

# Effect of Irritrol™ endodontic irrigant and ethylenediaminetetraacetic acid in smear layer removal from instrumented human root canal dentine: A scanning electron microscopic analysis

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## Abstract

**Introduction:** Ethylenediaminetetraacetic acid (EDTA) is a chelating agent that is most widely used for smear layer removal. Irritrol™ is a novel endodontic irrigating solution that contains EDTA and chlorhexidine that can be used as a final irrigating agent which claims of being more efficient but less aggressive. The aim of the study was to evaluate and compare the effects of Irritrol and EDTA in smear layer removal from instrumented human root canal dentine.

**Materials and Methods:** Thirty-nine extracted human single-rooted maxillary incisors were decoronated at the cemento-enamel junction. Chemomechanical preparation was done using ProTaper Gold rotary instruments and intermittent irrigation of 2.5% sodium hypochlorite. Random division of the samples into three groups ( $n = 13$ ) was done with Group A: Irritrol; Group B: 17% EDTA; and Group C: 0.9% saline solution. The samples were dehydrated, gold sputtered, and evaluated under scanning electron microscope.

**Statistical Analysis:** Statistical analysis was performed using Kruskal–Wallis ANOVA with *post hoc* Conover test with a significance level of  $P = 0.05\%$ .

**Results:** It was demonstrated that 17% EDTA was significantly more effective in removal of smear layer than Irritrol in coronal, middle, and apical third of the root canal.

**Conclusions:** 17% EDTA had better smear layer removal effect than Irritrol when used as a final irrigant.

**Keywords:** Ethylenediaminetetraacetic acid, Irritrol, scanning electron microscopy, smear layer

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## INTRODUCTION

Mechanical instrumentation of dentine during cavity preparation or root canal therapy produces microcrystalline

debris that coats the dentine and clogs the orifices of the dentinal tubules. This layer of debris is termed as smear layer.<sup>[1]</sup> The smear layer contains bacteria and prevents

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antimicrobial agents from gaining access to underlying contaminated dentinal tubules.<sup>[2]</sup> The removal of the smear layer holds paramount importance in disinfection of the root canal system. Irrigation is hence an essential part of endodontic therapy.<sup>[3,4]</sup>

Sodium hypochlorite (NaOCl) is the gold standard irrigating solution in root canal treatment due to its antimicrobial activity<sup>[5]</sup> and tissue-dissolving capability.<sup>[6]</sup> However, the inorganic portion of smear layer cannot be removed by NaOCl.<sup>[6,7]</sup> For this reason, it is advised to use the combination of NaOCl with a chelating agent.<sup>[8]</sup> Chelating agents such as ethylenediaminetetraacetic acid (EDTA), tetracycline hydrochloride, citric acid, maleic acid, MTAD (an acid, a tetracycline isomer mixture, and a detergent), and Decal (ammonium oxyl acetate, oxyl acetate, and cetrimide) are available in the market for the removal of the smear layer.

Disodium salt of EDTA is widely used chelating agent in endodontic therapy.<sup>[9]</sup> It is used to enlarge root canals and to prepare the dentinal walls for better adhesion of filling materials.<sup>[10]</sup> Wu *et al.* showed that the smear layer removal ability of 17% EDTA was significantly better than 20% of citric acid and MTAD.<sup>[11]</sup> However, EDTA has certain drawbacks like decreased efficiency in removal of smear layer from apical third of the root canal system.<sup>[12]</sup> Also, it is cytotoxic.<sup>[13]</sup>

Irritrol™ is a two-in-one endodontic irrigating solution (Essential Dental Systems, S. Hackensack, New Jersey, USA) that contains EDTA and chlorhexidine and is used as a final rinse after NaOCl. Manufacturers claim that Irritrol efficiently removes the smear layer less aggressively than conventional irrigants, thereby causing less demineralization of dentine. Previous study on Irritrol have shown better apical seal after obturation when compared to maleic acid and EDTA and speculated that Irritrol allowed better smear layer removal.<sup>[14]</sup> However, to date, comparative studies on the effect of Irritrol and EDTA in smear layer removal from instrumented human root canal dentine is lacking. The aim of this study was to evaluate and compare the effects of Irritrol and EDTA in smear layer removal from instrumented human root canal dentine.

