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Comparison of Cleanliness by Different Irrigants for Calcium Hydroxide Removal: SEM Analysis

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ABSTRACT

Aim: To evaluate and to compare the cleaning efficacy of different endodontic irrigants (5.25% Sodium Hypochlorite, 15% Citric Acid, 17% EDTA, SmearClear) in removal of calcium hydroxide from the root canals through scanning electron microscopic image analysis.

Materials and Methods: 44 freshly extracted human mandibular premolars with straight roots with single canals were decoronated 12mm from the apex. Root canal preparation was performed using K-files and NiTi Protaper File with apical preparation till #30 size followed by a final irrigation with 15ml of 5.25% sodium hypochlorite and 15ml of 17% EDTA solution. $Ca(OH)_2$ was filled and temporarily sealed with IRM and kept in incubator for 1 week. 40 roots were randomly divided into 4 groups ie. Group I 5.25% Sodium hypochlorite, Group II 15% Citric acid, Group III 17% EDTA and Group IV Smear Clear. For each sample, 15ml of the irrigating substance was used and splitting was done to observe in scanning electron microscope.

Results: Maximum amount of cleanliness was seen with Group IV (SmearClear) and least with Group I and Group II and Group III showed similar results.

Conclusion: None of the irrigating solutions were able to remove $Ca(OH)_2$ completely but SmearClear performed the best among all the groups.

Keywords: Calcium Hydroxide, Chelators, EDTA, Intracanal medicament, Surfactant.

INTRODUCTION

The success in root canal treatment is dependent on elimination of infection and on permanent obliteration of the root canal by a nontoxic material.[1] Clinicians should ideally adopt an antibacterial treatment protocol that has been shown to be effective in well-controlled studies so that a predictable outcome can be achieved.[2] The use of an intracanal dressing increases the power of the sanitization process achieved by cleansing and shaping the root canal.[3] Therefore, an intracanal medicament with profound antibacterial activity against most of the bacterial strains identified in root canal infections is required.[4,5]

Currently, calcium hydroxide [$Ca(OH)_2$] is the most used intracanal dressing, due to its antimicrobial effect within the root canal, which is caused by its dissociation and its indirect and direct

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Table 1: Groups of the Samples.

Group	N	Irrigation Solutions
I	10	15 ml of 5.25% Sodium Hypochlorite
II	10	15 ml of 15% Citric Acid
III	10	15 ml of 17% EDTA
IV	10	15 ml of Smear Clear (SybronEndo, Orange, CA)

Table 2: Scoring criteria for the removal of Calcium hydroxide.

Score	**Criteria**
1	80%-100% of removal of calcium hydroxide – total cleanliness
2	60%-80% of removal of calcium hydroxide – great cleanliness
3	40%-60% of removal of calcium hydroxide – partial cleanliness
4	20%-40% of removal of calcium hydroxide – light cleanliness
5	0%-20% of removal of calcium hydroxide – no cleanliness

Table 3: Mean Scores at the all the third for the removal of Ca(OH)2.

Group	Irrigation Solution	N	Mean Scores at Apical Third (Std. deviation)	Mean Scores at Middle Third (Std. deviation)	Mean Scores at Coronal Third (Std. deviation)
1	15 ml of 5.25% Sodium hypochlorite	10	4.80±0.42	4.60±0.51	4.30±0.67
2	15 ml of 15% Citric Acid	10	4±0.66	3.30±1.33	3.10±1.19
3	15 ml of 17% EDTA	10	3±0.66	2.40±0.51	2.40±0.51
4	15 ml of SmearClear	10	1.90±.82	1.70±0.82	1.60±0.69

Table 4: Comparison of Calcium hydroxide removal in all the thirds in between the groups.

