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COMPARATIVE EVALUATION OF DENTIN MICROCRACKS FORMATION IN ROOT CANAL PREPARATIONS AT THREE DIFFERENT LENGTHS USING THREE DIFFERENT ROTARY FILE SYSTEMS: AN INVITRO STUDY.

Endodontics

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ABSTRACT

Biomechanical preparation being essential part of root canal preparation also poses risk of dentinal microcracks or craze lines formation, which can later propagate into vertical root fractures under additional stresses. The present study was conducted to evaluate and compare the dentinal microcracks formation on root canal walls instrumented with three different rotary file systems at 3mm, 6mm, and 9mm instrumentation lengths. Forty-five extracted human mandibular premolar teeth were randomly divided into three groups: A, B, and C (n = 15) to be instrumented by HeroShaper, HyFlexCM, and TruNatomy file systems and inspected under Scanning electron microscope after horizontal sectioning at 3mm, 6mm, 9mm of root from apex. The presence of microcracks was noted with the help of SEM images. The data were analyzed with a Chi-square test using IBM SPSS Statistics software version 22. According to the statistical analysis, HeroShaper has the highest percentage of cracks in the coronal and middle thirds, while TruNatomy has the lowest in all cases. There was a statistical significance between the groups at coronal third ($P<0.05$), no statistical significance between the groups at apical and middle third ($P > 0.05$). Dentinal microcrack propagation was evident in all the rotary file systems. Fewest cracks were appreciated in TruNatomy file systems compared to other systems, whereas Heroshaper showed maximum microcracks.

KEYWORDS

Dentinal Microcracks, Scanning Electron Microscope, Trunatomy, Niti Rotary Files.

INTRODUCTION

The success of endodontic treatment dictates three-dimensional filling of anatomically cleaned and shaped canals. The root canal procedure is closely related to microbial management, cleaning, and shaping for successful root canal sealing but a proper seal comes from a good biomechanical preparation. Thus, preparing the canal is the most important factor in success of root canal treatment, especially the apical enlargement, which ensures cleanliness and improves the quality of canal filling. The introduction of engine driven file systems marked a major advancement in endodontics with improvements in the quality and predictability of canal preparations. The earlier standard 2% stainless steel hand files have been slowly replaced with the newer NiTi rotary files having varying taper with enhanced mechanical, metallurgical and other properties. The rotary files minimise time consumption for the treatment and reduce the procedural mishaps.

According to few studies, rotary files with large and varying tapers may cause significantly more of complete and incomplete dentinal cracks. And these dentinal micro-cracks or craze lines can later propagate into vertical root fractures (VRFs) under repeated stresses from endodontic or restorative procedures which would cause failure of treatment leading to tooth loss. [1] The microscopic studies defined the causal relationship between dentinal microcracks and instrumentation during the chemo-mechanical preparation. [2,3] Thus, measures have to be taken to preserve the root dentine as much as possible and maintain the original anatomy keeping in mind the concept of minimally invasive endodontics.

A major goal in biomechanical root canal preparation is to overcome the potential problem of dentinal microcrack formation associated with various rotary instrumentations. Hence this study is conducted to compare and evaluate the dentinal microcrack formation in 3 file systems, 4% taper rotary file systems TruNatomy (size 26/0.04), HYFLEX CM (size 25/0.04) and HERO SHAPER (size 25/0.04) when used in full continuous rotation at coronal, middle and apical thirds of the root.

Subjects And Methods

A total of 45 freshly extracted human mandibular premolars with single canals and caries free were included in the study and the teeth with multiple roots, decayed teeth/ root, VRF, curved and calcified canals and with internal and external resorption were excluded from the study. All the selected samples were examined under stereomicroscope. Any tooth exhibiting the presence of external cracks were discarded.

Preparation Of Specimens

The selected samples were cleaned free of debris and calculus and were stored in normal saline to prevent from dehydration under extraoral conditions. ..

The root was wrapped with single layer of aluminium foil and embedded in acrylic resin set in acrylic tube. Later, foil was peeled off from the root and coated with hydrophilic vinyl-polysiloxane impression material to replace the space created by foil to simulate periodontal-ligament and immediately repositioned in the tube.

