks. Dentinal cracks occur when the tensile stress of the root canal wall exceeds that of the dentin[8]. Dentinal microcracks under repeated occlusal forces have the potential to develop into vertical root fracture, which is one of the most frustrating complications of endodontic therapy, often leading to tooth extraction[9]. Kim et al., established a possible relationship between the design features of NiTi rotary instruments, the incidence of the vertical root fractures[10] and concluded that apical stress and strain concentration induced during root canal preparation is influenced by the design features of the rotary file. Ananya Guha et al. compared the incidence of dentinal crack formation after root canal preparation with Neoendo flex and Mani silk files[11]. She concluded that Both hand K files and NiTi rotary instruments may cause dentinal cracks. Mani silk and K-file tend to produce fewer dentinal cracks than Neoendo Flex files.

ProTaper Gold (Dentsply, Tulsa Dental Specialties, Tulsa, OK, USA) NiTi rotary system was developed with proprietary advanced metallurgy. ProTaper Gold files exhibit a convex triangular cross-section[11,12]. It has a progressively tapered design to improve the cutting efficiency and safety. ProTaper Gold files may appear slightly curved when removed from the package due to their metallurgy. ProTaper Gold system has been metallurgically enhanced through heat treatment technology.

TruNatomy (TN; Dentsply Sirona, Maillefer, Ballaigu/es, Switzerland) is a novel file system manufactured from a 0.8 mm NiTi wire, followed by special heat treatment. TruNatomy files exhibit an Off-centered cross-section, Operates at a higher speed with less torque. It is claimed that TruNatomy has a reduced risk of separation due to the increased resistance to cyclic fatigue and flexibility[12].

Profit S3 (PS3) (Kedo Dental, India) is based on Blue Technology, It is a novel heat-treated rotary file system with a titanium oxide coating. It has a variable taper design with a rectangular cross-section. Profit S3 has two-point contact, thereby reducing the apical extrusion of debris. PS3 has good flexibility, increased resistance to fracture, and shape memory [14]. It has a variably variable taper, which varies between 4% and 8%[13].

In the literature, there is no data about the influence of these novel rotary NiTi files on dentin crack formation after root canal preparation at different instrumentation lengths using ProTaper Gold, TruNatomy, and ProFit S3 files. Thus, the purpose of the present study is to observe the incidence of dentin crack formation after root canal preparation at different instrumentation lengths performed with the newly introduced ProTaper Gold, TruNatomy, and ProFit S3 files systems under stereomicroscope. Previously our team has a rich experience in working on various research projects across multiple disciplines [14-28] Now the growing trend in this area motivated us to pursue this project.

Materials And Methods

Forty Five teeth were randomly assigned to three groups of [15] teeth (n = 15) each. Working length was measured by inserting a No. 10 K-file (Mani, Japan) till it was just visible at the apical foramen and then subtracting 1 mm from the measurement. A glide path was prepared using 10/02 and 15/02 K-file (Mani, Japan). Apical preparation was completed up to size 25 of each system.

20 ml of 5% sodium hypochlorite (Paras Chemical Industries, Pune) with 27G side-vented needles (Prime Dental Products Private Limited) was used for irrigation for each specimen.

Group 1: ProTaper Gold

Root canals were prepared using ProTaper Gold files attached to an endomotor (X-Smart Plus, Dentsply) according to the manufacturer's instructions at speed of 350 rpm and a torque of 1.5 Ncm. Coronal flaring was done with (30/08) file. Apical shaping was done with 20/06 and 25/06 up to the full working length.

Group 2: TruNatomy

Root canals were prepared using TruNatomy files attached to an endomotor (X-Smart Plus, Dentsply) according to the manufacturer's instructions at speed of 500 rpm and a torque of 1.5 Ncm. Coronal flaring was done with (30/08) file. Apical shaping was done with 20/06 and 25/06 up to the full working length.

Group 3: ProFit S3

Root canals were prepared using a standard pack of ProFit S3 attached to an endo motor (X-Smart Plus, Dentsply) according to manufacturer's instructions in gentle in and out motion at speed of 300 rpm and a torque of 2.6 Ncm. Coronal shaping was done using (25/08). Apical shaping was done using 20/06 and 25/06 up to the full working length.

Sectioning And Microscopic Examination

Roots were sectioned perpendicular to the long axis of the teeth, using a diamond disc under water cooling at 3, 6, and 9 mm from the apex and each section was stained with 2% methylene blue (Merck, India) for better visualization. Sectioned root slices were viewed under a stereomicroscope at ×25 magnification. Digital images of each section were analyzed using an image analysis system (Chroma Systems Pvt. Ltd., India) attached to the stereomicroscope. Each sectioned slice was observed by a single examiner to check the presence or absence of dentinal cracks.

Two distinct categories were made according to the method given by Karataş et al.

- Crack – Any lines, microcracks, or fractures that were present in the root dentin
- No crack – Root dentin devoid of craze lines, microcracks on the external surface of the root, and microcracks on the internal surface of the root canal wall.

Statistical Analysis

One-way ANOVA was used to analyze the data using SPSS Statistics Software (version 23.0 - IBM) with the level of significance set as $P < 0.05$.

Results And Discussion

Dentinal cracks were observed in all three groups. [Figure 1] represents a bar graph with the mean number of dentinal cracks at 3, 6, and 9 mm. Group 2 (TruNatomy) and Group 3 (ProFit S3) produced a lesser number of cracks as compared to Group 1 (Protaper Gold). According to one-way ANOVA, there was no statistically significant difference among the three file groups at 3,6 and 9 mm ($P > 0.05$).