Irrigation Solution	Apical Third		Middle Third		Coronal Third	
	Z -value	p-value	Z -value	p-value	Z -value	p-value
Group 1 Vs Group 2	2.68	0.008 S,p<0.05	2.39	0.019 S,p<0.05	2.37	0.01 S,p<0.05
Group 1 Vs Group 3	3.82	0.000 S,p<0.05	3.91	0.000 S,p<0.05	3.75	0.000 S,p<0.05
Group 1 Vs Group 4	3.94	0.000 S,p<0.05	3.88	0.000 S,p<0.05	3.83	0.004 S,p<0.05
Group 2 Vs Group 3	2.75	0.006 S,p<0.05	1.74	0.08 NS,p>0.05	1.60	0.10 NS,p>0.05
Group 2 Vs Group 4	3.72	0.000 S,p<0.05	2.60	0.009 S,p<0.05	2.73	0.004 S,p<0.05
Group 3 Vs Group 4	2.86	0.004 S,p<0.05	2.02	0.04 S,p<0.05	2.46	0.014 S,p<0.05

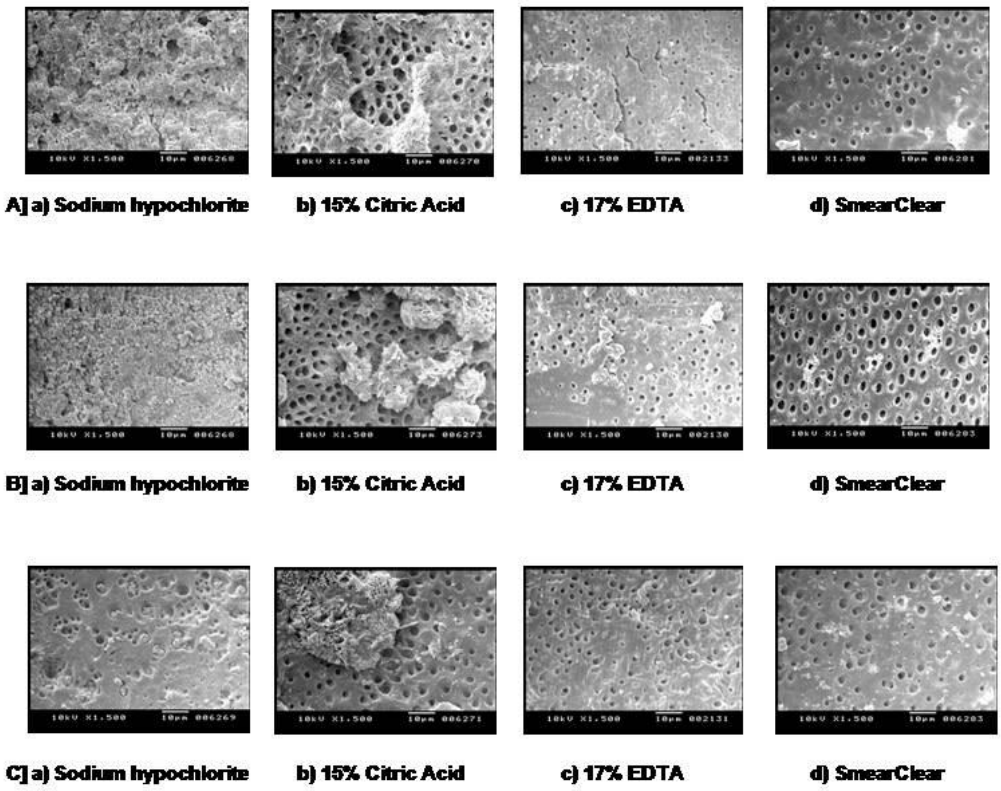

Fig 1: **SEM Images of the groups at X1500 magnification A) Apical third B) Middle third C) Coronal third**

