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Evaluation of Microcracks in Radicular Dentin Induced By Coronal Preflaring Instruments-An Invitro Study

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ABSTRACT
Aim and objectives:
To evaluate the incidence of microcrack formation after usage of two commonly used coronal pre flaring instruments: one flare (Micro Mega, France) and Hero shaper preflaring manual instrument (Micro Mega, France).
Materials and methods:
A total of single-rooted sixty human premolar teeth that were extracted for orthodontic reasons were collected. After selection, individual tooth is embedded in modelling wax. 3 different files were used for preflaring.

- Group 1- control group: in this the specimens left unflared
- Group 2- One flare Micro mega 5th generation rotary files
- Group 3- Micro mega Hero shaper individual manual files

Dentinal defects at 2,4 and 6mm sections from CEJ in the coded specimens were observed and recorded using scanning electron microscope.
Results:
Intergroup comparison for "craze lines" at different distances in coronal 3rd revealed that there was a statistically significant difference between the compared preflaring instruments with lesser number of "craze lines" observed with "Group 3-Hero shaper" at 2mm (13.3%, p=0.01), 4mm (20%, p=0.03) as well as 6 mm (20%, p=0.02). Intergroup comparison for "incomplete cracks" at different distances in coronal 3rd revealed that there was a statistically significant difference between the compared preflaring instruments with lesser number of "incomplete cracks" observed with "Group 3-Hero shaper" at 2mm (13.3%, p=0.02), 4mm (13.3%, p=0.009) as well as 6 mm (20%, p=0.01). Intragroup comparison revealed that there was no statistically significant difference betweendifferent distances in coronal 3rd for various dentinal defects such as: no defects, incomplete cracks and craze linespertaining to both the preflaring instruments and the control.
Conclusion:
From the results of the current study, it can be concluded that a smaller number of dentinal defects were observed with Hero shaper comparable with that of the control group. There is no statistically significant difference in presence of various dentinal defects with varying distances in the coronal 3rd of the teeth for all the three coronal preflaring instruments.

Keywords: Coronal preflaring, hero shaper, oneflare, endodontics, root canal treatment

I. INTRODUCTION

The successful endodontic treatment requires proper access opening in order to achieve straight-line access to the root canals [1].However in an attempt to achieve proper access opening, over-zealous or inadvertent instrumentation has led to weakening of the radicular dentin leading to formation of micro cracks, thinning of dentin or formation of defects that cannot be sealed adequately during obturation.

During cleaning and shaping of the root, a canal is shaped by the contact between instrument and dentin wall. These contacts create momentary stress concentration in dentin which may lead to dentin defects and micro cracks. This in turn, may be associated with increased VRF susceptibility during root canal obturation, retreatment or post endodontic restoration.

Evaluation of microcracks can be done by using several diagnostic methods. Some of them such as microscopic evaluation require horizontal root sectioning and other methods like radiographs/CT/CBCT etc do not require horizontal root sectioning [2].Scanning Electron microscope (SEM) imaging method scans objects after dehydration and coating procedures with a detailed

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high resolution and larger magnification [3]. SEM analysis has allowed better inspection of the craze lines than many other methods. There are only a few studies related to the effect of coronal flaring instruments on crack formation.

Preflaring of the cervical and middle thirds of the root canal improves anatomical diameter determination and the instrument used for preflaring plays a major role in determining the anatomical diameter at the working length [4]. Various rotary nickel–titanium systems with different configurations and designs have markedly improved the cleaning and shaping procedures of root canal preparation. However due to the increasing taper of the instruments, apart from achieving adequate coronal access, it also results in relatively more removal of dentine thereby reducing the fracture resistance of the tooth [5].Therefore, it has been hypothesized that dentinal microcracks of varying depths and extensions may occur depending on the design and configuration of the coronal pre-flaring instrument [6].

Hence, the aim of the present study is to evaluate crack formation after preflaring root canals with Oneflare (MicroMega, France), Hero (Sybron Endo, USA).

II. MATERIALS AND METHODS

Sample selection

A total of single-rooted sixty human premolar teeth that were extracted for orthodontic reasons were collected and kept in saline until use. Informed consent was taken from the patients who underwent extraction, that the extracted teeth would be used for the following study. The teeth were stored, disinfected and handled as per recommendation and guidelines laid down by Occupational Safety and Health Administration (OSHA) and Centre for Disease Control (CDC).