## MATERIALS AND METHODS

Ethical clearance was obtained from Institutional Review Board 858/2016. Thirty-nine extracted human single-rooted maxillary incisors were selected, and after surface debridement with scaling instruments, the samples were stored at 4°C in 0.2% sodium azide (Merck KGaA, Darmstadt, Germany) until experiment.

## Inclusion criteria

- Thirty-nine noncarious human permanent maxillary incisors with straight root and single canal
- Teeth with completely formed apex.

## Exclusion criteria

- Teeth with calcified canals
- Fractured/restored or cracked teeth
- Teeth with developmental defects
- Endodontically treated teeth.

The teeth were decoronated using a diamond disc (Kerr Endodontics and Kerr Rotary, Orange, California, USA) at the cemento-enamel junction to standardize root length to 15 mm. Determination of working length was done by placing a 10K file (Mani Inc., Utsunomiya, Tochigi, Japan) into the canal until the file tip was just visible at the apical foramen and subtracting 1 mm from this measurement. Mechanical preparation of the teeth was done till the working length using ProTaper Gold rotary instruments (Dentsply, Maillefer, Ballaigues, Switzerland) and each canal was enlarged to F3 size. Each set of ProTaper Gold instruments were replaced after preparation of five canals. Irrigation of the canals was done after each instrument change for 1 min using 2 mL of 2.5% NaOCl (KMC Pharmacy, Manipal, Karnataka, India). Samples were then randomly divided into three groups ( $n = 13$ ) according to the final irrigation regimen:

- Group A: 5 mL of Irritrol (Essential Dental Systems, S. Hackensack, New Jersey, USA) for 1 min
- Group B: 5 mL of 17% EDTA (Merck, Darmstadt, Germany) for 1 min
- Group C: 5 mL of 0.9% Saline (KMC Pharmacy, Manipal, Karnataka, India) for 1 min.

A 30-gauge Side Vent needle (Orkam, Gurgaon, Haryana, India) was used to introduce the irrigating solutions into the canal by placing it 1 mm short of the working length. To remove any precipitates that might have formed, 5 mL of distilled water was used to irrigate the canals. After irrigating with the respective irrigants, canals were dried using sterile paper points (Dentsply Sirona, Woodbridge, ON, Canada). A diamond disc attached to a slow speed handpiece was used to place the longitudinal grooves on buccal and lingual surfaces of the root of the tooth. This was accomplished without penetrating the disc into the canal. Finally, a chisel (Acharya Instruments, Manipal, Karnataka, India) was used to split the teeth into two halves. The better half, showing the anatomy of the root canal from the cervical to the apical third, was chosen for further evaluation under scanning electron microscope (EVO MA18, Carl Zeiss AG, Oberkochen, Germany). The samples were stored in 100%

humidity at 37°C until the scanning electron microscopic study could be performed. Dehydration of the specimens was done using increasing concentrations of 25%, 50%, 75%, and 100% ethyl alcohol. An ion sputter was used for the gold sputtering of the samples after mounting them on the metallic stubs. The teeth were then examined under microscope. The scoring criteria followed for the presence and absence of smear layer was given by Torabinejad *et al.* [Table 1].<sup>[3]</sup>

Multiple photomicrographs were taken to observe the morphology of the three-thirds of each specimen at ×1500 magnification at 10 kV [Figure 1]. Two independent investigators, unaware of the experimental groups, evaluated the samples.

### Statistical analysis

All the analyses were done using MedCalc Version 14.8.1 (MedCalc Software bvba, Ostend, Belgium). Interexaminer reliability was evaluated using Cohen's Kappa coefficient. Both inter- and intra-group comparisons of mean smear layer scores were done using Kruskal–Wallis ANOVA with *post hoc* Conover test.  $P < 0.05$  was considered as statistically significant.

## RESULTS

A good agreement between the two investigators was observed in the results of Cohen's Kappa coefficient, when scoring the presence of smear layer in the three-thirds of the root canal system for Irritrol, 17% EDTA, and 0.9% saline. The percentage agreement between the two investigators was 76.92%. Table 2 shows distribution of smear layer scores among the three test groups at all the three-thirds of the root canal system.

