Journal of Advanced Medical and Dental Sciences Research

@Society of Scientific Research and Studies

Journal home page: www.jamdsr.com doi: 10.21276/jamdsr Index Copernicus value = 85.10

(e) ISSN Online: 2321-9599; (p) ISSN Print: 2348-6805

Original Research

Comparative Evaluation of Smear Layer Removal Efficacy of Different Final Irrigating Solutions: A Scanning Electron Microscopic Study

Samriti Sharma[1], Riyaz Farooq[2], Aamir Rashid Purra[3], Fayaz Ahmad Ahanger[4], Priyanka Bhagat[5]

[1]Post Graduate Student, Department of Conservative Dentistry and Endodontics, Govt. Dental College and Hospital, Srinagar, J&K, India.
[2]Professor and Head, Department of Conservative Dentistry and Endodontics, Govt. Dental College and Hospital, Srinagar, J&K, India.
[3]Associate Professor, Department of Conservative Dentistry and Endodontics, Govt. Dental College and Hospital, Srinagar, J&K, India.
[4]Assistant Professor, Department of Conservative Dentistry and Endodontics, Govt. Dental College and Hospital, Srinagar, J&K, India;
[5]Post Graduate Student, Department of Conservative Dentistry and Endodontics, Dr HS Judge Institute of Dental Sciences and Hospital, Punjab university, Chandigarh.

ABSTRACT:
Objective: To compare smear layer removal in the root canal dentin after final irrigation with 17% EDTA, QMix 2 in 1 and BioPure MTAD. **Materials and Methods:** Forty recently extracted mandibular premolars were taken and decoronated to a standardized root length of 12mm. They were prepared using ProTaper system up to size F3. Prepared teeth were randomly divided into 4 groups according to the final rinse solution: Group 1(distilled water, control), Group 2 (17% EDTA), Group 3 (QMix 2 in 1) and Group 4 (BioPure MTAD). Samples were split longitudinally into two halves and examined under scanning electron microscope for presence or absence of smear layer at coronal, middle and apical portions of root canal. **Results:** QMix 2 in 1 and BioPure MTAD were more effective in removing smear layer than 17% EDTA in the apical third of root canal. However, no significant difference was observed between EDTA, QMix and MTAD in removal of smear layer from coronal and middle third of the canal spaces. **Conclusion:** QMix 2 in 1 and BioPure MTAD are better final irrigating solutions than EDTA at the apical third of root canal dentin.
Key words: Root canal irrigation, EDTA, MTAD, QMix 2in1, smear layer, scanning electron microscopy.

Received: 12May, 2020 Accepted: 28 May, 2020

Corresponding author: Dr. Samriti Sharma, Post Graduate Student, Department of Conservative Dentistry and Endodontics, Govt. Dental College and Hospital, Srinagar, J&K, India

This article may be cited as: Sharma S, Farooq R, Purra AR, Ahanger FA, Bhagat P. Comparative Evaluation of Smear Layer Removal Efficacy of Different Final Irrigating Solutions: A Scanning Electron Microscopic Study. J Adv Med Dent Scie Res 2020;8(6):21-26.

INTRODUCTION

The main objective of endodontic therapy is the complete elimination of microorganisms from the root canal system. This objective is achieved by thorough cleaning, shaping and disinfecting the root canal system. During cleaning and shaping procedures, instrumentation of the root canal system produces an irregular, granular and tenacious layer covering the canal wall surfaces known as the smear layer.[1] It consists of inorganic dentin debris, pulp tissues, severed odontoblastic processes, necrotic debris, microorganisms and their metabolic products.[2] Various investigators have reported that the smear layer contains bacteria, their by-products and necrotic tissue and

should be removed from the root canal. It may act as a substrate for bacteria, allowing their deeper penetration into the dentinal tubules.[3] The presence of a smear layer can inhibit or significantly delay the penetration of antimicrobial agents such as intracanal irrigants and medications into the dentinal tubules.[4,5] The smear layer can act as a barrier between filling materials and the canal wall and therefore compromise the formation of a satisfactory seal.[6] A recently conducted systematic review and meta-analysis concluded that smear layer removal improved the fluid-tight seal of the root canal system after obturation.[7] Thus, effective removal of smear layer becomes prudent to achieve a thorough disinfection and a three dimensional obturation of the canal which ultimately leads to long-term endodontic success.

