Efficacy of Various Final Irrigant Activation Procedures on Smear Layer Removal - A SEM Study

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Abstract

Background: This in vitro study was intended to compare the removing efficacy of smear layer of the EndoVac , EDDY tip, XP - endo Finisher and conventional needle irrigation in palatal roots of extracted maxillary first molars, at the apical, middle and coronal levels by using scanning electron microscopy.

Material and Method: The palatal roots of sixty recently extracted maxillary first molars were selected and divided into four groups (n=15) according to final irrigation agitation systems; EndoVac irrigation system,Eddy tip, XP - endo Finisher and conventional needle irrigation. Each root was prepared to 40/0.06 apical size with EDGEENDO X3 rotary files. Following splitting the root samples, single half of each sample was selected for examination under scanning electron microscope (SEM). The comparisons among irrigation activation devices were done using the Kruskal Wallis test and Mann-Whitney U test at 0.05 significance level.

Conclusion: Within the limitations of the present study, no one of the tested systems can remove the smear layer completely. However, EndoVac system , Eddy tip and XP - endo Finisher remove significantly more smear layer than conventional needle irrigation at the apical third but there was no significant difference at middle and coronal thirds.

Key words: *smear layer, EndoVac irrigation system , Eddy tip, XP - endo Finisher.*

Introduction

During root canal measures, root canals cleaning and shaping is valued one of the most significant steps which greatly influences the outcome of the endodontic management. Smear layer is created on the root canals surfaces during cleaning and shaping, this shapeless irregular film is made of organic pulpal residues and inorganic dentinal fragments accumulation which stick onto the radicular wall of canal [1]. It has been stated that the smear layer obstruct the dentinal tubules and impede the penetration of irrigants solutions, disinfectant materials and endodontic sealers into the dentinal tubules [2],which may deteriorate the canal seal and encourage the microleakage, it was also established that existence of this contaminated layer full with bacteria in the dentinal tubules , lessen the success ratio of the root canal therapy. Smear layer is produced during instrumentation either with hand or rotary instruments [3,4]. Various researches found that removing the smear layer results in better root canal sealing[5]. Numerous irrigating solutions and strategies have been utilized for better elimination of the smear layer, the most Frequently applied irrigating solution in endodontics is sodium hypochlorite (NaOCl), the widespread protocol for eradication of smear layer involves the use of sodium hypochlorite (NaOCl) then ethylenediaminetetraacetic acid (EDTA) since EDTA is a chelating agent of calcium, which is very effective in removing the smear layer [6]. Syringe and needle irrigation has been established to be unsatisfactory for a perfect cleaning of the complex configuration of root canal system (in particular the accessory canals, isthmuses and the apical area), consequently tries are being made to establish new irrigants and irrigating means to enhance the root canal treatment [7,8].

EndoVac (Discus Dental, Culver City, CA, USA) illustrates a modern approach of irrigations, rather than

supplying the irrigant by using the needle, the EndoVac method is built on a negative-pressure attitude whereby the irrigant situated in the chamber of the pulp is dragged down the root canal and move upward again via a specially designed thin needle [9].

XP-Endo finisher, is an innovative NiTi rotary file with a semi-circular figure and a diameter of 3mm.It was stated that it is able to well-match the complicated form of the root canals to make them cleaner and eradicate the smear layer from the canals with curves and irregular form[10].

The XP- file is straight in shape when it is in martensitic phase (20° low temperature). When subjected to body temperature (37°) as it inserted in the canal, it transforms to austenitic phase. On cooling, it alters back to the martensite phase and it retakes its straight form [11,12].

In recent times, EDDY (VDW, Germany), a new sonic power-driven tool for activation of the irrigation was familiarized , it is constructed of bendable polyamide, which can be utilized with numerous root canals with complex anatomy to perform sufficient cleaning[13]. EDDY is a one-use, germ-free, non-cutting tip which is activated by using air scaler with 5000 to 6000 Hz [14]. So the aim of the current study was to measure and compare the effectiveness of these recent irrigant agitation procedures on smear layer removal.

Material and Method

A total of sixty recently extracted human maxillary first molar teeth with straight palatal root collected from different health centers were utilized in this study. Immediately next to extraction, the tooth surfaces were cleaned from bone fragments, calculus and soft tissues manually with periodontal curette [15] .

The teeth were collected in plastic containers contain 0.1% thymol solution for 48 hours [16], then in distilled water at room temperature to prevent samples dehydration[17] (Abdo et al.,2012).

