SEM evaluation of apical smear layer removal by combining endoactivator with different irrigating solutions-An invitro study

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Abstract

Root canal instrumentation produces a layer of organic and inorganic material called the smear layer that contains bacteria and their by-products. It prevents the penetration of intracanal medicaments into dentinal tubules and influence the adaptation of filling materials to canal wall.

The aim of this invitro study is to compare and evaluate the efficacy of different final irrigating solutions on smear layer removal in apical third of root canal.

Materials and Methods: Sixty human single rooted mandibular premolars with single canal teeth were selected. All the samples were decoronated to standardize the root canal length of 15 mm. Teeth were divided into 4 groups, group 1, 2, 3, and 4 having 15 samples in each. The irrigants used during cleaning and shaping and as final irrigation were, as mentioned below: Group 1: Normal Saline. Group 2: EDTA. Group 3: Qmix 2in 1. Group 4: Sodium hypochlorite (3%). After completion of cleaning and shaping, Samples of all the groups were subjected to sonic irrigation for 10 seconds by endoactivator using respective irrigants. (Final irrigation). Teeth were sectioned longitudinally and observed under SEM (scanning electron microscope) and scoring was done.

Statistical analysis was performed using kruskal wallis test.

Results: Intergroup comparison showed statistical difference in the smear layer removal efficacy of the irrigants tested. Qmix 2in 1 is the most effective in removal of smear layer when compared to other tested irrigants

Conclusion: Q mix 2 in 1 is the most effective irrigant in smear layer removal.

Keywords: QMIX, Irrigation, Endoactivator, Smear Layer.

Introduction

Root canal instrumentation causes production of a layer of organic and inorganic substance that is called as smear layer that mainly consist of bacteria and their components that causes prevention of the infiltration and perfusion of intracanal medicaments into dentinal tubules and affects the adaptation of filling materials to canal walls.^[1] The triumphant accomplishment of root canal treatment is dependant on the procedure carried out and the quality of cleaning and shaping and irrigation, disinfection and three dimensional obturation of the root canal which is also very important for the success of the root canal treatment. Amongst the actions that are involved in the control of an endodontic infection, irrigation protocol plays a significant role in the eradication of microorganisms from the root canal system. Endodontic treatment cannot be limited to the removing of pulp remnants and the increasing the width of root canals, but in dire need should also focus on removal of smear layer.^[2] The irrigating process has three objectives as advocated by the Walker: 1) Dissolution of remnant tissue, 2) Antimicrobial action, and 3) lubrication of the canal. Many researchers have claimed that the smear layer is very difficult to remove.^[3]

Till now the most universally used technique of smear layer removal has been the chemical method by the use of chelating agents, such as ethylenediaminetetraacetic acid (EDTA) being the most common agent that is used in dental practise. The most commonly used blend of 17% EDTA plus 5.25% NaOCl causes removal of the smear layer wholly in the coronal and middle thirds but is less effective in removal of the smear layer in the apical third. For competent removal of smear layer other than EDTA, new irrigating agents such as QMix 2 in 1, MTAD, have been introduced into the market as final irrigants. Success of an endodontic treatment is dependent on meticulous chemo-mechanical preparation as well as three-dimensional obturation that provides for a thorough complete sealing of the root canal system.^[4]

Various manual or machine-assisted irrigant activation techniques (IAT) have been made to prevail over the drawbacks of CNI (conventional needle irrigation) with numerous popular and studied techniques including those of manual dynamic activation (MDA), passive ultrasonic irrigation (PUI), sonic irrigation (SI) and apical negative pressure (ANP).

SI devices, such as Endoactivator (DentsplySirona, York, UK), causes production of a hydrodynamic event through oscillation of extremely flexible smooth polymer tip

at frequencies of 1–10 kHz. The EndoVac ANP system (Kerr, Orange County, CA, USA) causes exertion of negative pressures on the irrigants to gather debris mainly through a vacuum similar to multivented microcannula, inserted to working length.^[5]

Conventional syringe irrigation is estimated to reach not more than 1.5– 2.0 mm beyond the tip of needle hence not reaching the apical areas. In the majority of the cases, this is mainly limited within the coronal to middle-third area of the root canal. As a result, intracanal agitation/activation of the irrigants is extremely obligatory to bring about these irrigating solutions in direct contact with the entire surface areas of the root canal walls and also penetrate into dentinal tubules.^[6]

This study was carried out with the purpose to evaluate the effect of various irrigating solutions combining Endoactivator on smear layer removal. The irrigants used were namely Sodium hypochlorite, Edta, Normal saline and Qmix.

