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Comparative evaluation of various irrigation techniques on smear layer removal: A scanning electron microscopy study

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Abstract:
Aim: The purpose of the present study is to evaluate the effectiveness of different irrigation techniques CNI, Ultrasound Irrigation, SonicMax on smear layer removal using Scanning electron microscopy (SEM).
Materials and Methods: Eighty extracted single-rooted teeth were instrumented with ProTaper rotary instruments. The roots were randomly divided into three experimental groups (n = 20): CNI, Ultrasound Irrigation, SonicMax and a control group, which was only irrigated with NaOCl. Next, the roots were sectioned in a buccolingual direction and the halves were examined by SEM. Smear layer was recorded in the cervical, middle and apical third of the roots. Data analysis was performed using the Kruskal–Wallis and Mann–Whitney U-tests with a level of significance $\alpha = 0.05$.
Results:UI had the greatest amount of smear layer compared to other groups ($P < 0.001$) while control group the lowest in the apical third, while it was ultrasonic in the middle third.
Conclusions: Sonicmax left the least amount of smear layer in all the three layers.

Keywords: irrigation; scanning electronic microscope; smear layer; apical, cervical

Introduction:
Dentinal walls are coated with an organic and inorganic smear layer during root canal preparation. First, there is a 1–2 mm-thick layer of smear that clings to the root canal wall; and second, there is a 40-mm-thick layer that is driven into the dentinal tubules to produce what are known as "pumps" (1). Root canal irrigants and material obturation into dentinal tubules (2) are hampered by the presence of this layer, increasing the risk of bacterial infection and microleakage (3). Therefore, removing the smear layer can increase the permeability of the dentinal tubules and the adaptability of root canal filling material and improve the sealing of the root canal obturation (4).
Mechanical root canal instrumentation results in a smear layer on the dentinal walls, according to studies . Is composed of both organic and inorganic matter. Despite the debate over whether or not the smear layer should be maintained, research has demonstrated that the smear layer itself may retain bacteria and protect bacteria within the dentinal tubules. Smear layer has also been found to inhibit the entry of dentinal tubules intracanal disinfectants andsealers and may affect the seal of the root canal filling (5)

Most typically, root canal irrigants are sodium hypochlorite (NaOCl) solutions because of their organic tissue disintegrating impact and high antibacterial qualities. A chelator, EDTA eliminates the inorganic smear layer component by chelating it. Irrigant application to the root canal is just as critical as the irrigant's characteristics. In endodontic therapy, the most often utilised final irrigation regimen is EDTA after irrigation with NaOCl solution.

The conventional (or manual) needle irrigation (MNI) approach, which utilises a syringe and a needle to administer the irrigant into the root canal system, is the most often utilised irrigation technique in dentistry. Irrigants generated by the MNI are seen as insufficient to completely clean the root canal walls. In small or curved canals, the irrigant's capacity to disinfect dentinal tubules is severely reduced. Most typically, root canal irrigants are sodium hypochlorite (NaOCl) solutions because of their organic tissue disintegrating impact and high antibacterial qualities. A chelator, EDTA eliminates the inorganic smear layer component by chelating it. Irrigant application to the root canal is just as critical as the irrigant's characteristics. In endodontic therapy, the most often utilised final irrigation regimen is EDTA after irrigation with NaOCl solution. (6)

Using a syringe and a needle, the conventional (or manual) needle injection (CNI) approach is the most common method of root canal irrigation. CNI-created irrigants are regarded insufficient to fully clean the root canal walls because of their mechanical flushing activity. In small or curved canals, the irrigant's capacity to disinfect dentinal tubules is severely reduced.. Irrigation's flushing power is amplified by ultrasonics.

The flushing activity of irrigation solution is amplified by the use of ultrasonics. When compared to a passive sonic agitation technology, PUI produced much cleaner canals. SonicMax (Maximum Dental Inc., Secaucus, NJ, USA) is a dental unit compressor-powered sonic irrigation system. a little file that should be placed in the canal's middle and activated sonically is used for irrigation. This study evaluated the effect of CNI, Ultrasound Irrigation (UI), SonicMax and a control group on smear layer removal using SEM analysis.

Materials and methods:

Selection of tooth: Single-rooted human mandibular premolars with mature apices recently excised teeth were employed in the experiment. To confirm the existence of a single canal, digital radiographs from the buccal and distal directions were taken. The teeth were then preserved in the physiological saline solution until they were needed again. A diamond disc was used to deconstruct each tooth's cement-enamel juncture. It was discovered that the WL was 1 millimetre too short by inserting an apical foramen-sized size 10 K-file.

All canals were instrumented crown-down with ProTaper rotary instruments using the manufacturer's recommended sequence (Sequence-S1-Sx-S2-F1-F2-F3-F4). A finishing file of size F4 was used for each canal. The apical patency of each instrument was checked using a size 10 K-file. Irrigation with 1 mL of NaOCl and a 27-gauge needle was performed for 20 seconds after each file was used. A minor amount of resistance was felt as the needle was inserted into the urethra.

Final irrigation of root canals: CNI, UI, SonicMax and control groups (n = 20 each) were randomly divided into three experimental (n = 20) and control groups (n = 20). Experimenters used five millilitres each of 2.5 percent NaOCl solution, 17 percent EDTA solution, and five millilitres of 2.5 percent NaOCl solution for their final root canal irrigation. Finally, the root canals were irrigated with 5 mL of saline solution to flush out any remaining solution and then dried with the paper points. To ensure consistency, each specimen was produced by a single person and under the same set of circumstances

These are the irrigation methods and materials that were employed in this study:

Sonic Max: A K-file number 15 was utilised in conjunction with SonicMax to activate the irrigation solution. In order to avoid making contact with the root canal wall, the file was centred and placed into the canal at an angle that was one millimetre shorter than the WL.

