

Comparative evaluation of the sealing ability of AH plus sealer after irrigation with different irrigants under a scanning electron microscope: an in vitro study

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ABSTRACT

Background: Sealers are essential to the effectiveness of endodontic therapy. How efficiently the root canal is irrigated determines how well sealers seal. This study aims to compare various irrigant combinations to allow better sealer penetration. The aim is to use a scanning electron microscope to assess the AH plus sealer's sealing capacity following irrigation with various irrigants.

Materials and Methods: Study was performed at Department of cons and endo at a private dental institute on twenty single-rooted recently extracted teeth. A scanning electron microscope was used to assess the AH plus sealer's sealing capacity following irrigation with four groups of different irrigants. A one-way ANOVA test was performed on the given data after the calculation of mean and standard deviation using SPSS 15.

Result & Conclusion: Both apical and coronal sections have $P \leq 0.001$, i.e., statistically significant results. The effectiveness of employing sodium hypochlorite and EDTA together, as well as Chitosan, to remove the smear layer was comparatively better than citric acid and sodium hypochlorite alone. The coronal region facilitated more sealer penetration and more smear layer removal by irrigation than the apical region.

Keywords: AH Plus Sealer, Root canal Irrigation, Sodium hypochlorite, EDTA, Chitosan, Citric acid, Scanning Electron microscope.

INTRODUCTION

The main factor affecting the clinical and radiographic outcome of root canal therapy is the avoidance of microbial contamination. To achieve a good sealing ability, a wide range of endodontic sealing materials have been developed. A sealer should ideally bind firmly to both the dentin and the core material being filled. This ability depends on the quality of material to prevent microleakage,

which is important for preserving the integrity of obturation material.¹⁻²

Root canal therapy (RCT) involves a chemical-mechanical preparation, followed by three-dimensional obturation to ensure proper shaping & cleaning of the canal. Endodontic therapy results in the deposition of an amorphous smear layer over the dentinal surface which covers the dentin surface

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as well as leads to plugging of dentin tubules.³ Combination of Ethylenediaminetetraacetic acid (EDTA)⁴ with sodium hypochlorite (NaOCl) is often used to clean out the smear layer.⁵

NaOCl, Citric acid, and Chitosan are used as irrigating solutions which have been proven to eliminate the entire smear layer⁶, organic and inorganic debris along with significant antibacterial effects. During root canal preparation they also clean the dentinal surface by acting as a lubricating agent for dentinal walls and flushing the debris out.⁷⁻⁸

The present *in vitro* study aims at comparison of four groups of irrigating solutions by the AH Plus sealer penetration⁹ following irrigation. The four groups consisted of sodium hypochlorite, along with EDTA, Citric acid, and Chitosan. A scanning electron microscope is used to document the precise depth of sealer penetration in the root's coronal and apical sections, as the irrigation techniques might affect how well resin-based sealants adhere to root dentin.¹⁰

MATERIAL & METHODS

Study design and study location: Study was performed at Department of cons and endo at a private dental institute in Maharashtra, India. The Institution Ethics Committee gave an ethical clearance for this study.

Sample size and sample selection: Twenty premolars with single root belonging to the mandibular and maxillary arch were used in the *in vitro* investigation, which were selected using convenience sampling. The debris was cleaned and the soft tissue of these teeth was preserved in a saline solution. De coronation procedure and sterilization were carried out for each tooth which was followed by their root canal treatment (RCT).

Inclusion criteria:

Premolars with a single root and a single root canal belonging to the mandibular and maxillary arch.

Exclusion criteria:

Calcified root canals, internally resorbed canals, or teeth with additional root canals visualized using RVG.

Carious or fractured root.

Tooth preparation protocol:

An Endo Access bur and a high-speed handpiece were used to achieve the access. Further, working length was determined. The bacteria leakage was prevented by using AH Plus sealer to seal the apical foramen of all the premolars and then placed in dental stone blocks. Biomechanical preparation of canal done 1mm short by #k file. Preparation was done till the master #k file of no.50. The rotary file by Dentsply Sirona is used for shaping the root canal as well as dentine removal. A magnetic stirrer was used to combine 1% acetic acid solution with roughly 0.2 g of chitosan powder, which was weighed out. The mixture was then agitated for two hours.¹¹ Materials and armamentarium are listed.

