



Comparative Evaluation of Smear Layer Removal in Retrograde Preparation Using 10% Citric Acid And 7% Maleic Acid - An *In Vitro* Scanning Electron Microscopy Study

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Abstract

Aim: The aim of this study is to compare and evaluate the smear layer removing ability of Citric acid and Maleic acid in retrograde preparations using scanning electron microscope.

Materials and Methods: Eighty single-rooted teeth have been chosen and decoronated at cemento-enamel junction. Root canal preparation was completed with ProTaper rotary Ni-Ti files upto F3 size. After each instrumentation, 3% NaOCl was used for irrigating root canals. Canals were obturated with 6% gutta-percha coated with AH plus resin sealer. Apical 3 mm of the root was resected at a plane perpendicular to the long axis of the root. A class I retrograde preparation was carried out using ultrasonic retrotips to a depth of about 3 mm. Debris was initially washed off using a normal saline. The specimens were categorized into four groups (n = 20) based on the irrigating solutions used which are 10% Citric acid and 7% Maleic acid as experimental groups and normal saline, 17% EDTA as control groups. The specimens will be sectioned longitudinally and examined under scanning electron microscope for the evaluation of smear layer.

Statistical Analysis: Statistical analysis was done using Kruskal-Wallis ANOVA and pairwise comparison using Mann-Whitney U-test.

Results: Group I (saline) was least efficient in removing the smear layer and most of the samples were occluded with smear layer. Group II (17% EDTA), Group III (10% Citric acid), and Group IV (7% Maleic acid) resulted in the efficient removal of the smear layer from the retrograde cavity with mean scores of 1.35, 1.60, and 1.35, respectively. Inter group comparisons showed statistically significant difference between Group IV (7% Maleic acid) and all other groups. There is no statistically significant difference found between Group III (10% Citric acid) and Group II (17% EDTA).

Conclusion: Within the limitations of this in vitro study, it can be concluded that irrigation with 7% Maleic acid is more efficacious in removing the smear layer than 17% EDTA and 10% Citric acid during retrograde root canal preparation.

Keywords: Citric Acid; Maleic Acid; Smear Layer; Retrograde Preparation; Ultrasonic Retrotips

Introduction

During bio-mechanical preparation smear layer is produced on the canal walls which is composed of dentin, pulp tissue remnants, bacteria, and their toxins [1]. With the introduction of smear layer over 4 decades, there still remains a debate about whether to remove it or keep it. According to some authors, it has been suggested that dentinal tubules may be occluded with the smear layer which limits the bacteria or toxin penetration by altering the permeability of dentin. On the contrary, some experts believe that the smear layer should be removed completely as it can harbor bacteria that hampers the efficacy of irrigants or intracanal medicaments by limiting their penetration deeper into the dentinal tubules [2].

During cleaning and shaping procedures, smear layer removal is done with a variety of chelating agents, including Citric acid,

Maleic acid, EDTA, and MTAD [3]. Maleic acid can be used as an alternative irrigant to EDTA. It effectively removes the smear layer with less toxic effects than EDTA. Its antibacterial activity has been shown against *E. faecalis*, *Listeria monocytogens*, *E. coli*, *S. typhimurium* [4].

Citric acid, a demineralizing organic acid when used in a concentration of 10-50% effectively removes the smear layer [5]. Faruk, et al. (2003) concluded that citric acid in its original pH was effective in smear layer removal irrespective of its concentrations [6].

Apical surgery which is a part of endodontic surgery involves procedures like removal of diseased tissues, perforation repair, retrieval of separated instruments beyond the apex, and root end re-

sections. This method is preferred when a tooth cannot be treated with nonsurgical endodontic therapy. This can be achieved by root-end resection, and root-end cavity preparation followed by an apical seal with retrograde filling [7].

The goal of this study is to compare and evaluate smear layer removal in retrograde preparation using 10% Citric acid and 7% Maleic acid.

Materials and Methods

Eighty extracted teeth with a single straight root canal were selected for the study. Prior to use teeth were stored in physiologic saline. Tooth samples were sectioned horizontally at the level of CEJ using diamond disc. ProTaper Gold rotary files (Dentsply Maillefer, Switzerland) were used to biomechanically prepare the root canals. The canals were instrumented till F3 size and the canals were irrigated with 3 ml of 3% NaOCl (Prime Dental Products Private Limited).

Root canal obturation was done using F3 ProTaper GP points and AH plus sealer. Carbide bur was used for the horizontal root end resection of 3mm. After the root end resection, class I retrograde preparation was performed 3mm deep to the length of the root using an ultrasonic handpiece (Mini Piezo; EMS, Nyon, Switzerland) and ultrasonic retro tips (Tun ultrasonics, Engineered Endodontics, USA). Initial debris was cleared using a regular saline solution.