Materials and Methods

This in-vitro study was conducted in the Department of Conservative Dentistry and Endodontics. Maratha Mandal's Nathagirao G. Halgekar Institute of Dental Science And Research Centre, Belagavi. Single rooted mandibular premolars with single canal were used in the study. Mandibular premolars with more than 1 canal, Resorbed roots and premolars with incomplete development of apex were excluded from the study

Rvgs were taken by exposing proximal surface of the mandibular premolars to confirm presence of single canal. Sixty human single rooted mandibular premolars with single canal teeth were selected for this study. Surface cleaning of the teeth was done with ultrasonic scaler. Samples selected were stored in distilled water. All the samples were decoronated to get the stable reference point and to standardize the root canal length of 15 mm. Teeth were divided into 4 groups, group 1, 2, 3, and 4 having 15 samples in each. Samples of all the groups were subjected to cleaning and shaping as described. Access opening was done using Endo z burs. Initial filing was done using 10k and 15 k files

to check the apical patency. Root canal preparation was done using protaper rotary files till size F2.

The irrigants used during preparation and as final irrigation were, as mentioned below: -

1. Group 1: Normal Saline.
2. Group 2: EDTA.
3. Group 3: Qmix 2in 1.
4. Group 4: Sodium hypochlorite (3%).

After completion of cleaning and shaping, Samples of all the groups were subjected to ultrasonic irrigation for 10 seconds by endoactivator using respective irrigants. Final irrigation was done by using irrigants mentioned for their respective groups. Teeth were sectioned longitudinally using chisel and mallet. The specimens were stored in air tight plastic containers until they went were then observed under SEM (scanning electron microscope) and scoring was done.

Scoring criteria: According to a three score system developed by Torabinejad et al.

Score 1: No smear layer — No smear layer was detected on the surface of the root canal, and all tubules were open.

Score 2: Moderate smear layer — No smear layer on root canal walls but tubules contained debris.

Score 3: Heavy smear layer — Smear layer covered the root canal wall surface and the tubules.^[7]

Results obtained were statistically analysed using kruskal wallis test. Conclusions were drawn based on the results obtained.

Statistical analysis

Kruskal wallis test was used for analysis of data. Comparison between the four groups will be done for overall significance using kruskal wallis test. $P < 0.05$ will be taken as statistically significant. Comparison between qmix, edta, hypo, saline using mann whitney test

Results

The results presented results presented in the following way.

Table 1: Statistical analysis was done using Kruskal-Wallis test and Mann-Whitney -test using software SPSS 17.0 version (SPSS Inc., Chicago). The results showed that QMix 2 in 1 showed least smear layer scores when compared to others.

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles		
						25th	50th (Median)	75th
QMIX	15	1.33	0.49	1.0	2.0	1.0	1.0	2.0
EDTA	15	2.27	0.59	1.0	3.0	2.0	2.0	3.0
Saline	15	3.00	0.00	3.0	3.0	3.0	3.0	3.0
Hypochlorite	15	2.67	0.49	2.0	3.0	2.0	3.0	3.0
Kruskal-Wallis test: Chi-square value: 38.61, degrees of freedom 3, p-value <0.001, Significant								

Table 2: Descriptive statistics of Smear Layer Removal score in percentage

Group		Smear Layer Removal score			Total
		No smear layer detected on surface of root canal and all tubules open	Moderate smear layer no smear layer on root canal walls but tubules contained debris	Smear layer covered the root canal wall surface and the tubules	
QMIX	N	10	5	0	15
	%	66.7%	33.3%	.0%	100.0%
EDTA	N	1	9	5	15
	%	6.7%	60.0%	33.3%	100.0%
Saline	N	0	0	15	15
	%	.0%	.0%	100.0%	100.0%
Hypochlorite	N	0	5	10	15
	%	.0%	33.3%	66.7%	100.0%
	N	11	19	30	60
	%	18.3%	31.7%	50.0%	100.0%

Table 3: Comparison between Qmix, Edta, Hypochlorite, Saline using mann whitney test.