On intragroup analysis in Group A (Irritrol), smear layer was removed more efficiently in coronal third when compared to middle and apical third of the root canal ( $P < 0.001$ ). However, there was no significant difference between middle and apical third. In Group B (17% EDTA), there was no significant difference in coronal and middle third. However, in apical third, smear layer was not completely removed ( $P < 0.001$ ). In Group C (0.9% saline), all the three-thirds were heavily smeared ( $P = 0.515$ ) [Table 3].

On intergroup comparison, there was significant difference in smear layer removal among all the three irrigants ( $P < 0.001$ ). *Post hoc* test showed that EDTA was significantly better than Irritrol and saline in all the thirds of the root canal system. On comparison between Irritrol

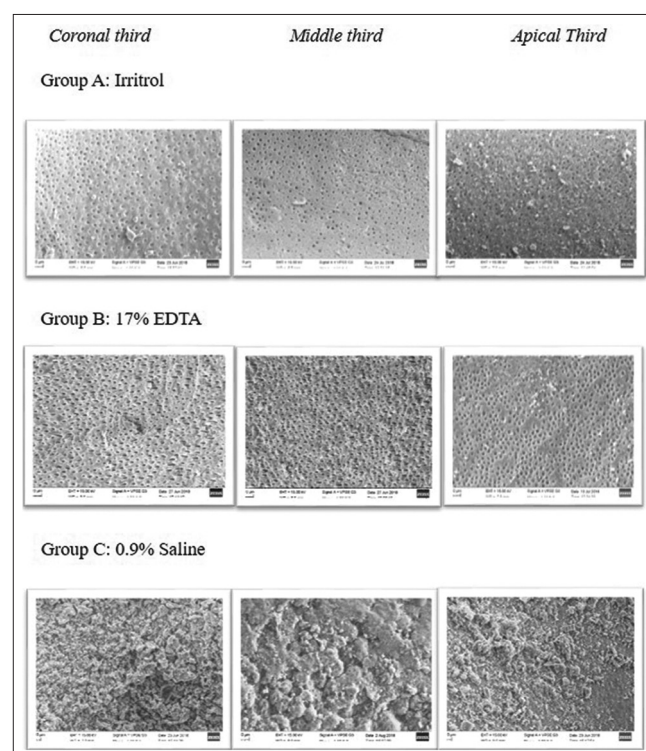
**Table 1: The scoring criteria given by Torabinejad *et al.* (2002) for the presence and absence of smear layer**

Smear score	Criteria	Description
1	No smear layer	No smear layer on the surface of the root canal; all canals were clean and open
2	Moderate smear layer	No smear layer on the surface of the root canal, but tubules contained debris
3	Heavy smear layer	Smear layer covered the root canal surface and the tubules

**Table 2: Distribution of smear layer scores of the three test groups at all the three thirds of the root canal system**

Experimental solutions	Smear score	Coronal third	Middle third	Apical third
Irritrol	1	4	0	0
	2	6	6	2
	3	3	7	11
	Total	13	13	13
17% EDTA	1	8	7	1
	2	5	6	4
	3	0	0	8
	Total	13	13	13
0.9% saline	1	0	0	0
	2	3	2	1
	3	10	11	12
	Total	13	13	13

EDTA: Ethylenediaminetetraacetic acid



**Figure 1: Representative scanning electron microscopic images of the three experimental groups in coronal, middle, and apical third**

and saline, there was no significant difference in middle third and apical third ( $P < 0.001$  and  $0.004$ ). However, in coronal third, Irritrol removed smear layer significantly better than saline [Table 4].

**Table 3: Intragroup comparison showing mean and standard deviation in coronal (C), middle (M), and apical third (A)**

Group	Site, mean (SD)			P	Post hoc test (presence of smear layer)
	Coronal third (C)	Middle third (M)	Apical third (A)		
Irritrol	1.88 (0.71)	2.54 (0.52)	2.88 (0.30)	<0.001; S	M, A>C
17% EDTA	1.42 (0.34)	1.46 (0.38)	2.54 (0.43)	<0.001; S	A>C, M
0.9% saline	2.81 (0.38)	2.88 (0.30)	2.96 (0.14)	0.515; NS	-

EDTA: Ethylenediaminetetraacetic acid, SD: Standard deviation, S: Significant, NS: Not significant

**Table 4: Intergroup comparison showing mean and standard deviation among experimental groups; Irritrol (A), 17% ethylenediaminetetraacetic acid (B), and 0.9% saline (C)**

