RESEARCH PAPER

In Vitro Comparative evaluation of smear layer removal in curved canals by using different irrigating solutions as final irrigants- Scanning electron microscopic study

Ashok Leburu[1], Pradeep Nivas[2], Pooraninagalakshmi J[3*], Janani Balachandran[4]

[1] Dr. Ashok Leburu, MDS, Professor, Department of Conservative Dentistry and Endodontics, Karpaga Vinayaga Institute of Dental Sciences, Chengalpattu, Tamilnadu, India. Email: ashokbds@gmail.com | ORCID: 0000-0001-6974-417X

[2] Dr. Pradeep Nivas, MDS, Associate Professor, Department of Conservative Dentistry and Endodontics, Karpaga Vinayaga Institute of Dental Sciences, Chengalpattu, Tamilnadu, India. Email: Pradeepnivas8@gmail.com | ORCID: 0000-0001-8383-7487

[3*] Dr. Pooraninagalakshmi J, MDS, Assistant Professor, Department of Conservative Dentistry and Endodontics, Sree Balaji Dental College and Hospital, Bharath Institute of Higher Education and Research, Pallikaranai, Chennai-600100, Tamilnadu, India (Corresponding Author). Email: pooranijana@gmail.com | ORCID: 0000-0001-7507-5283 | Phone: 95667 54150

[4] Dr. Janani Balachandran, MDS, Associate Professor, Department of Conservative Dentistry and Endodontics, Sree Balaji Dental College and Hospital, Bharath Institute of Higher Education and Research, Pallikaranai, Chennai-600100, Tamilnadu, India. Email: janani.balachandran@gmail.com | ORCID: 0000-0001-9432-9672

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ABSTRACT

Aim:

To evaluate the efficiency of smear layer removal in curved canals by using 17% EDTA, 10% citric acid and chloroquick solution as a final irrigant using a scanning electron microscope.

Method:

Fifty-five freshly extracted teeth with greater than 40-degree mesial root curvature were selected for the study. The teeth were digitally radiographed to ensure that they have two canals and orifices. Endodontic access was obtained and canals were prepared using E3 Azure (Endostar) till master apical size #30 4%. Standard Irrigation protocol was followed using Irriflex needle between each instrument change. Then the samples were randomly divided into 5 groups (n=11) for final irrigation. Group I with 17% EDTA, Group II with saline, Group III with 17% EDTA + 3% NaOCl, Group IV with 10% citric acid + 3% NaOCl, Group V with Chloroquick solution. Scanning electron microscope evaluation was done and the samples were scored according to standardised criteria. For statistical analysis Kruskal Wallis test for intergroup comparison and group comparison of smear layer at apical region with 5 different test solutions using Mann Whitney U test done with a significance level at P value < 0.05.

Results and Conclusion:

Chloroquick was better in removing smear layer at the apical third followed by citric acid and then EDTA.

Clinical significance:

Chloroquick showed superior smear layer removal even in curved canals, enhancing cleanliness and irrigant penetration in challenging apical regions.

Keywords: Chloroquick, Curved canal, citric acid, Root canal irrigant, Smear layer, SEM analysis

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INTRODUCTION

The success of the endodontic treatment primarily depends on the proper biomechanical cleaning, sterilization, and three-dimensional filling of the root canal system. According to Hapasalo et al., irrespective of the instrumentation and instrumentation technique we use, the obturation method and material used for the filling of root canal you follow if you don't execute a proper disinfection protocol it will lead to failure of the endodontic treatment. Disinfection should include disrupting the biofilm inside the root canal and also the smear layer which is formed during instrumention while cleaning the root dentinal walls. The smear layer consists of the dentin, coronal smear layer, remnants of odontoblastic processes, pulp tissue remnants and bacteria and the smear layer was first identified on the surface of the instrumented root canal by McComb & Smith.[1]

Some authors suggest maintaining the smear layer as it may block the dentinal tubules and limit the bacterial penetration by altering the dentinal permeability, while most of the authors focused on its removal as it may limit the effective disinfection of the endodontic irrigants, and prevent various intracanal medicaments and obturating materials getting adhere to the root dentinal wall.