Ultrasonic irrigation: Use of a size 15 file with an ultrasonic irrigation system coupled to an Acteon Suprasson Pmax SatelecMarignac France file was made possible through the use of an ultrasonic irrigation system. Activating an Irrisafe that had been put 1 mm below the WL proved to be quite a challenge. Ultrasonic activation of a vibrating file at power setting 5 irrigated the root canals extensively.(7) The file was inserted into the middle of the canal without making any contact with the tissue.

Smear layer analysis:

Using a diamond disc and chisel, the specimens were cut in half longitudinally after final irrigation in preparation for scanning electron microscopy (SEM) analysis. Root margin grooves were used to divide samples into apical, middle, and coronal sections. A 6400 electron scanning microscope (SEM) was used to analyse each specimen, which was dried in successively concentrated ethanol solutions, gold-coated, and viewed at a magnification of 1500.(8) The root region is scanned at a magnification ratio of 10 with the SEM's central light, and the magnification is gradually increased to 1500. The smear layer and erosion levels in the apical, middle, and coronal thirds of the root canals were then examined at a pressure of about 1500 psi.After a calibration exercise, two endodontists blindly reviewed the SEM pictures. Kappa tests were carried out for both smear and erosion evaluations to ensure inter-observer consistency.

Hülsmann et al. devised the following 5-scale rating systems for the smear layer: score 1, no smear layer, dentin tubules open; score 2, small amount of smear layer, most tubules open; score 3, homogeneous smear layer

covering the root canal wall, only a few tubules open; score 4, complete root canal wall covered by homogeneous smear layer, no open dentinal tubules; and score 5, heavy non - homogenous smear layer covering the complete root canal wall.

Data Analysis: Data distributions were examined for normality using the Kolmogorov–Smirnov test. Multiple pairwise comparisons were carried out using the Kruskal–Wallis and Mann–Whitney U-tests. At the apical, middle, and coronal third levels, the results of smear groups were compared. SPSS (version 23.0. Chicago: SPSS Inc., IL, USA) was used for all statistical analyses, with a significance level of 5% ($p = 0.05$).

Results:

When groups are compared at the apical third level, UI had the greatest amount of smear layer compared to other groups ($P < 0.001$) while control group the lowest. CNI group showed a greater amount of smear layer as compared to SonicMax. When groups are compared at the middle third level, UI had the greatest amount of smear layer compared to SonicMax and CNI($P < 0.001$). There was no difference between the groups when the amount of smear layer is compared at the coronal third level, except control ($P < 0.001$) (seen in Table 1)

Table 1: Table depicting smear layer at different levels of the roots between the groups

Smear layer (mean ± S.D)	Apical third	Middle third	Coronal third
CNI	3.31 ±0.03	1.03 ±0.11	1.00 ± 0.08
Sonic Max	1.00 ± 0.00	1.00 ± 0.00	1.00 ± 0.03
Ultrasonic	2.13 ± 0.57	2.82 +0.84	1.05± 0.21
Control	5.68 ± 0.03	5.84 ± 0.23	6.00 ± 0.00
P value	<0.001*	<0.001*	<0.001*

* =Significant

Discussion:

This study aimed to compare the effect of the various irrigation techniques such as manual, ultrasonic and sonic irrigation on smear layer removal.

When compared to passive sonic irrigation and manual irrigation, PUI has been demonstrated to be an effective irrigation method with reduced smear layer and debris. (9) Sonic and ultrasonic instruments have a frequency range of between 20 and 30 kHz.

Three to five times as much energy is expended by an ultrasonic oscillating file as by a sonically oscillating file. As a result, sonic vibration files are projected to remove dentin less aggressively than ultrasonic vibration files. SonicMax irrigation solutions may readily remove debris and smear layers from the canals even while the vibrating file is in touch with the dentin wall. With sonic irrigation, a greater amount of smear layer and debris was removed. (10,11) In addition to SonicMax's superior performance, CNI procedures removed more smear layer than PUI.

The removal of the smear layer using various irrigation procedures is vital to a successful treatment outcome. The following are the justifications for making this claim: Bacteria, their waste products, and necrotic tissue are all present in the waste. In the dentinal tubules, bacteria can thrive and grow, creating a reservoir of microbial irritants. Bacteria may be able to penetrate deeper into the dentinal tubules thanks to its role as a food source. Because of this, irrigants and intracanal medications may not reach their full therapeutic potency. Disinfectants can be blocked by a smear layer in dentinal tubules, where bacteria can hide. Filling materials and the canal wall might not be able to make a proper seal because of this. As a result, the root canal filling and dentinal walls are at risk of leaking and the passage of germs and other microorganisms.(12)

An important disadvantage of this study is the lack of accurate resemblance to the clinical settings of root canal therapy. Consequently, more study is needed to identify the influence of the presence or absence of the smear layer on bacterial colonisation of root canals in clinical relevant models.

Conclusion:

SonicMax approach left the least amount of smear layer as compared to ultrasonic technique. Within the limitations of this *in vitro* study, it can be concluded that none of the irrigation techniques completely removed all the smear layers from root canal walls at the coronal part of the canal.

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