Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 4, 2021, Pages. 10611 - 10617
Received 05 March 2021; Accepted 01 April 2021.

The Effect of Four Commonly Used Root Canal Irrigants on the Removal of Smear Layer: An In-Vitro Scanning Electron Microscope Study

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ABSTRACT

Introduction: To achieve a thoroughly clean root canal, mechanical instrumentation, supplemented with irrigants, and intracanal medications are employed. Irrigants play a vital role in the removal of the smear layer. Hence in the present study we intend to compare the efficiency of four commonly used chemicals in their ability to remove smear layer after instrumentation using scanning electron microscope (SEM).

Methods: 50 single-rooted, freshly removed human mandibular premolars were taken. They were separated into the equal groups of 10 each with a control group. After performing the access opening and gaining the access to the canals and the lengths measured, Irrigation was performed. The roots were then split with a hammer and chisel. One-half of each tooth was selected and prepared for SEM examination. After assembly on coded stubs, the specimens were placed in a vacuum chamber and sputter-coated with a 300 Å gold layer. The specimens were then analyzed using a Philips SEM XL 30. The dentinal wall of the 1,3,5 mm from apex was observed at magnifications of up to ×1000 for the presence/absence of smear layer and visualization of the entrance to dentinal tubules. Photomicrographs (×1000) of these area were made. Data were analyzed using statistical tools keeping p value less than 0.05.

Results: SEM study done on these prepared teeth with the popularly used four chemicals, namely, 3% NaOCl (Group 1), 3% NaOCl followed by 17% ethylene diamine-tetra-acetic acid (Group 2), 0.2% chlorhexidine (Group 3) and 3% NaOCl followed by MTAD (Group 4), with distilled water (Group 5) which is used as control, revealed that NaOCl showed statistically significant, better cleansing effect than distilled water. Chlorhexidine and NaOCl showed equal kind of efficacy but were statistically significant, with lower efficacy than MTAD. It may be concluded that MTAD appears to be the most effective solution compared to the rest.

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Conclusion: The study demonstrated that MTAD as a final rinse after the entire instrumentation with 3% NaOCl as irrigant provided the best cleansing in all parts of the root canal system.

Keywords: Root Canal Irrigants, Sodium hypochlorite, Smear layer, Scanning electron microscope.

INTRODUCTION

Elimination of the infection from the root canal marks the success of the endodontic treatment.[1] Irrigation of the root canal is inherent part of the debridement.[2] Sodium hypochlorite is the most frequently used irrigant used for the endodontic treatments as it dissolves organic substances. It also acts as an effective antimicrobial agent. When used along with EDTA, Sodium hypochlorite removes predentin, the pulp tissue and smear layer.[3] For the effective action of the irrigants they have to completely wet the entire surface of the root canal. Various factors influence the irrigant action including the delivery systems.[4] Various techniques have been proposed for the delivery to the root apex, the irrigant solutions.[5] Smear layer has been shown to hinder the penetration of intracanal disinfectants and sealers into dentinal tubules and has the potential of compromising the seal of the root filling. It has been shown that removal of the smear layer reduced the penetration of bacteria through the root canal system after root filling.[3,4] Goldman et al.[6] showed that when used alone, R ethylene diamine-tetra-acetic acid (EDTA) REDTA removed the inorganic portion and left an organic layer intact in the tubules. Sodium hypochlorite (NaOCl) has been shown to be very effective for this purpose. When used alone, NaOCl can dissolve pulpal remnants and predentin. Other studies showed that alternating the use of EDTA and NaOCl is an effective method for smear layer removal.[5-8]A new irrigation solution (MTAD), introduced in 2003 by Mahmoud Torabinejad of Loma Linda University, containing a mixture of a tetracycline isomer, an acid, and a detergent is claimed to remove smear layer.[9] Hence in this study, we compare the efficiency of four commonly used chemicals in their ability to remove smear layer after instrumentation using scanning electron microscope.

METHODOLOGY

Fifty freshly removed human mandibular premolars with radiographically confirmed straight mature roots with single canals without any other pathologies were used in this study. We randomly divided the teeth into five equal investigational groups based on the irrigant as Groups 1,2,3,4 and 5 containing 10 samples each.

- Group 1: Samples rinsed with 3% NaOCl during instrumentation and finally rinsed with the same solution.
- Group 2: Samples rinsed with 3% NaOCl during instrumentation and finally rinsed with 5 ml solution of 17% EDTA for 1 min.
- Group 3: Samples rinsed with 0.2% Chlorhexidine during instrumentation and finally rinsed with the same solution.
- Group 4: Samples rinsed with 3% NaOCl during instrumentation and finally rinsed with 5 ml MTAD for 1 min.
- Group 5/Control: Samples rinsed with distilled water during instrumentation and finally rinsed with the same solution.