The most commonly used endodontic irrigant sodium hypochlorite could not completely remove the smear layer as it was capable of destroying only the organic matter.[2] So various researches were made in identifying an optimal product for removing the smear layer. There are various products and techniques used for smear layer removal. [3] Among which 17% EDTA (Ethylene diamine tetraacetic acid), a chelating agent is the most commonly used one. Different formulations of EDTA are available for example RC Prep, REDTA (Cetrimide added to EDTA), EDTAC (EDTA+CETAVLON) and organic acids like citric acid were used ranging 10% -50% concentrations. However, none of them were able to completely destroy the smear layer at all levels of the root canal especially in the apical third.[4]

A product known as Chloroquick which is a one step irrigating solution which acts by chelating and emulsifying action. It contains 18% etidronate and 5% NaOCL premixed with surfactant Tween 80 for a complete root canal irrigating solution.

Thus the aim of this study was to evaluate the efficiency of smear layer removal in curved canals by using 17% EDTA, 10% citric acid and chloroquick solution as a final irrigant and to evaluate using an scanning electron microscope.

MATERIALS AND METHODS:

The study was conducted after obtaining approval from Institutional Ethics Committee from Karpaga Vinayaga Institute of Dental Sciences (KIDS/009/2020) approved on 11/01/2021.The manuscript was written according to Preferred Reporting Items for Laboratory Studies in Endodontology 2021 guidelines (Figure 1). Fifty five freshly extracted teeth with greater than 40 degree mesial root curvature were selected for the study. Selected teeth were cleaned and examined under a dental operating microscope at 12X magnification (Seiler) to rule out any cracks or craze lines present. All selected were cleaned to remove the debris and stored in 10% formalin until use.

The teeth were digitally radiographed to ensure that they have two canals and orifices. They were then decoronated by diamond disk to achieve a standard length of 14mm for all the samples. Endodontic access was obtained and patency of apical foramen was determined with a size 10K file. Working length was determined 1mm short of the apical foramen. All teeth were then prepared using E3 Azure (Endostar) till master apical size #30 4%. Irrigation protocol was done with1 ml of 3% sodium hypochlorite solution (Parcan, Septodont Health care, India) using Irriflex needle (Vevey Switzerland) between each instrument change. The irrigation needle was kept 1 mm short from the working length for effective irrigation of apical third area. Then the samples were randomly divided into 5 groups (n=11). GROUP I (n=11): Final irrigation with 17% EDTA, GROUP II (n=11): Final irrigation with saline, GROUP III (n=11): Final irrigation with 17%EDTA + 3% NaOCl, GROUP IV (n=11): Final irrigation with 10% citric caid+ 3% NaOCl, GROUP V (n=11): Final irrigation with Choloroquick solution.

After final irrigation, all root canals were dried with absorbent paper points. Longitudinal grooves were created on the buccal and lingual surfaces of each root using a diamond disc. The roots were

then split into two halves using a chisel and mallet to be observed under scanning electron microscope (SEM).

Coded samples were mounted on metallic stubs, gold sputtered and viewed under a SEM (JSM 5600LV) in ×3000 at apical third. The photomicrographs were observed by another experienced operator who was not informed about the experimental protocol.

Scanning Electron Microscope Evaluation:

The images were scored according to the criteria given by Torabinejad et al., which measure the presence, quantity, and distribution of the smear layer.Score I: No smear layer (the root canal surface was free of smear layer, with all tubules clean and open). Score II: Moderate smear layer (no smear layer on the root canal surface, but tubules contained debris). Score III: Heavy smear layer (the root canal surface was covered with smear layer, including debris in the tubules)

RESULTS:

As demonstrated in Image 1, Group I (17%EDTA) has no smear layer on the surface of the root canal, but all tubules contained debris. Group II (normal saline) has smear layer covering the root canal surface and the tubules. Group III (17%EDTA+3%Naocl) has no smear layer on the surface of the root canal, but all tubules contained debris. Group IV (10%Citric acid+3%Naocl) has no smear layer on the surface of the root canal, but few tubules contained debris. Group V (Chloroquick solution) has no smear layer on the surface of the root canal; all tubules were clean and open. There was statistical difference seen when the scores were compared at apical third among all the groups. At the apical third, Group V (Chloroquick solution) (1.36 ± 0.50) showed the least smear layer score followed by Group IV (10%Citric acid+3%Naocl) (2.36 ± 0.50) and Group III (17%EDTA+3%Naocl) (2.45 ± 0.52) (Table 2).