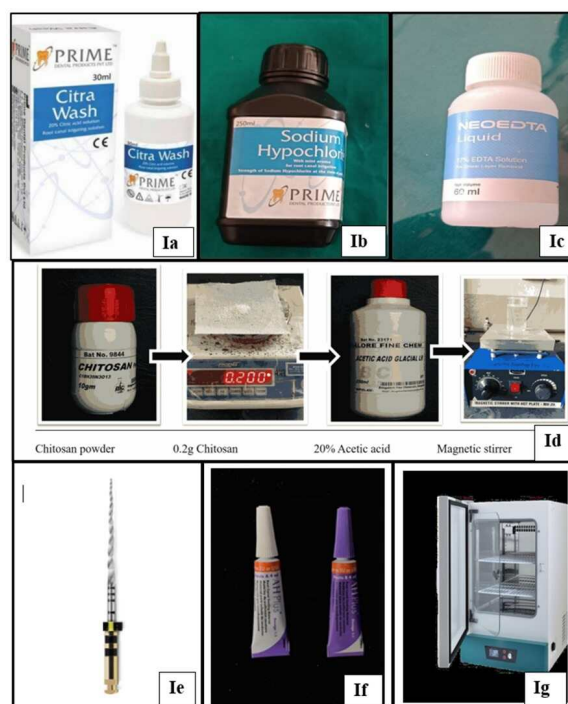


Figure I: Materials & Armamentarium

- Ia- Citric acid
- Ib- Sodium Hypochlorite solution (NaOCl)
- Ic- EDTA Solution
- Id- Preparation of Chitosan
- Ie- Rotary file Dentsply Sirona
- If- AH Plus sealer
- Ig- ncubator

Irrigation of specimen

The samples were split up into four groups, each with five premolars chosen at random. The irrigating solution was used as follows:

Group A: NaOCl (5ml) -1 min

Group B: NaOCl (5ml) with 17% EDTA- 1 min

Group C: NaOCl (5ml) with 20% of citric acid solution - 1min

Group D: NaOCl (5ml) with 0.2% Chitosan solution – 1min

After the irrigation of the canal by various agents according to the specified time, the root canals of all the specimens were sealed using AH Plus sealer. Sealer application was followed by obturation using gutta-percha of all the root canals thus completing the Root Canal Therapy (RCT). After that, they endured the following twenty-four hours in an incubator. The teeth were sectioned perpendicular to their long axis using a lubricated, moderate-speed diamond saw to create slices that were roughly 1 mm thick. These sections were scanned under a Scanning Electronic Microscope (DSM 940; Carl Zeiss, Oberkochen, BW, Germany)¹² in magnification of 1500X. The sealer penetration depth was calculated from the sealer and gutta percha interface to the root dentine in micro-meters (μ).

Statistical analysis

All specimens' penetration depths of sealer in the coronal portion and apical portions were tallied, the standard deviation was computed, and the One-Way ANOVA test was used to determine the outcome. The Statistical Package for Social Sciences 15 (SPSS 15) was used for statistical analysis. Regarding all the statistical. P values less than 0.05 were regarded as statistically significant in tests. For all the statistical tests, P value of <0.05 was considered statistically significant.

RESULT

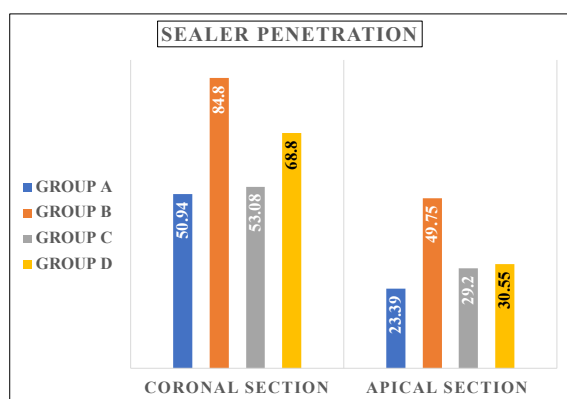
AH Plus sealer penetration depth (in μ) was observed using a Scanning Electronic Microscope

TABLE 1- (SEM) after various techniques of irrigation were calculated for each specimen in coronal as well as apical sections of root and then grouped accordingly.