The protocol was carried out as follows:

- Organic debris was removed by submerging the teeth in 1% sodium hypochlorite solution for 4 days.
- Calculus was mechanically removed by ultrasonic scaling.
- Teeth were stored in 10% formalin for 2 weeks as per standard sterilization protocol.
- After sterilization, samples were stored in distilled water until further use.

Coronal pre-flaring

Radiographs of each tooth were taken in the mesio-distal and bucco-lingual aspects to eliminate calcifications, curved root, and those with multiple canals. After selection, individual tooth is embedded in modelling wax. A 10k-file (MANI) was used to establish the canal patency. Three different files were used for preflaring.

The root canals (n=15) were then flared as follows,

- Group 1- control group: in this the specimens left unflared
- Group 2- One flare Micro mega 5th generation rotary files (n=15) is used.

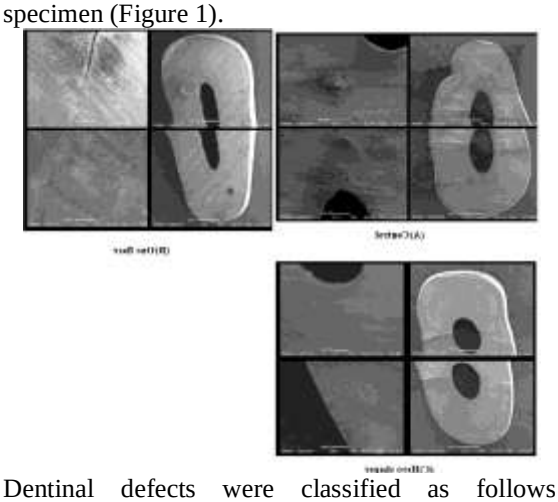
The rotational speed torque limits, and depth of insertion for each system were determined as suggested by the manufacturer. The files and drills was used with a gentle brushing motion using Endo motor. All root canals was irrigated with 2ml 3% NaOCL between each instrument. Final rinse was done using 5ml of normal saline.

- Group 3- Micro mega Hero shaper individual manual files(n=15)

Hero shaper manual pre flaring instrument was inserted in the coronal third to a maximum 3mm using a gentle back and forth motion.

Microscopic examination

All the samples were horizontally sectioned at 2, 4, and 6 mm from the CEJ with a low-speed double-sided diamond disc with water coolant and coded according to the groups and sections. Dentinal defects at 2,4 and 6mm sections from CEJ in the coded specimens were observed and recorded using scanning electron microscope operated between 15 and 20Kev under different magnifications according to the dimensions of the specimen (Figure 1).



Dentinal defects were classified as follows according to Barreto et al [7].

A. No defect: Root dentin without any lines or cracks on the external or the internal surface of the root
B. Incomplete crack: A line extending from the canal wall into the dentin Without reaching the outer surface.
C. Complete crack: A line extending from the root canal wall to the outer Surface of the root

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D. Craze lines: All other lines that did not reach any surface of root or extend from the outer surface into the dentin but did not reach the canal wall.

III. STATISTICAL ANALYSIS:

The statistical analysis was performed using statistical package for social sciences "SPSS Version 26.0" software package ("IBM, college station, Armonk, New York, USA"). The intergroup comparison for the different sub-categories of dentinal defects such as no defects, incomplete crack, complete crack and craze lines at different distances in coronal 3rd was performed using chi-square test. The post hoc tests pertaining to the different sub-categories of dentinal defects such as no defects, incomplete crack, complete crack and craze lines at varying distances from CEJ was performed using two samples proportion test to test the level of significance for each paired comparison. The intragroup comparison between different distances from CEJ pertaining to presence of dentinal defects was performed using Cochran Q test. For all comparisons, $p<0.05$ was considered to be statistically significant.

IV. RESULTS:

The discrete data pertaining to eachsub-categories of dentinal defects such as no defects, incomplete crack, and craze lines for each preflaring instrument at different distances in coronal 3rd were represented using frequency/percentage distribution and are represented in **Table 1 and 3.**

Intergroup comparison for no defects at different distances in coronal 3rd revealed that there was a statistically significant difference between the compared preflaring instruments with a greater number of "no defects" observed with "Group 3-Hero shaper" at 2mm (73.3%, p=0.01), 4mm (73.3%, p=0.008) as well as 6 mm (66.7%, p=0.001) **(Table 1)**. Post hoc analysis performed using two samples proportion test showed that statistically significant difference was observed between "group 1-control" vs "group 2-one flare" indicating presence of appreciable number of dentinal defects in "group 2-one flare" at all three distances in coronal 3rd**(Table 2)**. Post hoc analysis also revealed no significant difference between "group 1-control" and "Group 3-Hero shaper" at all three distances in coronal 3rd indicating lesser number of dentinal defects comparable with that of the control group **(Table 2)**.