Site	Group, mean (SD)			P	Post hoc test (presence of smear layer)
	Irritrol (A)	17% EDTA (B)	0.9% Saline (C)		
Coronal third	1.88 (0.71)	1.42 (0.34)	2.81 (0.38)	<0.001; S	C>A > B
Middle third	2.54 (0.52)	1.46 (0.38)	2.88 (0.30)	<0.001; S	A, C>B
Apical third	2.88 (0.30)	2.54 (0.43)	2.96 (0.14)	0.004; S	A, C>B

EDTA: Ethylenediaminetetraacetic acid, SD: Standard deviation, S: Significant

## DISCUSSION

Formation of smear layer is inevitable on mechanical instrumentation making irrigation an indispensable step in root canal therapy. The removal of smear layer using chelating agents for irrigation is the common norm which subsequently has shown to have better clinical and roentgenographic outcomes in teeth with initial signs and symptoms or in necrotic pulpal conditions.<sup>[15]</sup>

In this study, we have evaluated the efficacy of Irritrol and 17% EDTA as a final irrigating agent to observe the smear layer removal from the coronal, middle, and apical thirds of the human root canal dentine. The results showed that 17% EDTA showed better smear layer removal in all the thirds of the root canal system compared to Irritrol.

Irritrol, in the present study, showed poor chelating properties compared to EDTA. This may be attributed to the combination of chlorhexidine with EDTA leading to the formation of a salt with a white precipitate that adheres to the root canal, thereby diminishing the efficacy of removal of smear layer.<sup>[16,17]</sup>

The results of this study demonstrated that EDTA removed smear layer efficiently in coronal and middle third compared to apical third. This is in agreement with previous studies.<sup>[12,18]</sup> This may be due to the sclerosed dentin present in this region.<sup>[19]</sup> The decreased content of noncollagenous proteins and the less number of dentinal tubules in the apical region of root canal have been correlated to this reduction in chelating effect of EDTA and the resulting prominent removal of smear layer from the coronal third.

The use of 5 mL of test solutions as final rinse was based on the study by Mello *et al.*<sup>[20]</sup> who found that there

is no difference between 5 mL, 10 mL, and 15 mL of EDTA solution. De-Deus *et al.* reported earlier that the microhardness of root dentin decreased after the use of 17% EDTA.<sup>[21]</sup> 0.9% saline was used as a negative control in this study, and it did not have any effect on the removal of smear layer. This is in compliance with the study done by Ballal *et al.*<sup>[12]</sup>

As chemomechanical preparation of human root canal dentin requires removal of organic content of smear layer, 2.5% NaOCl was used. Demonstration of lower concentrations of NaOCl being equally effective<sup>[8]</sup> in removal of organic component as its higher concentrations has been done previously, and hence, a concentration of 2.5% was used in this study.

30-gauge Side Vent irrigating needles were utilized for the experiment which were positioned 1 mm short of the working length. This is in compliance with the study by Boutsoukis *et al.*<sup>[22]</sup> The volume (5 ml) and duration of irrigation (1 min) in this study were standardized.

There are other methods to evaluate efficacy of smear layer removal. Some of them are atomic force microscopy, microcomputed tomography, digital image analysis, and environmental scanning electron microscopy.<sup>[23]</sup> However, in this case, we have used scanning electron microscopy as this is a tool that is most commonly accessible for the evaluation of the presence of smear layer.

The scoring method employed was a qualitative form of analysis, but the multiple examiners presented concordance in their calibrations, as evaluated by Cohen's Kappa coefficient test, making the results reliable.<sup>[23]</sup> Other elaborate scoring systems are also available,<sup>[24,25]</sup> but quantitative analysis could have been compromised on using more convoluted criteria.<sup>[26]</sup>



The main benefit of Irritrol is that it can be used as a final irrigating solution that contains antibacterial as well as chelating properties which can be well harnessed in clinical practice. As this study is an *in vitro* analysis of the smear layer removal in straight canals, further analysis in curved and narrow canals along with *in vivo* experiments should be conducted to evaluate the smear layer removal efficacy of Irritrol to gain further knowledge.

## CONCLUSIONS

The results of this study demonstrated that 17% EDTA removed smear layer efficiently than Irritrol in all the thirds of the root canal system.

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Nil.

## Conflicts of interest

There are no conflicts of interest.

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