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A COMPARATIVE SEM ASSESSMENT FOR THE ABILITY OF PIPS, XP-FINISHER AND PUI TO ELIMINATE SMEAR LAYER AND OPEN DENTINAL TUBULES

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ABSTRACT

Aim: This study aimed to assess the removal of smear layer from the dentinal surfaces after canal cleaning and irrigants activation with different systems (Conventional needle irrigation, PUI, PIPS, XP-Finisher).

Methodology: Seventy human single rooted maxillary incisors were instrumented up to X5 (50/6) Protaper Next rotary system. The irrigation activation was performed using either: PIPS, PUI, XP-Finisher, or conventional irrigation. Samples were cut lengthwise, then examined under a scanning electron microscope. Data were analyzed with Kruskal- Wallis test. Significant difference between the groups was recorded statistically in the total scores of the smear layer on dentinal wall ($P<0.05$).

Results: PIPS and XP-Finisher groups showed more smear layer removal than the conventional and PUI groups and this was statistically significant ($P<0.05$). This was clearly presented by opened dentinal tubules in photomicrograph of SEM.

Conclusion: With the constraints of this in vitro study, PIPS and XP-Finisher are better in eliminating smear layer from dentinal walls.

KEYWORDS: PIPS; PUI; XP-Finisher; irrigation.

INTRODUCTION

An efficacious root canal treatment depends on accurate diagnosis followed by efficient mechanical preparation and irrigation of root canal systems together with adequate 3D obturation and coronal seal[1]. Literatures documented that after instrumentation, the root canal walls are masked with an irregular 1–2 μ thickness layer known as the smear layer [2,3] which comprises dentine debris, pulp remnants, and microorganisms [4].

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Even with the prevailing argument on the influence of smear layer on the adequacy of root canal cleanliness, researchers concluded that the smear layer is usually infected and preserve bacteria in dentine [5-7]. Moreover, it acts as a substrate for microorganisms [8,9]. The existence of this layer inhibits or slows up the diffusion of intracanal medicaments and sealers into dentinal tubules boosting the risk of reinfection [1,4,10]. Furthermore, adequate radicular seal cannot be guaranteed as it prevents direct contact of sealers with the inner walls of dentine, and this acts as an avenue for microleakage and decreases the prognosis after endodontic treatment [4,5].

With reference to the aforementioned , eliminating smear layer is mandatory. The usual followed protocol is by irrigating the canal with sodium hypochlorite (NaOCl) followed by Ethylene Diamine Tetra-Acetic acid (EDTA), each for 1 min [7]. Still, the reality showed limited ability of routine irrigant solution to penetrate and reach the complicated anatomy of root canal system [11-13]. Thus, many factors were modified during preparation to maximize irrigation penetration such as the degree of canal taper and preparation size [14]. Agitation of the irrigants inside the canal was another targeted factor. This can be categorized into two broad classes, manual or machine-assisted agitation which shows better results [15,16].

Ultrasonic devices had been used for this purpose in what is known as passive ultrasonic irrigation (PUI) [17]. This count on the cavitation phenomena that is coupled with the acoustic streaming and resulted from the oscillation of ultrasonically driven non-active smooth file, to push irrigants into the ramification of root canal [18].

Another example for the agitation devices is the one presented lately the XP-Endo finisher (XP-Finisher) NiTi file (FKG, Dentaire SA, Switzerland). The producer dues that this file can efficiently cleanse the complex anatomy of root canals and accredited this property to its unique design with small size central core (ISO 25 diameter) and 0% taper beside its high flexibility as it is made with Max-Wire NiTi alloy (18,19). This file is straight and in martensite phase at room temperature (20°). While, when it is inside the tooth at body temperature (35°), it curves and changes to austenite phase[20].

Laser activation of irrigants has been established recently to be used for irrigant agitation [16,21]. Photon-induced photo acoustic streaming (PIPS) employs an Erbium:Yttrium–Aluminum-Garnet (Er:YAG) laser at 2940 nm (LightWalker AT; Fotona, Ljubljana, Slovenia). It relies on the superior absorption of this laser wavelength by the irrigant that fills up the coronal chamber [22,23]. With each shot of laser, the irrigant fluid is immediately heated up beyond its boiling point forming a vapor bubble at the tip of the fiber. The later enlarges, reaching its extreme and then collapses resulting in a cavitation effect. This spectacle generates agitation in the form of turbulent photoacoustic streaming of the fluid through all canals' complexities [24].