Root Canal Preparation

Pre-operative radiographs were taken to verify the canal anatomy. Access opening was done for all the teeth followed by working length determination. Root canal patency was established with #15 K- File. The samples were divided randomly into three experimental groups (n=15), depending upon the file system used for instrumentation i.e. Group A- Hero Shaper File System, Group B- HyFlex CM instruments, Group C- TruNatomy.

Group A- Hero Shaper File (n=15)

In this group, HeroShaper NiTi files were used in a crown-down sequence to file #25 at 450 rotations per minute at torque of 1.2Newton cm. The order used was 20/04, 25/04.

Group B- HyFlex CM instruments (n=15)

The HyFlex files were operated by a gentle in-and-out motion with a rotational speed of 500 revolutions per minute and 2.5 Newton cm torque.

Group C- TruNatomy (n=15)

TruNatomy Glider (size 17, 0.02 v), Small (size 20, 0.04 v), and Prime (size 26, 0.04 v) files were used 2–3 gentle strokes approximately 2–5 mm length in-and-out motion in canal with 500 RPM at 1.5Ncm torque.

Throughout the instrumentation with different file systems, all the specimens were irrigated alternatively with 1% sodium-hypochlorite solution and normal saline to ensure proper debris removal and the instruments were lubricated using viscous 17% EDTA.

Sectioning Of The Samples

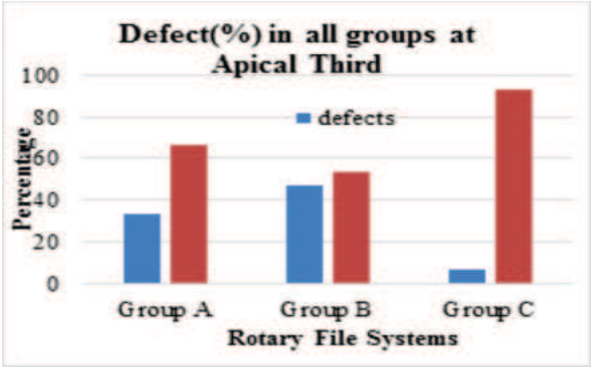
EDM Wire cutting was used to section the roots horizontally at 3mm, 6mm and 9mm at a low speed under water cooling to prevent the formation of cracks. Digital image of each section was captured at x 40 magnification using SEM (JEOL, JSM-IT500, Japan) and evaluated to observe the formation of dentinal microcracks on the root canal.

Statistical Analysis

Statistical analysis was done using SPSS version 22 software (IBM SPSS, Chicago, IL). Descriptive statistics, Pearson Chi-Square test was used to analyze the study data.

RESULTS

From the Statistical Analysis, Table 1 and Graph 1 shows the Cross Tab statistics for dentinal microcrack formation in three study groups at Apical third and differences in micro cracks among them three groups were statistically insignificant. Group B (HyFlex CM) showed higher number of defects with 46.67 %. Group C (TruNatomy file system) depicted lesser number of defects.



Graph 1: Comparison of dentinal microcrack formation between the study groups at Apical third.

Table 1: Cross Tab statistics for dentinal microcrack formation in three study groups at Apical third

DEFECTS			GROUP			Total
			A	B	C	
APICAL	.0	Count	10	8	14	32
		% within APICAL	31.3%	25.0%	43.8%	100.0%
	1.0	Count	4	6	1	11
		% within APICAL	36.4%	54.5%	9.1%	100.0%
	2.0	Count	1	1	0	2
		% within APICAL	50.0%	50.0%	0.0%	100.0%
Total		Count	15	15	15	45
		% within APICAL	33.3%	33.3%	33.3%	100.0%