One-way ANOVA test revealed no statistically significant difference between Group 2 and Group 3 ($P > 0.05$) and between Group 1 and Group 2 ($P > 0.05$). There was no statistically significant difference between Group 1 and Group 3 ($P > 0.05$). Overall, among the three rotary file systems, no statistically significant difference was seen in the crack formation. Protaper Gold Files produced more number of dentinal cracks across all sections than the other file systems used ($P > 0.05$). [Table 1] represents the percentage of teeth with a number of dentinal cracks for ProTaper Gold, TruNatomy and ProFit S3 files.

Biomechanical preparation is an important step to achieve success in endodontic treatment. At times, dentine damage can occur during procedures such as root canal cleaning, shaping and retreatment. The contact between the instrument and canal walls during preparation creates momentary stress concentrations in the root dentin, which may lead to dentinal defects from which vertical root fracture can originate. Instrument features such as tip design, cross-sectional geometry, taper, pitch design, and flute form may be related to dentinal crack formation.

In the present study, all root canal shaping files, produced microcracks in root dentin. These findings are in accordance with Yoldas et al. and Bürklein et al., who found cracks in the root canals prepared by rotary NiTi instruments but not in the root canals instrumented with hand K file[29,30,31]. According to Kesim et al, examination with any kind of magnification is not fully sufficient for detecting the preexisting craze lines or cracks that may be present on the inner surface of the root[30].

In the present study, cracks in the coronal region were more abundant than the cracks in the apical region for all the three groups, which is similar to previous studies done by Adorno et al. and Liu et al[32].

Bier et al.,stated that taper of files influences crack formation. The orifice opener used in our study is a larger taper (8%) instrument which causes more stress concentration in the root dentin, leading to microcracks[33]. Failure to identify pre-existing internal cracks that become visible after sectioning and the sectioning method itself could explain the reason for more microcracks in the coronal region.

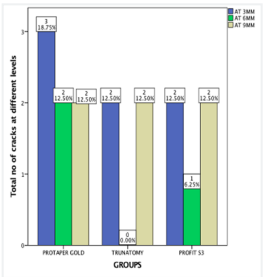
Taper of files are reported to cause increased stress on canal walls[34]. Thus, the taper of the files could be a contributing factor in dentinal crack formation[33,34]. Additionally, a greater taper means a reduced remaining thickness of dentine. Wilcox et al. (1997) mentioned that the likelihood of root fracture increases with the amount of tooth structure removed[35]. Root canal instrumentation with larger instruments is associated with crack development and propagation of existing cracks[35,36].

In this study, ProtaperGold Files showed a more number of cracks than ProFit S3 and TruNatomy Files. All the file systems used in this study are heat-treated rotary NiTi files[37]. TruNatomy Files differ from Protaper Gold and ProFit S3 Files mainly differ in their taper and cross section. Protaper Gold and ProFit

Table 1: Represents the percentage of teeth with a number of dentinal cracks for ProTaper Gold, TruNatomy and ProFit S3 files.

		Sum of Squares	df	Mean Square	F	Sig.
AT 3MM	Between Groups	.133	2	.067	.222	.804
	Within Groups	3.600	12	.300		
	Total	3.733	14			
AT 6MM	Between Groups	.400	2	.200	1.200	.335
	Within Groups	2.000	12	.167		
	Total	2.400	14			
AT 9MM	Between Groups	.000	2	.000	.000	1.000
	Within Groups	3.600	12	.300		
	Total	3.600	14			
TOTAL CRACKS	Between Groups	.933	2	.467	.700	.516
	Within Groups	8.000	12	.667		
	Total	8.933	14			

Figure 1: The graph shows the mean of canal centering ratio of Group I – Protaper Gold (purple - 3mm), Group II – TruNatomy, Group III - ProFit S3 at 3(Purple), 6(Green) and 9 (Grey)mm from the root apex of the teeth. There was no statistically significant difference between the three groups (P > 0.05)



S3 Files are available in 6% taper, TruNatomy Files are available in 4% taper.

TruNatomy shaping file has an off-centered parallelogram cross-sectional design with uniform taper, Protaper Gold has an convex triangular cross-sectional design combined with the flute design with its progressive tapers sequence along the shaft. ProFit S3 has a variable taper design with a rectangular cross-section, It has two-point contact

Protaper Gold file has a unique convex triangular cross-sectional design, so it establishes three point contact with the root canal dentinal wall while it rotates in the canal during biomechanical preparation, Which transmits more tensile stresses to the root canal dentinal wall, leading to dentinal microcracks more than that of TruNatomy and ProFit S3 Files. On the other hand,TruNatomy Files has an off-centered parallelogram cross-sectional design, so each time the file rotates in the canal during biomechanical preparation; there is at least a one or two point contact between the instrument and the root canal wall. ProFit S3 Files has a off-centered rectangular cross-sectional design, so each time the file rotates in the canal during biomechanical preparation; there is at least a two point contact between the instrument and the root canal wall.

This is an in vitro study, so there is a possibility of the clinical scenario and outcome to be completely different. Versiani et al. stated that, in the clinical setting, it is highly unlikely that some ordinary root canal procedures could cause microcracks in a range of 40%–80%, as reported by most of the studies.

The possible limitations of our in vitro study are the sectioning method, difficulty in identifying internal pre-existing cracks, and the inability to standardize the speed and torque of both the rotary files used.

Our institution is passionate about high quality evidence based research and has excelled in various fields [38-48]

Conclusion

Within the limitations of this study, we can conclude that different NiTi instruments tend to produce varying degrees of dentinal damage during root canal preparation. Various factors cause dentinal cracks, Taper of file are the most significant ones.

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