The use of chemicals, ultrasonics and lasers alone or in combination has been evaluated for removal of the smear layer with varying results.[8,9,10] Chemical irrigant solutions are most commonly used for smear layer removal. Among these, sodium hypochlorite (NaOCl) is the most widely used irrigant because of its antimicrobial activity and tissue dissolving ability.[11] However, its capacity to remove the smear layer from the root dentin appears to be limited as it has no effect on the inorganic portion of the smear layer[12]. The inorganic portion of the smear layer is removed by decalcifying solutions such as EDTA (ethylenediaminetetraacetic acid).[11] However, it has no bactericidal activity.[13] Thus, combination of NaOCl and EDTA in irrigation protocol becomes prudent. Syringe needle irrigation with NaOCl (0.5–6.15%) followed by a final rinse with EDTA (15-17%) is the recommended protocol for endodontic irrigation.[14]

Many new irrigating solutions have been introduced with added antimicrobial agents and detergents for simultaneous removal of smear layer and disinfection of the root canal system.

BioPure MTAD (Dentsply Tulsa Dental Specialties, Johnson City, TN) was introduced in Endodontics in 2003 as a substitute to EDTA to eradicate the smear layer. It is an aqueous solution of 3% doxycycline (a broad-spectrum antibiotic), 4.25% citric acid (a demineralizing agent) and 0.5% polysorbate 80 detergent (Tween 80).[15]

QMix 2 in 1 (Dentsply Tulsa Dental, Tulsa, OK,USA) is a novel endodontic irrigating solution introduced in 2011 for both smear layer removal and antimicrobial action.[16] It is composed of a polyaminocarboxylic acid chelating agent, a bisbiguanide antimicrobial agent, a surfactant, and deionized water.[17] QMix combines the antimicrobial and substantivity properties of chlorhexidine with smear layer removal capacity of EDTA. It is a clear solution, ready to use with no chair-side mixing.

The aim of the present study was to evaluate the smear layer removal efficacy of different final irrigating solutions at the coronal, middle and apical third of root canal.

MATERIALS AND METHODS

Forty intact human single-rooted permanent mandibular premolar teeth having a single canal and fully developed apices, indicated for extraction due to orthodontic reasons were selected for the study.

The teeth were disinfected in 5% sodium hypochlorite solution for 30 minutes. They were cleaned of soft tissue tags and debris with ultrasonic scaler and kept in normal saline until used. The teeth were decoronated to a standardized root length of 12 mm with a diamond disc. The working length of each specimen was measured by deducting 1 mm from length recorded when the tip of #15 K-file (DENTSPLY Maillefer) was just visible at the apical foramina. All apices of the root were sealed with wax to simulate clinical conditions.

Before root canal preparation, all the roots (n=40) were randomly divided into four groups (n=10) according to the solution to be used in the final rinse protocol: Group 1 (Control), Group 2 (EDTA), Group 3 (QMix 2 in 1) and Group 4 (BioPure MTAD).

The root canals were then instrumented with the ProTaper (DENTSPLY Maillefer) rotary file system up to F3 file. Between each file, canals were irrigated with 2 ml of 5% NaOCl, except for the roots in the MTAD group, where 1.3% NaOCl was used (manufacturer' recommendation).[18]

Final Rinse Protocols:

All groups were then subjected to final irrigation protocol as follows:

Group 1 (Control): irrigation with distilled water for 1 min.

Group 2 (EDTA): irrigation with 5 ml of 17% EDTA for 1 min.

Group 3 (QMix 2in1): irrigation with 5ml of QMix for 1 min.

Group 4 (BioPure MTAD): irrigation with 5 ml of MTAD for 5 min.

To ensure adequate and even distribution of the solutions, the roots were irrigated with 30G side-vented closed end needle (Canal Clean; Biodent Co. Ltd., Korea) with a short in-and-out motion within 1 mm of the working length to avoid any binding of the needle. Finally, the root canals were rinsed thoroughly with 5 ml distilled water to remove any residue of the chemical solution and dried using sterile absorbent paper points.

Scanning Electron Microscopic Evaluation:

Two longitudinal grooves were prepared on the buccal and lingual surfaces of each root using a diamond disc, avoiding penetration into the canal. The roots were then

split longitudinally with a bi-bevelled chisel and a mallet in corono-apical axis, exposing the entire root canal. One half of each root was selected depicting the entire root canal length and prepared for scanning electron microscope examination. The selected samples were then grooved at three levels at coronal third (9mm from apex), middle third (6mm from apex), and apical third (3mm from apex) using a diamond bur.

Each sample was dehydrated in graded series of ethanol solutions (25%, 50% and 75% for 20 min, 95% for 30 min and 100% for 60 min), mounted on metallic stubs, gold-sputtered, and examined on SEM.