Intergroup comparison for "craze lines" at different distances in coronal 3rd revealed that there was a statistically significant difference between the compared preflaring instruments with lesser number of "craze lines" observed with "Group 3-Hero shaper" at 2mm (13.3%, p=0.01), 4mm (20%, p=0.03) as well as 6 mm (20%, p=0.02) **(Table 1)**. Post hoc analysis performed using two samples proportion test showed that statistically significant difference was observed between "group 1-control" vs "group 2-one flare" indicating presence of a greater number of "craze lines" in "group 2-one flare" at all three distances in coronal 3rd**(Table 2)**. Post hoc analysis also revealed no significant difference between "group 1-control" and "Group 3-Hero shaper" at all three distances in coronal 3rd indicating lesser number of "craze lines" comparable with that of the control group **(Table 2)**.

Intergroup comparison for "incomplete cracks" at different distances in coronal 3rd revealed that there was a statistically significant difference between the compared preflaring instruments with lesser number of "incomplete cracks" observed with "Group 3-Hero shaper" at 2mm (13.3%, p=0.02), 4mm (13.3%, p=0.009) as well as 6 mm (20%, p=0.01) **(Table 1)**. Post hoc analysis performed using two samples proportion test showed that statistically significant difference was observed between "group 1-control" vs "group 2-one flare" indicating presence of a greater number of "craze lines" in "group 2-one flare" at all three distances in coronal 3rd**(Table 2)**. Post hoc analysis also revealed no significant difference between "group 1-control" and "Group 3-Hero shaper" at all three distances in coronal 3rd indicating lesser number of "incomplete cracks" comparable with that of the control group **(Table 2)**.

Table 1: Intergroup comparison with respect to various dentinal defects performed using chi square test

Distance	category	Group I (Control group)		Group II (oneflare group)		Group III (Hero shaper group)		P value
		n	%	n	%	n	%	
No defects								
2 mm	No	14	93.3%	8	53.3%	11	73.3%	0.01*

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	defects							
	Defect	1	6.7%	7	46.7%	4	26.7%	
4 mm	No defects	14	93.3%	7	46.7%	11	73.3%	0.008*
	Defect	1	6.7%	8	53.3%	4	26.7%	
6 mm	No defects	14	93.3%	6	40%	10	66.7%	0.001*
	Defect	1	6.7%	9	60%	5	33.3%	
Craze lines								
2 mm	Absent	14	93.3%	9	60%	13	86.7%	0.01*
	Present	1	6.7%	6	40%	2	13.3%	
4 mm	Absent	14	93.3%	9	60%	12	80%	0.03*
	Present	1	6.7%	6	40%	3	20%	
6 mm	Absent	14	93.3%	8	53.3%	12	80%	0.02*
	Present	1	6.7%	7	46.7%	3	20%	
Incomplete cracks								
2 mm	Absent	15	100%	11	73.3%	13	86.7%	0.02*
	Present	0	0%	4	26.7%	2	13.3%	
4 mm	Absent	15	100%	9	60%	13	80%	0.009*
	Present	0	0%	6	40%	2	20%	
6 mm	Absent	15	100%	9	60%	12	80%	0.01*
	Present	0	0%	6	40%	3	20%	
	Present	1	6.7%	9	60%	5	33.3%	

***p<0.05 is statistically significant**

Table 2: Post hoc tests for pairwise comparison performed for various dentinal defects using two sample proportions test

Distance	G1 Vs G2	G1 Vs G3	G2 Vs G3
No defects			
2 mm	0.01*	0.04*	0.26
4 mm	0.005*	0.04*	0.14
6 mm	0.002*	0.03*	0.14
Craze lines			
2 mm	0.03*	0.44	0.10
4 mm	0.02*	0.52	0.23
6 mm	0.03*	0.52	0.12
Incomplete cracks			
2 mm	0.03*	0.26	0.36
4 mm	0.006*	0.71	0.09
6 mm	0.03*	0.27	0.23

***p<0.05 is statistically significant**

G1- Group I (Control group), G2- Group II (oneflare group), G3- Group III (Hero shaper group)