The specimens were categorized into 4 groups of 20 teeth each based on the solution being used for smear layer removal.

- **Group I:** Negative control, only Normal saline was used.
- **Group II:** Positive control, 17% EDTA 5ml for about 30 s.
- **Group III:** Experimental group, 10% Citric acid
- **Group IV:** Experimental group, 7% Maleic acid.

Both the experimental groups were treated with 5 ml of solution 1 min. All the samples were longitudinally sectioned using the diamond disk for SEM (Carl Zeiss, Japan: Neon 40) evaluation.

The blind evaluation was performed independently by two operators. Smear layer evaluation was done according to the scores given by Hulsmann., *et al.* [8]. Score 1: Dentinal tubules completely

open, Score 2: >50% of dentinal tubules open, Score 3: <50% of dentinal tubules open, and score 4: Almost all dentinal tubules are occluded with the smear layer. When the resultant scores were not coinciding, the least score was chosen.

Statistical analysis was done using Kruskal-Wallis ANOVA and pairwise comparison using Mann-Whitney U-test.

Results

The current *in vitro* investigation employed a scanning electron microscope to assess the effectiveness of 10% Citric acid, 7% Maleic acid, and 17% EDTA for the smear layer in retrograde root canal preparation. Photomicrographs of SEM images were used to score the samples, and the outcomes were tabulated.

Group I (saline) was least efficient in removing the smear layer and most of the samples were occluded with smear layer. Group II (17% EDTA), Group III (10% Citric acid), and Group IV (7% Maleic acid) resulted in the efficient removal of the smear layer from the retrograde cavity with mean scores of 1.35, 1.60, and 1.35, respectively. Smear layer removal efficacy between the groups was compared using Mann-Whitney U-test. Retrograde Smear layer removing ability was highest with Group IV (7% Maleic acid) followed by Group III (10% Citric acid) and Group II (17% EDTA). Inter group comparisons showed statistically significant difference between Group IV (7% Maleic acid) and all other groups. There is no statistically significant difference found between Group III (10% Citric acid) and Group II (17% EDTA).

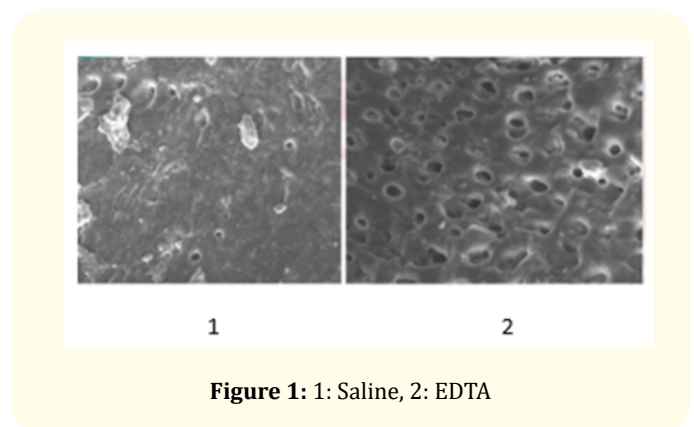
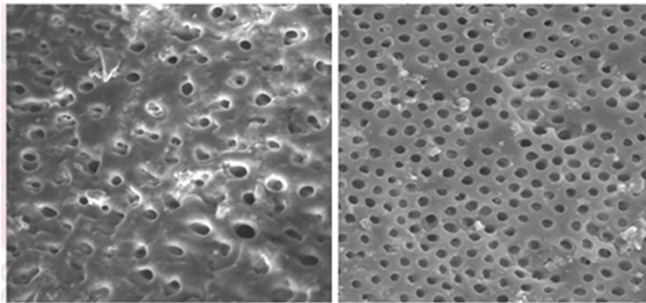


Figure 1: 1: Saline, 2: EDTA



3

4

Figure 2: 3: 10% Citric acid 4: 7% Maleic acid

Discussion

Retrograde root end cavity preparation, which is a crucial step in the apicoectomy procedure generates a smear layer on the dentinal surfaces. It consists of pulp tissue remnants, microorganisms, and dentinal chips. In order to prevent microleakage, effective removal of the smear layer is essential for the proper adaptation of root-end filling material.