Column1	Qmix	Edta	Hypo	Saline
Qmix	-	<0.001	<0.001	<0.001
Edta	-	-	0.059	<0.001
Hypo	-	-	-	0.016

1. Q mix was found to be most effective in smear layer removal (median score 1) compared to all other three irrigants.
2. Saline was found to be the least effective in smear layer removal (the median score of 3)
3. Saline was significantly worse than other three irrigants in smear layer removal.
4. However in this study there was no significant difference between Edta and hypochlorite when compared for smear layer removal.

Results showed that Q mix was more efficient and better in smear layer removal than compared to other irrigating solutions used in this study for evaluating smear layer removal. Saline did not show any smear layer removal and has no smear layer removal properties at all. Whereas EDTA and Hypochlorite did not show much difference in smear layer removal in this study. Q mix showed a median score of 1 which meant that most of the samples showed the score of 1 ie.no smear layer was present on the root canal surface and all the tubules were open whereas saline samples showed a median score of 3 which meant heavy smear layer covering root canal wall surface and the tubules. Even though this study showed that there is no significant difference between Edta and hypochlorite on smear layer removal, there is sufficient evidence in literature that EDTA is better at smear layer removal when compared to hypochlorite.

Fig. 1: a): Armamentarium used; b): split section; c): Qmix; d): Sem image Edta; e): Sem image Hypochlorite; f): Sem image Q mix; g): Sem image Saline

Discussion

During the process of cleaning and shaping, smear layer is formed on the root canal walls that leads to blockage of dentinal tubules, thus for efficient disinfection, thorough cleaning and sealing of the root canal system its removal is vital and of utmost importance. Irrigation is a key step during and after instrumentation for efficient elimination of smear layer and also for serving for lubrication of root canal system.^[4]

Biomechanical preparation of root canal system has clear and well defined goals that is to remove all pulp tissue, necrotic debris, or microorganisms and to shape smoothen, and enlarge the pulpal space to accept a three dimensional obturation. Pulpal space preparation today is said to be carried out more efficiently, more predictable with the rotary versions than with the conventional hand instruments. Clinical documentation and in vitro studies have to some extent radically put forward the advantages of using rotary versions that do not come under the conventional ISO standardized endodontic instruments. Clinical experience has shown that the preparations resulting from rotary versions are faster and more predictable. However long standing clinical trials are still needed. The endodontic smear layer was recognized some years ago and the clinical endodontists and researchers have been trying to understand the relationship between the presence of this layer and the success of pulp space therapy.

Endodontic instruments in themselves vary in their debris removal efficacy due to their specific flute design. It has been shown that rotary crown down technique is very effective, creates predictable shaping with significantly less time than conventional technique. The rotary versions create a smooth funnel formed shape with the orifice shaper used as the first instrument that permits deeper penetration of needled and irrigating solutions during early instrumentation phases.^[8]

The uncertainty of preserving or eliminating the smear layer is still a controversial (Drake et al. 1994, Shahravan et al. 2007) topic according to researchers. Some researchers believe on its removal (Garberoglio & Braˆnnstroˆm 1976, Outhwaite et al. 1976, Pashley 1985), whereas numerous others consider the ill effects of it on apical and coronal microleakage (Madison & Krell 1984, Goldberg et al. 1995, Chailert vanitkul et al. 1996), bacterial penetration of the tubules (Pashley 1984, Williams & Goldman 1985, Meryon & Brook 1990) and the adaptation of root canal materials (White et al. 1987, Gencog˘lu et al. 1993a, Gutmann 1993).^[1]

Sodium hypochlorite (NaOCl) is the most common irrigant that is used in root canal treatment, and it has proven to be an exceptional irrigating solution, due to its supreme and brilliant tissue dissolving capability and microbicidal activity. NaOCl is a conventional irrigant, on the other hand due to its inability to get rid of inorganic part of smear layer, other irrigants were introduced after instrumentation for effective smear layer removal.^[9]