Apparently, there are inadequacy in records comparing these irrigant agitation systems regarding the ability to eliminate the smear layer in literature. Hence, the goal of this in vitro study is to assess by scanning electron microscope (SEM) images the dentinal surfaces after canal shaping with a traditional NiTi rotary system, under irrigation activation with different systems (PUI, PIPS, XP-Finisher) regarding the elimination of smear layer. Our null hypothesis is that there are no differences in smear layer elimination with different irrigant agitation systems used.

MATERIALS AND METHODS

This research was done in full accordance with ethical principles, including the World Medical Association Declaration of Helsinki (version 2008). Seventy extracted human single rooted maxillary central incisors with intact roots, mature apices and without any resorption or visible cracks were used.

The reason of extraction was unknown. Teeth were checked by conventional radiograph to prove the existence of single canal and absence of calcifications, resorption and/or other anomalies then all teeth were stowed in saline at room temperature. Access cavity was drilled, and patency of the canals was established using #K-file10 (MANI, Matsutain Seisakusho Co., Tochigi-Ken, Japan), then root canals were instrumented with Protaper Next rotary system till X5 (50/6) using X-Smart Endo Motor (Dentsply Sirona, Pennsylvania, USA) at speed of 300 RPM and 2.5 N.Cm torque following the manufacturer guides. All samples were irrigated with 3ml of 2.5% NaOCl (Wizard, Guided Chemical) solution using a 30-gauge Navitip needle (NaviTip; Ultradent, South Jordan, UT) between files and after finishing the instrumentation. Finally, the apex was coated with hot glue then wrapped with soft wax to resemble closed end channels [25].

Samples grouping and testing:

The final irrigation consisted of 5 mL of 5.25% NaOCl followed by 5 mL 17%EDTA and finally 5 mL of 5.25% NaOCl separated by 5mL normal saline. Samples were distributed randomly according to the irrigation activation protocol into four groups:

PIPS Group (n=20): A cylindrically tapered PIPS® tip 400/14 was used to activate irrigants. The laser was Er:YAG (LightWalker®, Fotona, d.o.o., Ljubljana, Slovenia) of 2940 nm wavelength operated at 20 mJ, 15 Hz, 0.3W, and 50 µs (SSP) for 30 seconds on, then 30 seconds off. The PIPS tip was placed in coronal cavity near canal orifices. This cycle was performed six times (i.e., total of 180 seconds of activation).

PUI Group (n=20): irrigants were activated with ultrasound (EMS, Nyon, Switzerland), using #20 Irrisafe ultrasonic files (Satelec, Acteon, Merignac, France) that was introduced inside the canal, without touching the walls, 1 mm shorter than the working length. The power setting of 4 was used for 3 cycles of 1 minute.

XP-Finisher Group: (n=20) The irrigants activation was done using XP-Finisher NiTi file operated at 800 rpm and 1 Ncm torque using endodontic motor (X Smart, Dentsply-Maillefer). 6-7mm lengthwise movements were done for 1 minute and repeated 3 times.

Control Group (CSI) (n=10): The irrigants were delivered using a 30-gauge Navitip (NaviTip; Ultradent, South Jordan, UT), without any kind of irrigant agitation nor activation.

Sample preparation and evaluation:

To facilitate samples' splitting, a cone of gutta-percha was fitted within the canal then a longitudinal groove on the external surface of the root was cut with a diamond disc without reaching the canal lumen. The specimens were separated into halves with a chisel then coded. Samples were dehydrated for 1 hour per solution in 50%, 70%, 80%, and 100% ethanol then left to dry. After spluttering with gold–palladium, samples were assessed under SEM (SEM; JSM–5600LV, JEOL, Tokyo, Japan) at 20 kV and images at 2000× have being taken. The residual smear layer in the apical, middle, and coronal thirds was scored by two separate observers following 4-point scoring system (26). Score1, no debris and opened dentinal tubules; score 2, debris covering less than 50% of the area and opened dentinal tubules; score 3, debris covering more than 50% of the area and opened dentinal tubules with; and score 4, dentinal tubules covered by debris in more than 90% of the examined area.