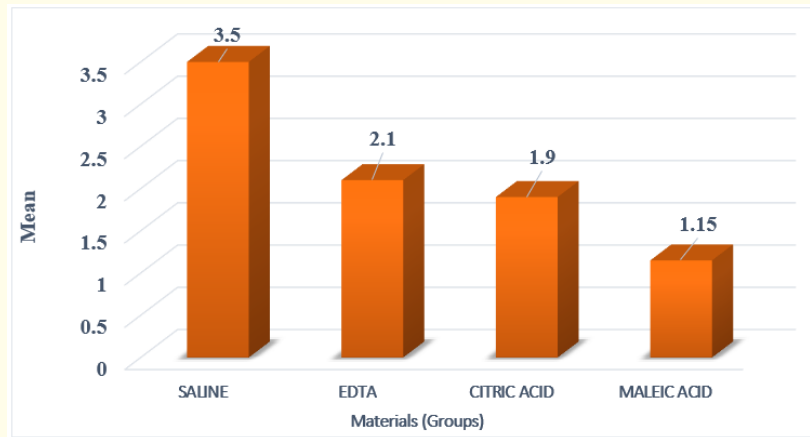
In this study, we compared the smear layer removing ability of 17% EDTA, 10% Citric acid, and 7% Maleic acid during retrograde cavity preparation.

Materials	N	Mean	Std. Deviation	Median	Std. Error	Mean Rank	Minimum	Maximum	H	P
Saline	20	3.5	0.513	3.5	0.115	68.00	3	4	52.150	<0.001
EDTA	20	2.1	0.718	2	0.161	40.45	1	3		
Citric acid	20	1.9	0.718	2	0.161	35.80	1	3		
Maleic acid	20	1.15	0.366	1	0.082	17.75	1	2		

Table 1: Kruskal-Wallis ANOVA test for the smear layer removing ability between all 4 groups.

Groups	N	Mean	Std. Deviation	Median	Mean Rank	U	Z	P
Saline	20	3.5	0.513	3.5	29.00	30.000	-4.836	<0.001
EDTA	20	2.1	0.718	2	12.00			
Saline	20	3.5	0.513	3.5	29.50	20.000	-5.068	<0.001
Citric acid	20	1.9	0.718	2	11.50			
Saline	20	3.5	0.513	3.5	30.50	0.000	-5.728	<0.001
Maleic acid	20	1.15	0.366	1	10.50			
EDTA	20	2.1	0.718	2	22.00	170.000	-0.883	0.377
Citric acid	20	1.9	0.718	2	19.00			
EDTA	20	2.1	0.718	2	27.45	61.000	-4.157	<0.001
Maleic acid	20	1.15	0.366	1	13.55			
Citric acid	20	1.9	0.718	2	26.30	84.000	-3.564	<0.001
Maleic acid	20	1.15	0.366	1	14.70			

Table 2: Pairwise comparison was performed using Mann-Whitney U-test.



Graph 1: Graphical representation showing retrograde smear layer removal of all 4 groups.

EDTA and NaOCl are commonly used for smear layer removal. EDTA is a chelating agent and is effective at a neutral pH. pH drops in dentin when calcium is exchanged by hydrogen which results in reduced efficacy of EDTA over time.

Citric acid is a chelator with the ability to remove the smear layer at the same time it doesn't weaken the root surface [1]. It shows the maximum amount of demineralization of the radicular dentin compared to 17% EDTA and MTAD [11]. Kumar, *et al.* [11] reported that 10% Citric acid shows the maximum amount of demineralization of radicular dentin than MTAD and 17% EDTA.

Maleic acid which is highly acidic, has a better demineralizing effect. Vasiliadis, *et al.* [14] and Paque, *et al.* [15] reported that the apical third of root dentin is sclerosed. Hence EDTA would be less effective than Maleic acid to remove the smear layer in retrograde cavity preparation. Additionally, the surface tension of 17% EDTA (0.0783 N/m) is more than 7% Maleic acid (0.06345 N/m) owing to the more wetting ability of Maleic acid [10]. 7% Maleic acid when used as a final irrigant is more efficient in the smear layer removal from the apical third of the root canal system (10), quicker in its antimicrobial action against *E. faecalis* [4] and gives better post obturation seal compared to 17% EDTA [12].

Apart from SEM, smear layer removing ability can also be analyzed under digital image analysis, atomic force microscopy, optical microscopy, and micro-computed tomography [10]. SEM was opted

in this study since it is a commonly available tool for evaluating the smear layer.

Conclusion

Within the limitations of this *in vitro* study, it can be concluded that irrigation with 7% Maleic acid is more efficacious in removing the smear layer than 17% EDTA and 10% Citric acid during retrograde root canal preparation.

Acknowledgements

NIL.

Conflict of Interest

NIL.

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