V. DISCUSSION:

The success of endodontic treatment lies in proper cleaning and shaping as well as adequate debridement of the infected canal. One of the major problems involving endodontic treatment is the fact that a larger portion of the endodontic anatomy remains un-instrumented/ under-instrumented and thereby jeopardizing the quality of the final endodontic filling [8]. Previous studies have concluded that a percentage of 35–53% of the root canal surface remains un-instrumented during endodontic treatment [9]. Another crucial aspect which has to be considered is that the irrigants used for canal disinfection need to reach all throughout the endodontic anatomy in order to be effective [10]. This purpose is difficult to be achieved without accomplishing adequate coronal preflaring. Consequently, a dentin surface which has been rendered clean, disinfected and adequately prepared could be obtained for the third stage of endodontic treatment, which is the three-dimensional sealing of the root canal space. The study done by Shiv Aditya et al. also shows that cervical pre-flaring plays an indispensable role in reducing the discrepancy between initial apical file diameter and apical canal diameter [11].

But overzealous instrumentation during coronal pre-flaring leads to inadvertent sequelae such as microcracks, weakening of supportive dentin and vertical root fractures [12]. Therefore, apart from accomplishing adequate coronal preflaring the clinician should try to minimize these iatrogenic dentinal defects in order to enhance the longevity of the endodontically treated teeth. Therefore, the objective of the current invitro study was to compare three commonly used coronal preflaring instruments with respect to occurrence of dentinal defects and thereby determine the coronal preflaring instrument which causes minimal dentinal defects during instrumentation.

In the current study, scanning electron microscopy (SEM) was used to evaluate the dentinal defects and microcracks occurring due to instrumentation with various coronal preflaring instruments. Scanning electron microscopy is adequately sensitive in determining the surface topology of complex objects with even non-linear or curvilinear surfaces. Although an optical microscope provides an image with a relatively large depth of focus, a much larger depth of focus could be obtained with SEM [13]. This can be attributed to the fact that the aperture angle of the electron probe in SEM is much smaller than that of the objective lens in an optical microscope.

In the current study, more number of dentinal defects were observed with “one flare” system. This can be due to wider taper of “one flare” system comparable with that of “Gates Glidden drills” although its rpm (250-400 rpm) is less than that of “Gates Glidden drills” (800 rpm).

Ogus Yoldaz et al. observed 60% dentinal microcracks with Hero shaper group in his study [14]. This is in contrary to the results of the current study in which Hero shaper outperformed the other coronal preflaring instruments with mean incidence of dentinal defects as low as 13.3%. This can be due to manual instrumentation with hero shaper rather than rotary instrumentation which induces less momentary stress concentration in the surrounding dentinal walls. The results of the current study are in agreement with that of the previous studies done by Iracema C et al., Anup panda et al, Shafia Rashid et al [15,16,17].

Pinto and coaguila ellerena et al. and Burcu Nihan yuksel et al. observed that in their study a greater number of dentinal defects were observed in middle third rather than coronal or apical third for all the file systems [18,19]. This is contradictory to the results of the current study which shows that there is no statistically significant difference in the incidence of dentinal defects with varying distances from CEJ. The difference in results could be due to difference in canal morphology as in their study they examined microcracks in molars rather than premolars as done in the current study.

Conclusion of the study:

Hence from the light of the results of the current study it can be concluded that a smaller number of dentinal defects were observed with Hero shaper comparable with that of the control group. There is no statistically significant difference in presence of various dentinal defects with varying distances from CEJ for both the coronal preflaring instruments. More number of dentinal defects are caused after instrumentation with “one flare” system due to greater dimension of taper of the instrument than “Heroshaper”.

Limitations of the current study:

Scanning electron microscopy (SEM) usually shows a greater number of dentinal cracks which might be produced as a result of the steps involving preparation of samples (usually loss of hydration) and it can affect the results of the study. Evaluation of dentinal defects using micro-CT would provide more accurate non-destructive quantitative as well as qualitative assessment of these iatrogenic dentinal defects.

Future research:

Future studies are warranted to evaluate the effect of factors (i.e.) degree of taper of the instruments, RPM, contact time of the instruments with the dentinal wall, etc. affecting incidence of microcracks with various coronal pre-flaring instruments. Future studies involving micro-CT evaluation could be performed to more accurately assess the location, size and propagation of the microcracks and craze lines. Longitudinal invivo studies are also required to assess the survival rate of teeth prepared with various coronal pre-flaring instruments. Future studies should also assess the relationship between severity of the dentinal defects and bending resistance after instrumentation using various coronal pre-flaring instruments.

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Conflict of interest: The authors declare that there is no conflict of interest.

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