Standardization of palatal root length (12mm) was performed with the assistance of a digital caliper and a permanent marker. The teeth were then fixed on a bench vice, and a dual-faced diamond disc attached to a straight handpiece was employed, with water coolant, for segmenting the palatal root perpendicular to the root long axis following the drawn line. The pulpal tissues were eradicated using barbed broaches, and the correct location of the apical foramen and the canals patency were confirmed by inserting a #10 stainless steel K-file and progressed slowly until it is observed at the apical foramen. Next to the adjustment of the silicon stopper, the file was pulled and the working length was gained by subtracting 1mm from the definite length of the root using endodontic ruler [18,19] .To facilitate management of the samples during the succeeding steps, the samples were inserted, excluding the coronal 3 millimeters, in clear plastic tubes occupied with silicone rubber base impression material of putty texture and mounted on a bench vice to demonstrate a standardized position during the subsequent steps. The apex of each root was closed with a hot glue to mimic the clinical condition [20]. All the canals were instrumented with EdgeFile® X-3 rotary system (EdgeEndo, Albuquerque, NM, USA) with the instrumentation sequence initiating with the N1 (17/06) file, followed by N2(17/04), C1(20/06), C2(25/06), C3(30/06) and reaching a final size of C4(40/06).

Before instrumentation, the canals were irrigated with 1 mL of 5.25% NaOCl. At each file switch the canals were rinsed with 2 mL of 5.25% NaOCl by using a 5-mL syringe and side vented needle calibrated at -2 mm from the working length. The total volume of NaOCl was 13 mL per sample during instrumentation before the final irrigation protocol .At the finish of preparation the sample irrigate with 3ml distilled water to avoid prolonged effect of sodium hypochlorite and dried with paper point size 40/06.

The samples were then distributed into four groups of 20 samples according to the activation procedure of the final irrigation.

Group A:- EndoVac device

Thirty seconds period of irrigation with 5ml, 5.25% NaOCl will be done by using the master delivery tip while the macrocannula will be constantly moved up and down in the canal. This will be followed by leaving the canal full of irrigant for 30s. Three irrigation cycles using the microcannula placed at full working length will be followed. The first cycle will be 30 s of 5 ml, 5.25% NaOCl ; the second cycle will be 1 min of 3 ml, 17% EDTA followed by 1 min of soaking; and the third

cycle will be 2 ml of distilled water delivered over a period of 1 min. The canal then dried with paper point.

Group B :- EDDY tip

The tip made of flexible polyamide with a size of 25.04, driven by an air scaler will be moved up and down over a distance of 3 mm starting 1 mm from the apical terminus without pressure according to the manufacturer's recommendations (6000 Hz) for 30 s. The procedure will be repeated 3 times. In between each activation cycle, the canal will be flushed with 3 mL irrigant (NaOCl 5.25%) using a side vented needle (Hage et al .,2019) . Afterwards, another 1mL of irrigant will used to flush the canal and remove debris .This will be followed by 3 mL of 17% EDTA solution activated for a period of 1 min which will be allowed to remain for 2 min in total. A final rinse of distilled water (2 mL) will be activated over a period of 1 min. The canal finally dried with paper point.

Group C:- XP-endo Finisher

In the first step, the canal will be flushed with 3mL of 5.25% NaOCL and activated for 30s.The procedure will be repeated for 3 times. Afterwards, another 1mL of irrigant will used to flush the canal and remove debris. This will be followed by 3 mL of 17% EDTA solution activated for a period of 1 min which will be allowed to remain for 2 min in total. A final rinse of distilled water (2 mL) will be activated over a period of 1 min. At the end the canal dried with paper point.

Group D :- Conventional irrigationt

A 30G needle will be used to deliver 10 mL of 5.25% NaOCl over a period of 90 s. This will be followed by 3 mL of 17% EDTA, which will be left within the root canal for 2 min. The root canals will be then rinsed with 2 mL of distilled water for 1 min [21] . The canal then dried with paper point.

Scanning electron microscopic examination preparation:

Deep channels were prepared on the buccal and palatal roots surfaces, utilizing diamond discs, without entering inside the canal. The roots were then separated longitudinally using a blade and a mallet. Only single half of each root was chosen for assessment under SEM. After that, the specimens will be gold sputtered and will be observed under 5000x magnification. The dentinal surface of each sample will be studied for the presence/ absence of smear layer according to following score [22]:

Score 1: Dentinal tubules completely open.

Score 2: More than 50% of dentinal tubules open.

Score 3: Less than 50% of dentinal tubules open.

Score 4: Almost all dentinal tubules covered with smear layer.

Finally, representing photomicrographs will then be taken .

Statistical Analysis

The differences between irrigation techniques were compared non-parametrically using Kruskal-Wallis and Mann-Whitney U tests. The significance level was set at $P \leq 0.05$.

Results

For the coronal level, results presented insignificant difference among tested groups (p=0.176), for the middle section, the difference was non-significant (p=0.067), while the apical third revealed significant difference (p=0.011)(table 1).