Group 1 and 2 were finally irrigated with 10 ml of distilled water to remove precipitates that may have formed from the irrigants used. Irrigation was done using 2 ml of irrigant for every

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instrument change and lastly washed by 5 ml of the irrigants. The irrigants were delivered with an endodontic irrigating needle supplied along with MTAD. After the irrigating, absorbent paper points (DiadentGroupInternational Inc,Chongju,Korea) were used to dry out the root canal. The teeth were decoronated with diamond discs at the cement-enamel junction level. The roots were then fragmented with a chisel and hammer. One-half of each tooth was selected and prepared for SEM examination.

After assembly on coded stubs, the specimens were placed in a vacuum chamber and sputter-coated with a 300 Å gold layer. The specimens were then analyzed using a Philips SEM XL 30. The dentinal wall at the one, three and five millimeters from the apical end were seen corresponding to apical, middle, cervical areas at magnifications of up to ×1000 for the presence/ absence of smear layer and visualization of the entrance to dentinal tubules. Photomicrographs (×1000) of these areas were made. Later analysis was performed using appropriate statistical tools keeping the level of significance as $P < 0.05$.

RESULTS

The following observations were made using SEM study on prepared teeth with the popularly used four chemicals, namely, 3% NaOCl (Group 1), 3% NaOCl followed by 17% EDTA (Group 2), 0.2% chlorhexidine (Group 3) and 3% NaOCl followed by MTAD (Group 4), with distilled water (Group 5). The distilled water showed the least cleaning effect in this study.

- *At 5mm*

MTAD (Group 4) showed the greatest effect, trailed by NaOCl + EDTA (Group 2), NaOCl (Group 1) and least with chlorhexidine (Group 3). NaOCl had statistically significant, better cleansing effect than distilled water.

- *At 3 mm*

Distilled water has shown the least cleansing effect compared to all the other groups. This was also statistically significant. The order of cleansing efficacy was, first NaOCl + MTAD (Group 4), followed by NaOCl + EDTA (Group 2), which was followed by NaOCl and chlorhexidine (Group 3). Chlorhexidine (Group 3) and NaOCl (Group 1) seem to have equal kind of efficacy but were statistically significant, with lower efficacy than MTAD.

- *At 1 mm*

The control group (Group 5) showed the least cleansing effect. Interestingly NaOCl (1) appeared to be almost same as distilled water (Group 5). The best cleansing was seen with MTAD (Group 4). EDTA (Group 2) was found to be better than chlorhexidine (Group 3), but inferior to MTAD (Group 4). In General, it may be concluded that MTAD appears to be the most effective solution compared to the rest.

There was a statistically significant difference between the groups with respect to the median smear layer scores ($P < 0.001$). The difference in median smear layer scores between Group 1 and Group 4 is found to be statistically significant ($P < 0.001$). Statistically significant difference is observed between Group 2 and Group 3 ($P < 0.05$), Group 2 and Group 4 ($P < 0.01$), as well as Group 2 and Group 5 ($P < 0.001$) with respect to median smear layer score. Group 2 has a higher mean and median smear layer score compared to Group 4 and a lower mean smear layer score compared to Group 3 and Group 5. The difference in median smear layer scores between Group 3 and Group 4 is found to be statistically significant ($P < 0.001$).

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Statistically, significant difference is observed between Group 4 and Group 5 with respect to the median smear layer score ($P < 0.001$). (Table 1, 2)

Table 1: Comparison of the various irrigants.

		Number	Std. Deviation	Mean	95% Confidence Interval for Mean		Repeated measures ANOVA F value	**P**
					Lower Bound	Upper Bound		
Group 1	1 mm distance	21.78	20	304.10	293.91	314.29	1355.657	**.000**
	3 mm distance	42.15	20	548.07	528.34	567.79		
	5 mm distance	23.42	20	754.60	743.64	765.56		
Group 2	1 mm distance	36.76	20	426.15	408.95	443.35	1654.846	**.000**
	3 mm distance	42.60	20	892.18	872.24	912.12		
	5 mm distance	44.76	20	992.99	972.05	1013.94		
Group 3	1mm distance	43.19	20	442.96	422.75	463.17	989.178	**.000**
	3 mm distance	29.69	20	721.32	707.42	735.21		
	5 mm distance	43.13	20	943.40	923.21	963.59		
Group 4	1 mm distance	38.45	20	345.55	327.56	363.54	436.671	**.000**
	3 mm distance	42.09	20	602.30	582.60	622.00		
	5 mm distance	55.03	20	632.45	744.70	796.20		
Group 5	1 mm distance	37.45	20	655.55	322.56	355.54	424.125	**.000**
	3 mm distance	41.09	20	611.30	456.60	602.00		
	5 mm distance	52.03	20	701.45	644.70	654.20		

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Table 2: Comparison of the four irrigants at various levels of the root canal in removal of the smear.