Data were studied using the statistical package for social sciences, version 23.0 (SPSS Inc., Chicago, Illinois, USA). The qualitative variables were presented as number and percentages. The Comparison between groups with qualitative data was done using Chi-square test and Fisher's exact test instead of Chi-square test only when the expected count in any cell less than 5. The confidence interval was set to 95% and the margin of error accepted was set to 5%. P-value <0.05 was considered significant.

RESULTS

Data are presented in table1 and figure 1. It shows highly statistically significant difference between groups in all thirds (P<0.001). In the apical third, there was a significant difference between the groups except PUI versus control group (P=0.141) and PIPS versus XP-finisher (P=0.298). In the remaining areas, again, there was a significant differences between all groups except PIPS and XP-finisher (P=0.344, P=0.055) in the middle and coronal thirds respectively.

SEM images (fig.2) showed that the control group had the uppermost amount of remaining smear layer followed by PUI group while PIPS and XP-finisher showed the least.

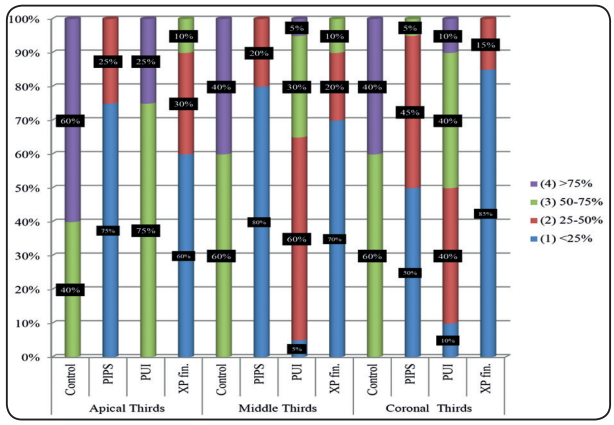

Fig. (1): stacked bar chart showing the percentage score for the remaining smear layer in all thirds of the root canals in each group

TABLE (1): Smear layer score percent for the tested groups at the coronal, middle, apical thirds

Thirds	Score	Control		PIPS		PUI		XP fin.		x^2	p-value
		No.	%	No.	%	No.	%	No.	%		
Apical	1	0	0.0%	15	75.0%	0	0.0%	12	60.0%	71.606	<0.001**
	2	0	0.0%	5	25.0%	0	0.0%	6	30.0%		
	3	4	40.0%	0	0.0%	15	75.0%	2	10.0%		
	4	6	60.0%	0	0.0%	5	25.0%	0	0.0%		
Middle	1	0	0.0%	16	80.0%	1	5.0%	14	70.0%	63.045	<0.001**
	2	0	0.0%	4	20.0%	12	60.0%	4	20.0%		
	3	6	60.0%	0	0.0%	6	30.0%	2	10.0%		
	4	4	40.0%	0	0.0%	1	5.0%	0	0.0%		
Coronal	1	0	0.0%	10	50.0%	2	10.0%	17	85.0%	57.348	<0.001**
	2	0	0.0%	9	45.0%	8	40.0%	3	15.0%		
	3	6	60.0%	1	5.0%	8	40.0%	0	0.0%		
	4	4	40.0%	0	0.0%	2	10.0%	0	0.0%		
Chi-square test	*x^2*	0.000		5.846		21.071		3.961			
	p-value	1.000		0.211		0.002*		0.411			