Edta is the most common chelating agent that is used. It was introduced by nygaard ostby for cleaning and shaping of the canals. It contains four acetic acid attached to ethylene diamine. Wu et al. has shown in their study that the smear layer elimination capacity of 17% EDTA was considerably better than 20% of citric acid and MTAD (Biopure™ mixture of tetracycline isomer, acid and detergent).^[10]

QMIX 2 in 1 is a new root canal irrigating solution, and it contains a mixture of a bisbiguanide an antimicrobial agent, a polyaminocarboxylic acid, a calcium-chelating agent,

saline, and a surfactant.²⁶ QMiX contains EDTA, CHX, and a detergent (surface active agent), and its pH is slightly above neutral. It is recommended as final rinse after NaOCl. Benefits of QMiX 2in1 irrigating solution is a single root canal irrigant that is used as a final rinse after bleach for single step smear layer elimination and disinfection. It has an outstanding bacteria killing property and eliminates greater than 99.99 % of planktonic bacteria – including the resistant species *Enterococcus faecalis*. Q mix offers a fast working time of 60-90secs for complete effectiveness.^[11]

The EndoActivator® System is currently used in endodontic practise by applying of sonic energy. The Activator tips are used in combination with the Handpiece/Driver to give the energy for tip oscillation and vibration. Evidence-based endodontics reveals that cavitation and acoustic streaming enhance debridement and the interruption of the smear layer and biofilm. The EndoActivator® System is mainly composed of the handpiece and Activator tips of various sizes.

The Dentsply Sirona reference number for the handpiece is A0912 The reference number of the Activator tips are A0913 022-015 (Small) A0913 022-025 (Medium) A0913 022-035 (Large) The reference number of the protective barrier is A0914.^[12]

In this study, we have studied thoroughly the prime effects of different irrigating solutions on smear layer removal combining ultrasonics. Samples were allotted to respective groups and all the procedures were carried out accordingly to the methodology stated. Results showed that Q mix was more efficient and better in smear layer removal than compared to other irrigating solutions used in this study for evaluating smear layer removal. Saline did not show any smear layer removal and has no smear layer removal properties at all. Whereas EDTA and Hypochlorite did not show much difference in smear layer removal in this study. Q mix showed a median score of 1 which meant that most of the samples showed the score of 1 ie.no smear layer was present on the root canal surface and all the tubules were open whereas saline samples showed a median score of 3 which meant heavy smear layer covering root canal wall surface and the tubules. Even though this study showed that there is no significant difference between edta and hypochlorite on smear layer removal, there is sufficient evidence in literature that EDTA is better at smear layer removal when compared to hypochlorite.

A study by mozayeni et al results have showed that NaOCl was an hopeless irrigant to eliminate the smear layer. Calt and Serper have established that 10-mL irrigation with 17% EDTA for 1 min was efficient in removing the smear layer.^[13]

Vemuri et al (2015) in their study quoted a study by ludin et al (2013) that sodium hypochlorite is a traditional irrigant which is most frequently used but due to its incapability to eliminate inorganic components of smear layer other irrigants were introduced.^[4] In this study the reduced smear layer scores seen in the hypochlorite group may be attributed to use of endoactivator, which increases the

efficacy of smear layer removal. So this can be justified according to a study by Haapsalo et al. that states endoactivator improves penetration of irrigant and facilitates mechanical cleaning.^[14]

Thus I would like to conclude saying that QMIX is by far superior to all other irrigants used in the study and NORMAL SALINE has no effect in removal of the smear layer, whereas studies in the past have shown EDTA to be efficient in removal of smear layer and sodium hypochlorite having no effect on smear layer removal.

Conclusion

Within the limitations of the study, we can conclude that, Qmix is the most effective irrigant in smear layer removal, being superior compared to others.

EDTA is the next effective irrigant in removal of smear layer almost similar to sodium hypochlorite, and sodium hypochlorite is not far behind EDTA in smear layer removal in this study that was carried out. Literature supports that EDTA is superior than Sodium Hypochlorite in smear layer removal. Saline was the least effective irrigant in smear layer removal as compared to other irrigants in this study.

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Conflict of Interest

None.

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