			Mean Difference	Std. Error	p
1 mm distance	Group 1	Group 2	-122.05	11.37	**.000**
		Group 3	-138.86	11.37	**.000**
		Group 4	-41.45	11.37	**.003**
	Group 2	Group 3	Group B	11.37	.860
		Group 4	Group B	11.37	**.000**
	Group 3	Group 4	Group B	11.37	**.000**
3 mm distance	Group 1	Group 2	Group C	12.49	**.000**
		Group 3	Group D	12.49	**.000**
		Group 4	-54.23	12.49	**.000**
	Group 2	Group 3	170.86	12.49	**.000**
		Group 4	289.88	12.49	**.000**
	Group 3	Group 4	119.02	12.49	**.000**
5mm distance	Group 1	Group 2	-238.39	13.64	**.000**
		Group 3	-188.80	13.64	**.000**
		Group 4	-15.85	13.64	1.000
	Group 2	Group 3	49. 59	13.64	**.003**
		Group 4	222. 54	13.64	**.000**
	Group 3	Group 4	172.95	13.64	**.000**

DISCUSSION

One of the major aims of endodontic therapy is to debride the root canals, executing them free of the pulp tissue, necrotic debris, microorganisms /toxins. Root canal irrigants aid in chemo-mechanical preparation by eliminating the above.[1-3] Many irrigants have been used for the removal of smear layer of which the common were citric acid, tannic acid, maleic acid, polyacrylic acid, tetracyclines, chlorhexidine, EDTA, and sodium hypochlorite.[10,11] In the our study 3% Sodium hypochlorite (NaOCl), 17% EDTA, 0.2% chlorhexidine and MTAD have

been applied with distilled water as control. Sodium hypochlorite is both an oxidizing and hydrolyzing agent. The effectiveness of NaOCl to remove the organic part of the smear layer becomes evident and significant at higher concentrations (1.3-5.25%). EDTA is often suggested as an irrigation solution, because it has the capability to chelate and remove the mineralized portion of smear layer.[7,14,15] Numerous studies have reported that irrigation with a 17% EDTA solution has a good cleaning effect on the root canal walls.[16] Hence in the present study 17% EDTA solution has been used for 1 min for irrigating after the completion of instrumentation. In the endodontic literature, chlorhexidine has been shown to be tested in the concentrations of 0.2% w/v and 2%. Since 0.2 % w/v is the most common available type, the same is used for this study for its cleaning ability.[17-20] MTAD is an acidic solution with a pH of 2.15 that is capable of removing inorganic substances.[9] Therefore in the current study 3% NaOCl was used during instrumentation and finally rinsed with MTAD.[21,22] The outcomes obtained from our study shows that rinsing the canal with MTAD for 1 min following thorough preparation using 3% NaOCl can be used in routine clinical practice. From this study it may also be concluded that MTAD may be made a routine chemical to be used at the end of the preparation, particularly in the cases where the root canal system is found to be heavily infected. Despite tetracycline effectiveness in its anti-bacterial property and cleansing ability, it should be studied further in clinical conditions. In all the SEM analysis, the ability of all the chemicals, excepting MTAD was least in the apical third of the root canals. This gives a clue for applying caution to conduct the study in a clinical environment. In real in-vivo situation intrusion of body fluid into the root canal system may interfere with the nature and effectiveness of the chemicals. It may be settled that smear layer removal can be routinely practiced, chiefly in cases of teeth with established apical infection.

CONCLUSION

Thorough cleaning and sealing of the apical third of the root canal system is of great significance. In our study the SEM results showed that the four irrigants were relatively more effective in cleansing the coronal third, but less effective in the apical third. Among the four MTAD as a final rinse after the entire instrumentation with 3% NaOCl as irrigant provided the best cleansing. Hence we can conclude that using MTAD as a final rinse may be made a part of routine cleansing procedure in the root canal treatment, mainly in cases of teeth with established infection in the apical part of the root canal. Further studies are warranted to analyze the entire canal rather than a portion with bigger sample size as these factors may be important in future successful endodontics.

ACKNOWLEDGEMENT:

We thank Mina Doos, BDS, Faculty of dentistry and oral medicine pharos university in Alexandria, Egypt for assisting in literature collection and reviewing the manuscript.

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