Irrigants Used	Coronal section penetration (in μ)	Apical section penetration (in μ)
Hypo 1	69.8	29.42
Hypo 2	30.76	24.76
Hypo 3	71.76	20.56
Hypo 4	40.31	20.67
Hypo 5	40.34	21.56
Hypo + EDTA 1	109.2	71.56
Hypo + EDTA 2	98.48	51.76
Hypo + EDTA 3	54.78	39.72
Hypo + EDTA 4	91.28	45.3
Hypo + EDTA 5	70.32	40.43
Hypo + Citric acid 1	29.96	24.01
Hypo + Citric acid 2	45.41	15.38
Hypo + Citric acid 3	59.31	32.8
Hypo + Citric acid 4	75.43	42.41
Hypo + Citric acid 5	55.32	31.43
Hypo + Chitosan 1	65.51	28.8
Hypo + Chitosan 2	97.67	37.23
Hypo + Chitosan 3	65.86	26.2
Hypo + Chitosan 4	47.57	25.11
Hypo + Chitosan 5	67.76	35.42

The mean depth of sealer penetration in the coronal portion of the root in various groups is Group A 50.59 μ , Group B 84.8 μ , Group C 53.08 μ and Group D 68.8 μ .

The mean depth of sealer penetration in the apical portion of the root in various groups is Group A 23.39 μ , Group B 49.75 μ , Group C 29.20 μ and Group D 30.55 μ .



Graph 1: Mean sealer penetration after various groups of irrigating solution combinations

The mean sealer penetration depth in the coronal section of the root in various groups is Group A 50.59 μ , Group B 84.8 μ , Group C 53.08 μ and Group D 68.8 μ .

The mean sealer penetration depth in the apical section of the root in various groups is Group A 23.39 μ , Group B 49.75 μ , Group C 29.20 μ and Group D 30.55 μ .

Pictographic representation of mean sealer penetration depth in the coronal and apical sections is shown .

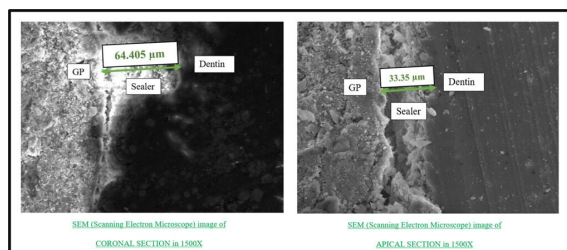


Figure 2: Scanning electron microscope (SEM) images.

The sample was subjected to a one-way ANOVA test following the computation of the mean and

standard deviation. This test should, in theory, show a significant difference at $P \leq 0.05$.

Section	Groups	N	Mean (in μ)	Standard deviation	P value
Coronal	Hypo	5	50.94	16.85	<0.01
	Hypo + EDTA	5	84.8	19.67	
	Hypo+ Citric acid	5	53.08	15.07	
	Hypo + Chitosan	5	68.8	16.15	
Apical	Hypo	5	23.39	3.37	<0.01
	Hypo + EDTA	5	49.75	11.72	
	Hypo + Citric acid	5	29.20	9.05	
	Hypo + Chitosan	5	30.55	4.89	

Table 2: One-way ANOVA test applied to the sample after calculation of mean and standard deviation, the test indicates statistically significant at $P \leq 0.05$ and $P \leq 0.01$ indicates statistically highly significant

Comparative evaluation of sealer penetration in coronal and apical sections in the respective groups concluded $P \leq 0.01$ i.e., statistically significant in all groups.