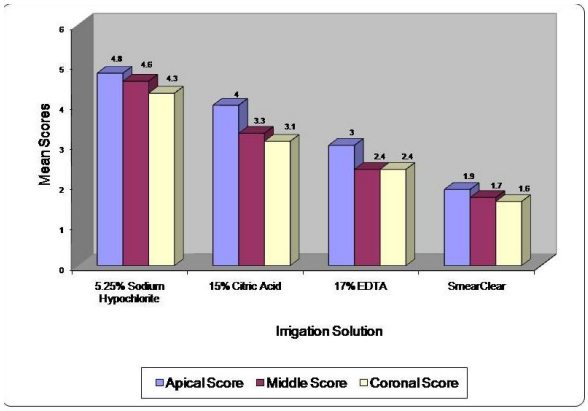

Fig 2: Comparison of the scores for Calcium hydroxide residue left after group wise irrigation.

actions in the dentinal tubules.[3,6] It is a strong alkaline substance, which has a pH of approximately 12.5.[7] Calcium hydroxide is widely used in dentistry and especially in endodontics as a dressing in periapical tissue inflammation, in cases of tooth root fracture, mechanical or inflammatory perforations, pulp capping, pulpotomy, internal and external root resorption as well as in the process of apexification.[8,9]

However, if this medication is not completely removed, its presence on the dentine walls could compromise the endodontic treatment.[10] Persistence of $Ca(OH)_2$ residues may interfere with sealing ability of endodontic sealers resulting in poor cohesion, granular appearance and markedly increasing the apical leakage.[11,12] Kim and Kim (2002)[13] also showed that sealing ability of ZOE sealer was reduced with higher water sorption values with residual calcium hydroxide. Chung 2001 & Barbizam (2008)[14] reported that residual $Ca(OH)_2$ interfered with adhesion of Ketac-Endo Epiphany™ respectively, to the root dentine resulting in reduced bond strength.[15] Ricucci and Langeland (1997)[16] reported a case of a failed root canal treatment because of incomplete removal of $Ca(OH)_2$.

The removal of $Ca(OH)_2$ has been investigated by various methods and techniques such as irrigation with a combination of sodium hypochlorite and EDTA.[17-19] **Salgado et al (2009)**[20] utilized master apical file along with irrigation with various chelating agents. CanalBrush, rotary file agitation, passive ultrasonic agitation along with sodium hypochlorite have also been studied but none of technique resulted in complete removal of the $Ca(OH)_2$ from the root canals.[9,21-27]

Considering the importance of the complete removal of intracanal dressing before root canal filling, this study aimed at evaluating the efficacy of 4 types of irrigating solutions in removing $Ca(OH)_2$ residues from root canal dentine walls, using scanning electron microscopic (SEM) image analysis.

MATERIALS & METHOD

44 freshly extracted, intact, non carious, unrestored human mandibular premolars were used in the study. After extraction the teeth were cleaned and stored in saline solution at room temperature. The crowns of the teeth were decoronated 12 mm from the apex to standardize the length of the roots. The orifices were flared using SX Protaper File and working length was determined at 1 mm from the apical foramen with radiographic confirmation. Root canal preparation was performed using K-files (Mani, Japan) and NiTi Protaper File (DENTSPLY-Maillefer, Ballaigues, Switzerland) and 5.25% sodium hypochlorite with Glyde (Dentsply, Tulsa Dent, India) in crown down technique. All teeth were prepared till F3 master apical file size #30 (MAF), followed by a final irrigation with 15 ml of 5.25% sodium hypochlorite and 15 ml of 17% EDTA solution.

The roots were dried using absorbent points and filled with calcium hydroxide (ApexCal, Ivoclar Vivadent AG) using lentulo spiral until the material extruded out of the apex, with exception of 2 teeth used as negative control. All teeth were temporarily sealed with IRM. Mesio-distal and bucco-lingual radiographs were taken to confirm complete filling. All roots were then incubated at 37ºC in 100% humidity for 1 week. Two roots with calcium hydroxide were used as positive controls in which no irrigant was used. 40 roots were randomly divided into 4 groups, according to the solution used for $Ca(OH)_2$ removal (Table I). For each sample, 15 ml of the irrigating substance was used, divided into 3 rinses of 5 ml each. After each rinse, a K-file #15 was inserted inside the canal and oscillated in clockwise direction for 5 seconds.