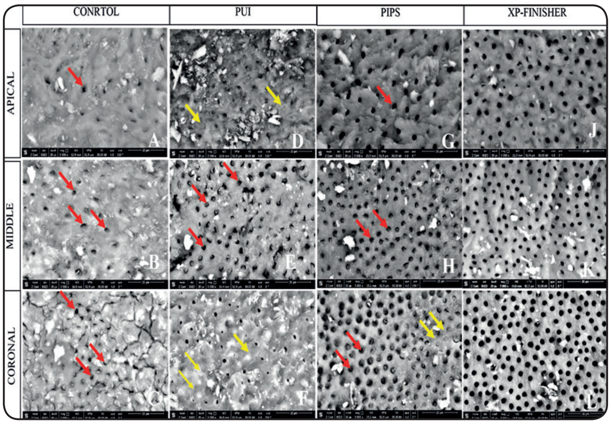

Fig. (2): SEM photomicrograph (X2000) showing: Control group (first column): closed dentinal tubules (DT) more than the opened ones in all thirds (A,B,C) PUI group (second column): opened DT in the middle third (E). Apical and coronal thirds showed obliterated DT by smear layer (D,F) PIPS group (Third Column): opened DT in all thirds (G,H,I). Few DT in the coronal third are obliterated (I) XF Finisher group (fourth column): opened DT in all third (J,K,L). (Red arrows: opened DT, Yellow arrows: Obliterated DT).

DISCUSSION

Smear layer is generated after instrumenting the root canals. Till now, there is no proof suggesting that its elimination is clinically of great importance [27], but it is quietly clear that this allows better cleaning of the canal walls and improves the adaptation of root filling materials [5]. It is known that this layer is formed of organic content eliminated by NaOcl irrigant and inorganic content eliminated by EDTA [7,9]. But still there are many arguments regarding the ideal method of irrigant activation to adequately eliminate this layer and open the dentinal tubules[28]. Thus, the aim of our research was to compare different irriga entional needle irrigation regarding their efficacy in eliminating the smear layer from root canal wall.

While an in vivo scenario is preferred, a comparative in vitro study design was preferred to guarantee adequate management of variables and consistency of results. Single rooted teeth with single canal were chosen since they have an oval cross section and the cleaning ability of rotary instruments is restricted by the rounded cross-sectional design of files, leaving large areas of canal walls untouched with accumulation of hard-tissue debris [29]. Teeth apices were closed to simulate in vivo circumstances as regards gas trap in root canal and to allow the root canal space to act as a reservoir for irrigant during the irrigation/activation process [25].

The findings obtained in this study demonstrated that the effectiveness of all systems in the elimination of the smear layer drops apically in all groups and this is consistent with previous studies revealing that irrigation are least effective in the apical region [11-13]. The incompetence in eliminating the smear layer apically was justified by the truth that the apical is tinier in size than the other thirds with a superior level of tubular sclerosis [30].

Our results revealed that the conventional irrigation exhibited the least ability in removing smear layer in all thirds and this was in agreement with Saber and Hashem [31]. The change of smear layer elimination between PIPS and XP-finisher was not statistically significant, but both devices were significantly superior to the control and PUI groups.

Even though the capability of PUI to eliminate the smear layer has been stated formerly [32] our results revealed no difference between PUI and control group. This agrees with Saber and Hashem [31] who concluded that final irrigant activation with PUI was not efficient in removal of the smear layer. On the other hand, PIPS and XP-Finisher eliminated more smear layer apically. For PIPS, our findings were in a line with Ayranci et al. [30] who stated that irrigant activation by PIPS using the Er: YAG laser was more efficient in smear layer removal in both middle and apical regions compared to the ultrasonic activation. They attributed this to the photomechanical and photothermal effects correlated with Er:YAG laser which leads to the formation of shock waves causing quick changes in pressure and elevated amplitude resulting in a powerful acoustic streaming of fluids [26]. For XP-Finisher, Sousa et al [33] claimed that this is due to its manufacturing from Max-NiTi wire making it very flexible. The later can expand its range to 100-fold greater than a corresponding file allowing better cleaning of the canal in inaccessible areas [3]. Moreover, Živković et al [34] conclusion was like ours in which they stated that the rotary NiTi XP-endo Finisher was a proficient irrigation in instrumented canals and could eliminate smear layer and dentin debris from impenetrable areas.

The findings of our research have revealed that the irrigation activation systems varied in the degree of cleansing promoted in root canal walls. Subsequently, the null hypothesis was denied. Upcoming studies are necessary to validate the usefulness of these systems regarding the overall disinfection of the root canal system using different irrigants.

CONCLUSION

Apparently, it can be assumed that irrigation activation is mandatory as it improves the elimination of the smear layer from the canal walls. None of the methods used were capable to have smear layer free walls however, PIPS and XP-Finisher were better than PUI and conventional irrigation.

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