After general evaluation of the canal wall, SEM photomicrographs were taken at magnification of 2000X at 15kV in the coronal third (9mm from apex), middle third (6mm from apex), and apical third (3mm from apex). The images were then analysed for the amount of smear layer present. The amount of smear layer remaining on the surface of root canal and dentinal tubules was scored according to the criteria used by Torabinejad et al.[19]

Score 1 - No smear layer: No smear layer on the surface of the root canals; all tubules were clean and open.

Score 2 - Moderate smear layer: No smear layer on the surface of root canal, but tubules contained debris.

Score 3 - Heavy smear layer: Smear layer covered the root canal surface and the tubules.

RESULTS

Statistical analysis was done using Kruskal–Wallis H test and Mann-Whitney U- test using software version SPSS 23.0 version.

The examination of the surface of root canal walls in group 1 (control group) showed the presence of a heavy smear layer throughout the entire length of the root canals.

Inter-group comparison among the test groups (group 2, group 3 and group 4) showed no significant difference between EDTA, QMix and MTAD in the removal of the smear layer in the coronal and middle third. All these irrigants removed the smear layer efficiently in the coronal and middle third of the instrumented root canal walls. (Table 2). However, in the apical third MTAD and QMix showed significantly cleaner surface than that of EDTA. ($P < 0.05$)

Intra-group comparisons of coronal, middle and apical sections within each group showed no statistically significant difference in group 3 (QMix 2 in 1) and group 4 (BioPure MTAD). But in group 2 (EDTA) the efficacy of the agent was significantly less in the apical third of the samples compared with the coronal and middle thirds.

Table 1: The mean smear scores ± SD of root canal treated with different chelating solutions

Groups	Root Canal Regions		
	Coronal	Middle	Apical
Group 1 (Control)	3.00 ± 0.00	3.00 ± 0.00	3.00 ± 0.00
Group 2 (EDTA)	1.30 ± 0.6749	1.40 ± 0.699	2.30 ± 0.823
Group 3 (QMix)	1.30 ± 0.483	1.30 ± 0.483	1.50 ± 0.527
Group 4 (MTAD)	1.30 ± 0.483	1.30 ± 0.483	1.50 ± 0.527

Table 2: Intergroup comparison of smear layer among various groups

Comparison Groups	P- value		
	Coronal	Middle	Apical
1 vs 2	0.000*	0.000*	0.013*
1 vs 3	0.000*	0.000*	0.000*
1 vs 4	0.000*	0.000*	0.000*
2 vs 3	0.726	0.786	0.027*
2 vs 4	0.726	0.888	0.027*
3 vs 4	1.000	0.648	1.000

Statistical Analysis: Mann-Whitney U-test. Statistical significance if P value < 0.05 (denoted by *)

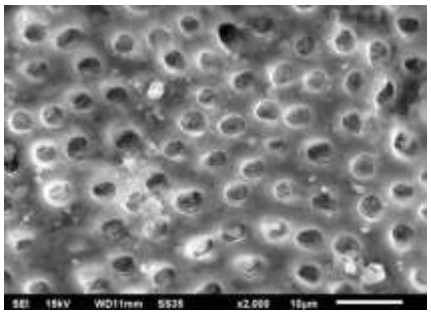
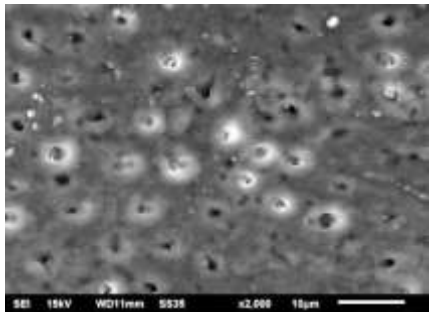
a.  b. 

Fig 1: SEM photomicrographs (X2000) after final irrigation with 17% EDTA at coronal (a) and apical (b) portions of root canal dentin.

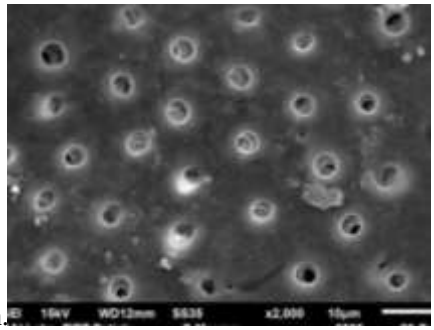
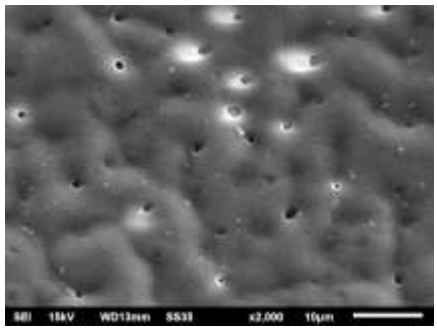
a.  b. 