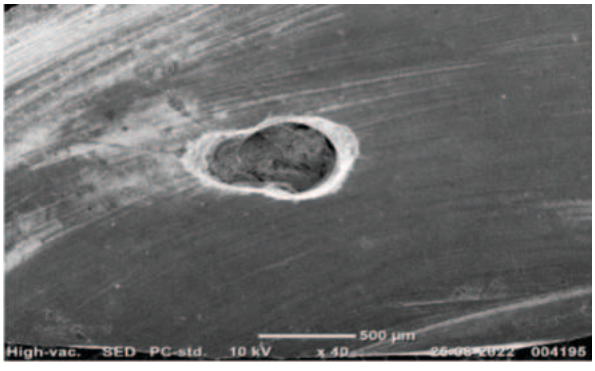
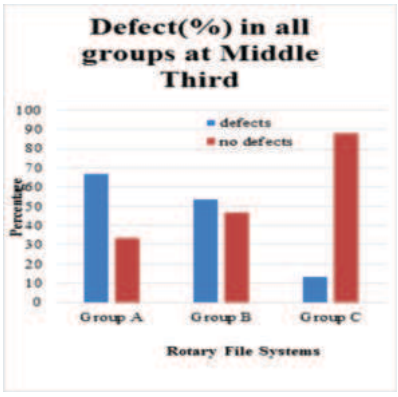


Figure 1: Group A- Apical third at 3mm

Table 2 and Graph 2 shows the Cross Tab statistics for dentinal microcrack formation in three study groups at Middle third and differences in micro cracks among them three groups were statistically insignificant. Group A (Hero shaper) showed higher number of defects with 66.67 %. Lesser number of defects was observed in Group C (TruNatomy file system).



Graph 2: Comparison of dentinal microcrack formation between the study groups Middle third.

Table 2: Cross Tab statistics for dentinal microcrack formation in three study groups at Middle third

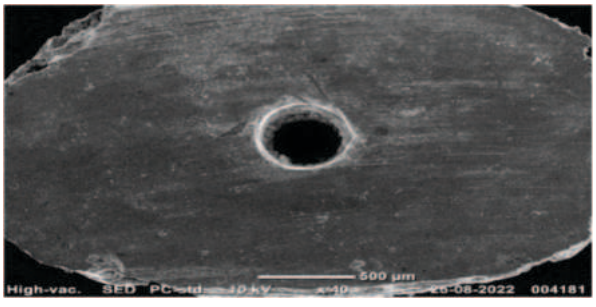
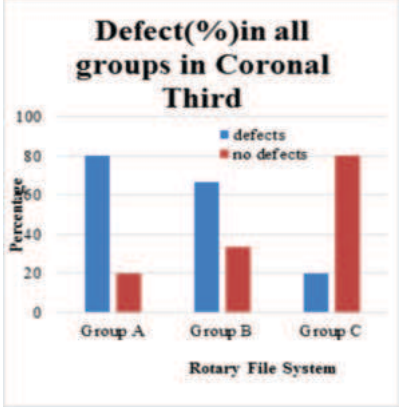


Figure 2: Group B- Apical third at 3mm

Table 3 and Graph 3 shows the Cross Tab statistics for dentinal microcrack formation in three study groups at coronal third and differences in micro cracks among them three groups were statistically significant. Group A (Hero shaper) showed higher number of defects with 80 %. Lesser number of defects was observed in Group C (TruNatomy file system).



Graph 3: Comparison of dentinal microcrack formation between the study groups coronal third.

Table 3: Cross Tab statistics for dentinal microcrack formation in three study groups in coronal third

DEFECTS			GROUP		Total	
			A	B	C	
MIDDLE	.0	Count	5	8	13	26
		% within MIDDLE	19.2%	30.8%	50.0%	100.0%
	1.0	Count	5	4	2	11
		% within MIDDLE	45.5%	36.4%	18.2%	100.0%
	2.0	Count	4	2	0	6

		% within MIDDLE	66.7%	33.3%	0.0%	100.0%
	3.0	Count	1	1	0	2
		% within MIDDLE	50.0%	50.0%	0.0%	100.0%
Total		Count	15	15	15	45
		% within MIDDLE	33.3%	33.3%	33.3%	100.0%