All roots were split in the bucco-lingual direction. The sections were dehydrated by a series of graded ethanol solutions and then coated with a gold layer (JEOL-JFC 1600) after drying. The selected dentinal surfaces of cervical, middle, and apical thirds (9, 6, and 3 mm from the apex, respectively), equidistant from lateral walls, were observed by SEM (JEOL-JSM-6380A) at X1500 magnification. The removal of $Ca(OH)_2$ and cleanliness of the dentinal walls was graded using a 5-grade scale (Table 2) by five calibrated examiners. Statistical analysis was performed using Mann Whitney U test and Kruskal-Wallis ANOVA at 5% level of significance.

RESULTS

The mean scores at the cervical, middle and apical third are shown in table 3. The results suggested that none of the irrigating solutions were able to remove $Ca(OH)_2$ completely from the root canal system. However maximum amount of cleanliness was seen with Group IV (SmearClear) and least amount of cleanliness was seen with Group I (5.25% Sodium Hypochlorite) which was statistically significant with a p-value 0.000 ($p<0.05$) when compared to Group II(15% Citric acid) and Group III (17% EDTA) (Table 4). Figure 1 represents the images obtained by scanning electron microscope for the comparison of the groups at all thirds.

When removal efficiency of the $Ca(OH)_2$ dressing was compared in all the thirds irrespective of the irrigants used it was found that maximum amount of cleanliness was found in the coronal third followed by middle third and least in the apical third (Figure 2).

DISCUSSION

Elimination of all bacteria from the root canal is normally accomplished by mechanical instrumentation supported by various irrigating solutions and antibacterial agents.[18] $Ca(OH)_2$ is the recommended intracanal medication for the

treatment of apical periodontitis as it has been associated with periradicular healing.[28] In general, three types of vehicles are used: aqueous, viscous or oily. Aqueous type of vehicle promotes a high degree of solubility, thus rapidly solubilized and resorbed by macrophages and root canal may become empty in a short period.[7] In clinical situations that require a gradual and uniform ionic liberation, a viscous vehicle having high molecular weight like propylene glycol containing paste should be used. Prior to definite filling of the root canal, the temporary dressing has to be removed completely to exclude any negative interference between medicament and the filling material.[29]

Sodium hypochlorite is one of the most effective endodontic irrigant; however there is limited ability to dissolve inorganic substances such as $Ca(OH)_2$.[30-32] In the present Sodium hypochlorite was least effective in removing $Ca(OH)_2$. Similar finding were obtained by other authors (Kenee et al. 2006, Salgado et al. 2009, Rodig et al 2010, Tasdemir et al 2011).[19,20,22,27] 15% Citric acid and 17% EDTA performed better than Sodium hypochlorite as they are able to remove inorganic substances.[31,33,34] SmearClear was the best among all the irrigants tested as it had two additional proprietary surfactant add to it which reduced the surface tension.[35] The surface tension is the force between molecules that produces the tendency for the surface area of a liquid to decrease.[36] The low surface tensioned EDTA facilitates the wetting of the entire root canal wall and thereby increases the ability of the chelator to penetrate to the dentine.[37]

Mechanical agitation with K-file and low surface tensioned EDTA i.e. SmearClear was most effective in removing $Ca(OH)_2$ in all the thirds of the root canal. These results are similar with the study Salgado et al. (2009)[20] in which EDTA-T was used which is another low surface tensioned EDTA having sodium lauryl ether sulfate as detergent. In the Apical third maximum amount of $Ca(OH)_2$ remnants were seen as it is difficult to clean and there is a tendency for the debris to get collected in the apical third.[21,22,38]

CONCLUSION

None of the irrigating solutions used in this study were efficient in removing complete calcium hydroxide from the root canals. Cleaning efficacy of 5.25% Sodium Hypochlorite was least and best for SmearClear among all the groups. Irrespective of the irrigating solution used maximum amount of cleanliness was observed in coronal third followed by middle third and least amount of cleanliness was observed in the apical thirds.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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