Fig 2: SEM photomicrographs (X2000) after final irrigation with QMix 2 in 1 at coronal (a) and apical (b) portions of root canal dentin.

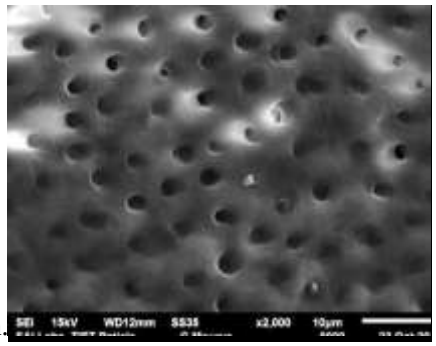
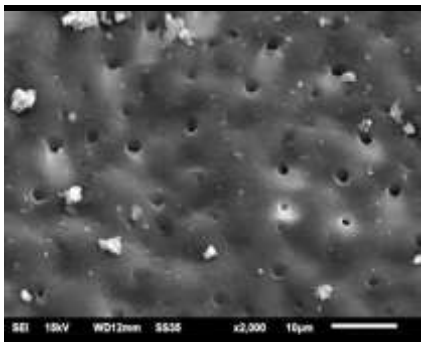
a.  b. 

Fig 3: SEM photomicrographs (X2000) after final irrigation with BioPure MTAD at coronal (a) and apical (b) portions of root canal dentin.

DISCUSSION

During mechanical instrumentation, smear layer formation occurs on the root canal dentinal wall, occluding dentinal tubules. Its removal is necessary for efficient disinfection and sealing of the root canal system.[1] For effective removal of both the organic and inorganic components of the smear layer, irrigation with NaOCl and EDTA has been recommended.[14]

In recent years, several new irrigants such as BioPure MTAD and QMix 2 in 1 have been introduced with added surfactants and antibacterial agents to facilitate the eradication of microorganisms from the root canal and to promote an effective cleaning of dentinal surface.

The purpose of this study was to compare the efficacy of 17% EDTA, QMix and MTAD as a final irrigant in the removal of the smear layer from the coronal, middle, and apical thirds of the human root canal system.

In the present study EDTA was used for 1 minute based on the study that use of EDTA in root canal treatment longer than 1 minute may cause inadvertent erosion of the intraradicular dentin.[20] QMix was used for 1 minute and MTAD was used for 5 minutes as per their respective manufacturer recommendations.

The results show that QMix and MTAD have a better smear layer removing ability in apical third of root canal system than EDTA. However, no significant difference was found between QMix and MTAD. In the

coronal and middle third, EDTA, QMix and MTAD were equally effective without any statistical difference between them.

Lower smear layer removing capability of 17% EDTA in the apical root third has been shown in various previous studies.[19,21,22]

Our results are in accordance with various previous studies which have established superior effect of QMix in removing the smear layer in the apical third than that of EDTA.[16,23,24] Improved efficacy of QMix in apical third could be attributed to its chemical composition. Presence of detergents decreases surface tension of solution and facilitates the contact of irrigant with the dentinal walls, enabling better smear layer removal.[25,26] Dai et al. and Stojicic et al. reported that QMiX was as effective as 17% EDTA in smear layer removal.[17,27]

MTAD showed significantly better smear layer removal than EDTA in apical third. These results correlate with various previous studies which showed that MTAD is better irrigating solution for removing smear layer in the apical third.[28,29] The removal of smear layer by MTAD can be attributed to the demineralizing property of 4.25% citric acid and the detergent polysorbate 80, which decreases the surface tension and allows MTAD to penetrate into dentinal tubules.

MTAD showed similar smear layer removal efficacy as QMix in apical third. Similar result was obtained by Nogo – Zivanovic et al. in a study.[30] In contrast Vemuri et al. reported that QMix showed significantly better smear layer removal efficacy than MTAD in apical third. This could be explained by the difference in time of application where they used QMix and MTAD for 3 min each, while in the present study, QMix was used for 1 min and MTAD for 5 min based on manufacturer recommendation.[24]

CONCLUSION:

Based on the results of this investigation, it seems that QMix 2 in 1 and BioPure MTAD are effective solutions for the removal of the smear layer in the coronal, middle and apical thirds when used as a final rinse. However, 17% EDTA is less effective in the apical third of the canals.

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