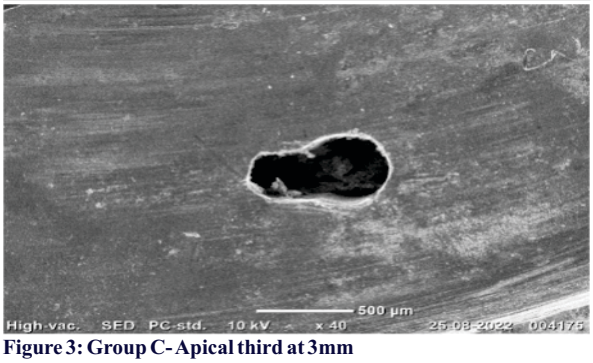


Figure 3: Group C- Apical third at 3mm

DISCUSSION

The successful outcome of endodontic treatment depends primarily on biomechanical preparation and is directly related to subsequent disinfection and filling. The aim is to approach the infected pulp and create way to remove it by allowing space for proper irrigation protocol. The objective is to maintain original canal anatomy and preservation of dentin thickness of a root canal system which is critical to successful shaping of root canal. [4]

According to Kim et. al., the occurrence of VRFs and design of NiTi instruments may be related. Study concluded that file design affected apical stress-strain concentrations during root canal instrumentation. [5] Therefore, it is crucial to prevent any iatrogenic damage to the root dentin during endodontic operations, since this will improve the tooth's prognosis.[5]

In this study, extracted mandibular premolar teeth were used as these teeth are probably more prone to be influenced by forces during instrumentation as result of their smaller dimension and thin dentinal wall. Teeth were kept moist in pure filtered water during all testing procedures to prevent any artifacts caused by dehydration.[6]

The roots were surrounded with a hydrophilic vinyl-polysiloxane impression material to mimic bony socket that may change force distribution around tooth when external forces were used. However various attempts conducted by Onnink et al. 1994, Ribeiro et al. 2008, to imitate bone or periodontal ligament, clinical situation is more complex because of presence of the periodontal ligament that could further influence the distribution of forces. [7,8]

Higher concentrations of NaOCl solution significantly alters the mechanical properties of human dentin like such microhardness, roughness, elastic modulus, flexural and fatigue strength compared with physiologic saline and solutions of lower concentrations.[9] Henceforth, the use of 1% NaOCl solution was considered for irrigation purpose.[10]

The evolution into engine driven NiTi rotary instruments has gained popularity by its own means. The walls of the root canal are rotated when NiTi rotary tools are utilised. Extent of defect formation by the usage of NiTi rotary instruments was related to tip design, cross-section geometry, constant or progressive taper type, constant or variable pitch, and flute form of the instruments. [11] The specific anatomy of the root canal, post space preparation dentinal wall thickness and canal diameter are other contributing factors related to stress concentration.

In this study, scanning electron microscope (SEM) was selected as the first choice in detection of dentinal micro defects when compared to other methods. This study was in agreement with Cicek et al. who found that craze line (micro cracks) was more obviously seen using high magnification power (×40 µm) this might be attributed to greater magnification power used (×35 and ×75 µm) in SEM. [1] In the present study, SEM images at magnification of 40x were used to examine the presence of microcrack.

In this study all the selected instruments Heroshaper, Hyflex CM, and TruNatomy instruments possess tip diameter equal to size 25 to standardize the apical preparation size. Consequently, taper of the instruments, and the motion of instrumentation were also standardised. Hero Shaper has cutting edges that vary in helical angle from tip to shank and pitch depending on taper, positive rake angle, and large inner core, all of which tend to put additional stress on the root walls and have very poor flexibility. Increased stiffness and less flexibility of HeroShaper may have contributed to many defects in HeroShaper group in present study.[14]

Metallurgy and design contribute to the stress induction in the dentinal walls. The instrument's taper, design, and rotations per minute (rpm) all affect the dentinal defect that develops in the root during cleaning and shaping.

It has been concluded that TRN instruments are less destructive for root canal system due to the regressive tapers and heat treatment of the NiTi alloy. It was stated that the TruNatomy (TN) instruments safeguard the structural dentin and tooth integrity due to their instrument geometry, regressive tapers, and slim design, along with the heat treatment of the NiTi alloy.[9] Regressive taper make instruments slimmer at end of working part than most conical NiTi instruments of comparable ISO size, preventing unnecessary loss of tooth substance in coronal part.As TruNatomy (TN) files having regressive taper preserved more amount of dentin in coronal part.

CONCLUSIONS:

Dentinal microcrack propagation was evident in all rotary file systems. Fewest cracks were appreciated in TruNatomy file systems compared to other systems, whereas Heroshaper showed maximum microcracks.

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