DISCUSSION

Irrigation is an extremely essential step of endodontic therapy. The root canal's bacterial burden is reduced by irrigation, which additionally assists with root canal shaping & cleaning. The procedures in RCT, like cleaning, shaping, and obturation, use biocompatible, dimensionally stable as well as impermeable material. These qualities are necessary for effective endodontic treatment.¹³⁻¹⁴

According to primary components or structure, sealants are grouped as ZnOE based sealers, resin sealers, Ca(OH)₂ sealers, GIC, etc. Derived from AH 26, AH Plus is a slow-setting epoxy resin sealer that solves the problem of formaldehyde leaks during

setting. Epoxy resin has a greater bond strength along with good flow qualities but certain tests have shown leakage during setting.¹⁵⁻¹⁶

The specimen had a root canal prepared apically up to #50 K files (Agrawal et al).¹⁷ This was done to prepare the canal even and wide which in turn ensured complete irrigant penetration along the root canal.

Earlier, the idea that the presence of impurities or precipitate can hamper the bonding of resin-based AH Plus sealer to dentin was partially rejected attributed to the push bond test. The AH Plus group of controls had a maximum bond strength of (29.30 ± 0.19), which was higher than that of the other groups. Results were stronger than the Resilon epiphany group having lower bond strength (13.28 ± 1.35). The higher strength of AH Plus sealer was discovered to be comparable to the findings made by **Gesi et al**. Epoxy-based resin sealers have shown higher quality characteristics and minimum shrinkage while curing combined with higher dimensional stability.¹⁸

For endodontic therapy to be successful, the smear layer must be eradicated and sealer must permeate. Depending on which sealer is utilized, different sealers have different levels of penetration into the dentinal tubules (**Balguerie et al**).¹⁹ Of all the sealers evaluated, the AH Plus sealer demonstrated the best penetration into dentinal tubules and the best root canal wall adaptation.

In the present study, a comparison was made between four irrigant combinations for the evaluation of better sealer penetration following their application. The main component of all the irrigation solutions is sodium hypochlorite. Sodium hypochlorite possesses excellent antibacterial activity but it alone cannot facilitate complete smear layer removal (**Vallabhaneni et al**).²⁰ In the present study, a similar interpretation is made.

As a solution to this, **Zehnder M et al**, in their study, advocated the use of 17% EDTA along with 2.5% sodium hypochlorite for irrigating root canals. This method is considered very effective to eliminate smear layer by combining antibacterial properties of NaOCl with demineralizing and chelating properties of EDTA. This combination showed favorable results in the present study as well.²¹

Combination of 20% citric acid and sodium hypochlorite as root canal irrigant (**Yamaguchi et al**)²². A similar combination was used in our study and results were similar in both studies. This combination is less effective than the NaOCl + EDTA group.

Chitosan is a natural glucosamine. 0.2g chitosan powder when mixed with 1% acetic acid is used for root canal irrigation along with NaOCl. The sealer penetration depth achieved by using this combination was as good as the NaOCl + EDTA group in the coronal section (**Carpio et al**).²³

Apart from the irrigants used in this study, several other irrigants are used in dental practice nowadays. This study majorly focused on the comparison of the four most commonly used irrigating solutions.

There should be more ex-vitro research done on this subject for further understanding. Newer irrigation protocols can be developed with varying combinations of other materials. The properties of such newer materials need to be studied thoroughly for a greater positive impact in the field of endodontics and to learn more about the potential of irrigation.²⁴

Limitations of the study

The results cannot be generalized as only four groups of irrigants were compared. The study needs to be made extensive by involving more irrigants for comparison.

Factors such as pH, concentration, and exposure time of irrigating solution need to be taken into consideration as well.

Since this is an *in vitro* investigation, the real clinical findings may differ. The longitudinal study might be conducted *ex-vitro* to verify the findings.

CONCLUSION

It was evaluated how well the AH Plus sealer penetrated the dentinal tubules following the application of different irrigating solutions. When using chitosan as well as sodium hypochlorite & EDTA were combined, the smear layer could be removed more effectively than when citric acid and NaOCl were used alone. It was discovered that

greater sealer penetration was possible through the coronal part of the root as well as more smear layer removal by irrigation compared to the apical section of the root. A wide range of studies considering factors like pH, concentration, exposure time for optimal chelation, etc. need to be carried on for further insight into this topic.

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