Table (1): Kruskal-Wallis test for comparisons among the mean ranks of smear layer removal of the four tested group at each level.

Levels	groups	Mean Rank	df	Asymp. Sig.
Apical	Group A	21.27	3	0.011 (S)
	Group B	31.10		
	Group C	31.33		
	Group D	38.30		
Middle	Group A	22.53	3	0.067 (NS)
	Group B	35.33		
	Group C	35.63		
	Group D	28.50		
Coronal	Group A	23.90	3	0.176 (NS)
	Group B	31.00		
	Group C	36.87		
	Group D	30.23		
P ≤ 0.05 Significant (S), P > 0.05 Non-Significant (NS)				

Mann-Whitney test for apical third results showed significant difference between groups A&D(p=0.001), between group B&D(p=0.029), and between group C&D (p=0.045).However, difference among groups A,B and C was insignificant(table2).

Table(2): Mann-Whitney U test for comparison between groups at apical level.

groups	N	Mean Rank	Sum of R	Sig.
Group A	15	12.83	192.50	0.098 (NS)
Group B	15	18.17	272.50	
Group A	15	12.93	194.00	0.116 (NS)
Group C	15	18.07	271.00	
GroupA	15	10.50	157.50	0.001 (S)
Group D	15	20.50	307.50	
Group B	15	15.43	231.50	0.967 (NS)
Group C	15	15.57	233.50	
Group B	15	12.00	180.00	0.029 (S)
Group D	15	19.00	285.00	
Group C	15	12.30	184.50	0.045 (S)
Group D	15	18.70	280.50	
P ≤ 0.05 Significant (S), P > 0.05 Non-Significant (NS)				

Discussion

It is essential that the irrigants have to be brought into direct contact with the whole canal wall surfaces for efficient action principally in the apical sections of root canals because of the typically not easy complexity of the root canal configuration. For the irrigants to attain the apical area there must be a good delivery method. Many irrigation delivery and activation techniques have been created for efficient root canal irrigation [23].

Regarding apical area, the efficiency of EndoVac system in creating clean canals walls might be the result of its apical negative pressure methodology. The apical negative pressure makes the irrigant move towards the apex, generating a swift turbulent current influence towards the terminal end of the microcannula. The vents of the microcannula empty debris from the closed end of the canal systems. This procedure helps to overcome the vapor lock, thus aiding better irrigation [24]. Our results are compatible with the findings of Ribeiro et al. [25] who informed that EndoVac remove significantly more debris than NaviTip. Saber and Hashem [26] in their study also established that EndoVac was significantly better in eliminating debris than NaviTip in the apical level of the root canal.

Eddy group resulted in more clean surface and a lesser amount of smear layer at the apical third of the root canal surfaces in comparison to conventional needle irrigation. This result could be attributed to acoustic streaming and cavitation created by EDDY tip which cause movement of the irrigating solution in three dimensions and so aids penetration of the irrigant to the unreachable areas and apical third of the canal to wash it and help elimination of smear layer [14,27].

Xp endo finisher file also resulted in less smear layer than syringe and needle irrigation in apical area. Xp endo finisher builds on shape memory of the NiTi alloy, since it takes a sickle curved profile when inserted into the root canal at 37° temperature (austenitic phase) which lets it to contact the root canal surfaces and distributing the irrigant to the unreachable parts and apical third of the canal. This exclusive shape with the non- cutting flutes assist cleansing of the smear layer on the dentinal walls without causing any alterations to the dentin shape. When XP endo finisher cools down (20°) it converts to straight shape(martensitic phase) [28,29] .

In addition to that there was no significant difference among groups A,B and C in apical thirds this could be the result of their ability to damage smear layer and augment contact between irrigant liquids and canal walls more than static style of irrigant solution delivered by ways of conventional needle irrigation.

For coronal and middle regions, for all groups, the results showed that the coronal and middle thirds are more clean than apical third. This outcome could be linked to the dentinal tubules larger diameter in coronal and middle thirds when comparing with tubules in apical third and hence they exposed to high quantity of irrigant solutions [28,30].

Besides that, there was no significant differences among all tested groups at coronal and middle thirds and this could be attributed to the high volume of irrigating solution utilized in this study which consequently remove the differences associated to the effect of activation devices [31].

Conclusion

Within the limitations of the present study, no one of the tested systems can remove the smear layer completely. However, EndoVac system , Eddy tip and XP - endo Finisher remove significantly more smear layer than conventional needle irrigation at the apical third but there was no significant difference at middle and coronal thirds.

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Conflict of Interest: None to declare.

Ethical Clearance: "All experimental protocols were approved under the College of Dentistry were carried out in accordance with approved guidelines".

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