DISCUSSION:

Smear layer removal can be beneficial in many ways rather than retaining it. Most of the studies and authors suggest its removal as it can allow optimum penetration of the endodontic irrigants and intracanal medicaments and also creates proper adaptation of the rootcanal sealers with the root dentinal walls thereby reducing microleakage which can result in endodontic failure. Various chemical agents has been evaluated to remove the smear layer but none was able to completely remove the smear layer. The most commonly used chelating agents EDTA and Citric acid lack antibacterial effectiveness though they are used to remove smear layer .[4,5] It is also less efficient in narrow portions of the canal, requiring a longer application time for optimum results and can seriously damage the dentin causing erosion of the dentinal tubules resulting in decreased fracture resistance compared to Citric acid which require short term application (30 seconds).[5] In this study Irriflex needle has been used for irrigation which can be precurved and penetrate more deeply into the apical third and also control the flow rate of irrigants used. A highly significant factor in determining the flow pattern in irrigation dynamics is flow rate which has been shown to influence the replacement of the irrigant.[6]

In this study smear layer removal was evaluated in the apical third, as apical canal diameter is narrower than middle and coronal third, more over apical region has complex anatomy which further prevents the proper contact of irrigant to canal wall in the apical region. Several studies have confirmed their effectiveness in cleaning the apical third of straight and wide canals, however, there is not enough evidence supporting their adequacy in curved and narrow canal, this study wanted to determine if the final rinse protocol affects the removal of smear layer in the apical area of curved canals.[7] The reason why E3 Azure file system is used in this study is according to Jad Rebeiz et al [8] who conducted a study on shaping ability of E3 Azure in artificial curved canals resulted in less canal transportation and maintains the original canal anatomy. Since no literature findings on using this file for studying the efficiency of smear layer removal, E3 Azure file was selected for study. Solution modified with surfactants had significantly lower surface tension than its normal composition, thereby increasing their adaption to dentin and penetration into the dentinal tubules.[9] Normal saline when used alone produces a sludge layer made up of residual debris that occluded the dentinal tubules. Hence, maximum smear layer score was recorded in Group II (normal saline).[10-12]. The result of the current study is in accordance with Hegde and Thakkar and De-Deus *et al*., Hegde verified that chloroquick shows improved removal of smear layer and does not significantly change the

structure of dentin. De-Dues et al. demonstrated that soft chelating irrigation (HEBP) protocol optimizes bonding quality of the sealer because of better opening of dentinal tubules which were covered with smear layer.[13-15]

The null hypothesis for this study was rejected as there was statistically significant difference observed in smear layer removal at apical third of the root canal. Chloroquick was better in removing smear layer at the apical third followed by citric acid and then EDTA.

Limitations:

The present study was conducted *in vitro*, so the results may vary if it is conducted *in vivo* as there are so many variables in the oral environment which may affect the actions of agents used in the root canal system.

CONCLUSION:

Within the limitations of this study it may be concluded that

- Chloroquick was the most effective in removing the smear layer from apical third, more efficiently compared with other irrigants as it removes both organic and inorganic parts of smear layer because of soft chelating action.
- This was followed by 10% Citric acid which only removes the inorganic portion of smear layer followed by 17% EDTA which only dissolves the smear layer.
- It is the need of the hour to have a final irrigant which can assist in the process of continous chelation while removing smear layer from the apical third of the root canal.Use of Chloroquick may provide an efficient method for removal of smear layer from apical third and can be used routinely as a final irrigant for more predictable endodontic outcomes.

CLINICAL SIGNIFICANCE:

Effective smear layer removal is essential for enhancing the penetration of irrigants, medicaments, and sealers into dentinal tubules, thereby improving the overall disinfection and sealing ability of root canal treatment. The present study highlights that Chloroquick, an irrigant combining both chelating and antimicrobial properties, demonstrated superior smear layer removal efficiency even in curved root canals, where irrigant penetration is often compromised. This suggests that Chloroquick can serve as a clinically effective single-step final irrigant, simplifying the irrigation protocol while ensuring cleaner canal walls and potentially improving the long-term success of endodontic therapy

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Ethical approval: This study was approved by the Institutional ethical committee of Karpaga Vinayaga Institute of Dental Sciences, Chengalpattu, Tamilnadu, India (IEC-KIDS) with IEC Registration number - KIDS/009/2020 dated 11/01/2021.

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Conflicts of interest

All authors declare no conflicts of interest.

Figures and figure legends

FIGURE 1:

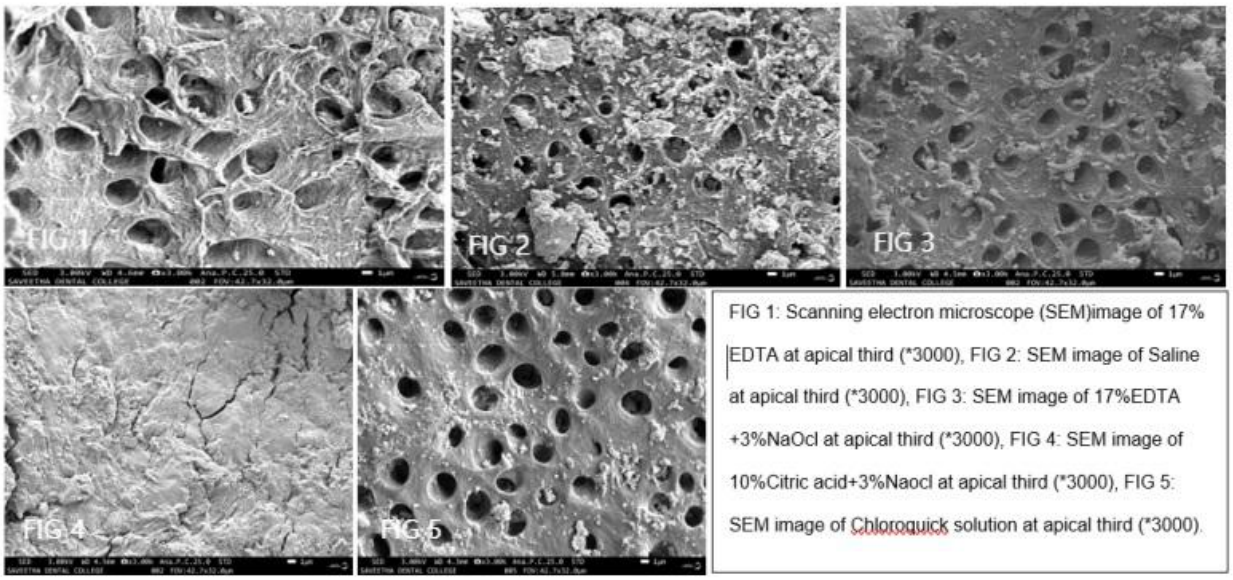

FIG 1: Scanning electron microscope (SEM)image of 17% EDTA at apical third (*3000), FIG 2: SEM image of Saline at apical third (*3000), FIG 3: SEM image of 17%EDTA +3%NaOcl at apical third (*3000), FIG 4: SEM image of 10%Citric acid+3%Naocl at apical third (*3000), FIG 5: SEM image of Chloroquick solution at apical third (*3000).

Tables And Table Legends

Table I: Tests of Normality

SCORE	STATISTICS	DF	SIG
1	.353	11	.000
3	.353	11	.000
4	.401	11	.000
5	.401	11	.000

*Lilliefors Significance Correction

**SCORE is constant when GROUP = 2. It has been omitted.

Table II: Kruskal Wallis Test for Intergroup Comparison

GROUP	N	Mean±SD	Mean Rank
17%EDTA	11	2.55 ±0.52	31.59
SALINE	11	3.02 ±0.03	42.50
17%EDTA+3%NaOCl	11	2.45 ±0.52	29.41
10%CITRIC ACID+3%NaOCl	11	2.36 ±0.50	27.23
Chloroquick solution	11	1.36 ±0.50	9.27

Table III: Mann Whitney U Test

Groups	Mean Rank	P value
17%EDTA and SALINE	9.00 14.00	0.013
17%EDTA and 17%EDTA+3%Naocl	6.00 0.00	0.032
17%EDTA and 10%citric acid+3%Naocl	7.05 9.17	0.384
17%EDTA and Chloroquick solution	6.00 0.00	0.128
SALINE and 17%EDTA+3%Naocl	0.00 6.00	0.273
SALINE and 10%citric acid+3%Naocl	0.00 6.00	0.015
SALINE and Chloroquick solution	0.00 6.00	0.021
17%EDTA+3%Naocl and 10%citric acid+3%Naocl	3.72 4.11	0.170
17%EDTA+3%Naocl and Chloroquick solution	4.17 7.21	0.320
10%citric acid+3%Naocl and Chloroquick solution	6.00 0.00	0.128

P value <0.05*- Statistically significant