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TITLE: Comparative evaluation of Smear layer removal using heated Sodium hypochlorite at different temperature using SEM: An in-vitro study.

Authors: Dr. B Sonika Devi[1], Dr. Mohit Sharma[2], Dr.Mohit Kumar[3],Dr.Deepak Tomar[4], Dr. Pulkit Arora[5]

[1]M.D.S (PG 3rd year), [2]Professor,[3]Professor& Head,[4]Professor,[5] Senior Lecturer
Department of Conservative Dentistry & Endodontics.
Shree Bankey Bihari Dental College and Research Centre
Masuri, Ghaziabad.
Phone no: 9862828048
E- mail: sonikas539@gmail.com

Corresponding Author-

Dr.Mohit Kumar
Professor & Head
Department of Conservative Dentistry & Endodontics.
Shree Bankey Bihari Dental College and Research Centre
Masuri, Ghaziabad.
Phone no: 9862828048
E- mail: sonikas539@gmail.com

Abstract

Aim: The aim of this study is to evaluate the surface of apical 3rd of the root canal walls after treating with sodium hypochlorite under different heating temperature i.e., unheated NaOCl at room temperature, preheated NaOCl at 50°C and intracanal heated NaOCl at 180°C**.**

Materials and method: Root canals of forty single rooted teeth were decoronated and instrumented and then randomly divided on the basis of final irrigation protocol of sodium hypochlorite under different heating temperature: unheated NaOCl at room temperature, preheated NaOCl at 50°C and intracanal heated NaOCl at 180°C into Group A, B, and C respectively. Samples were than sectioned longitudinally and examined under scanning electron microscope. Data was analyzed using statistical Package for Social Sciences (SPSS), version 19.0. at significance level of P value < 0.05.

Results: Group difference in score was found to be statistically significant for overall assessment in apical third of root canal (P< 0.05).

Conclusion: Intracanal heating of sodium hypochlorite proved to be more effective in obtaining cleaned root canal walls, whereas unheated and heated NaOCl at 50°C left a higher quantity of debris & smear layer at apical third.

Keywords: Heating of irrigating solution, scanning electron microscope, sodium hypochlorite, smear layer.

Introduction

Successful endodontic therapy depends on the clinical traid of diagnosis, thorough cleaning & shaping and obturation of root canal system in 3 dimensions to promote apical healing.[1,2] The root canal system is complex beyond the limits of the main root canal, having macroscopic parts outside the reach of mechanical preparation.[3,4] Therefore, the apical area in the root canal system is the critical zone for instrumentation.[5]

Irrigating solutions are necessary to simplify the debridement and disinfection of root canal space.[6,7] Sodium hypochlorite (NaOCl) is the most commonly used irrigant because of its numerous advantages like antimicrobial action, ability of the solution to dissolve vital and necrotic tissue, lubricating action, mechanical flushing of debris from the canal, low cost, and availability.[8,9]. Although NaOCl is a highly effective antimicrobial agent, it does not remove the smear layer from the dentin walls. So, chelating agents like EDTA, CA were introduced to use as an adjunct into endodontic for clearing smear layer.[10,11,12]

To improve the root canal irrigation, endodontic research tried to develop various techniques and strategeies.[13,14] One of the important approaches is the warming or preheating of the irrigant. A heated sodium hypochlorite solution allows for improvements in its antimicrobial properties, tissue dissolution capacity; removal of organic debris from dentinal shavings and cleanse the canal more efficiently than unheated hypochlorite solutions, also heating NaOCl lower its viscosity allowing better penetration.[15,16,17,18]

An alternative approach is intracanal heating, where sodium hypochlorite is heated within root canals using heat carrier tips. With a heat source, the clinician is able to produce and maintain precisely controlled, preselected temperatures.[19,20,21]

The purpose of this study is to evaluate the removal of smear layer at the apical 3rd of the root canal walls after treating with sodium hypochlorite under different heating temperature i.e., unheated NaOCl at room temperature, preheated NaOCl at 50^{0}C (extra canal) and intracanal heated NaOCl at 180^{0}C using scanning electron microscope.

Materials and Method

Sixty freshly extracted single rooted human permanent single rooted teeth with mature apex were collected and stored in saline. The exclusion criteria were as follows: teeth with calcified canals, teeth having extra canal, vertical or horizontal root fracture, cracks, internal and external resorption.

For standardization of root length (14mm), decoronation was done with a diamond disc in a slow speed under constant water cooling to gain unrestricted access to the root canal system and to obtain a constant reference point for all measurements.

#10 K-file was inserted into the root canals until the tip of the instrument was just visible at the major apical foramen to verify patency of the canal space and the apical foramen. Chemo mechanical preparation was performed using ProTaper Gold rotary files in a sequential manner (Denstply Maillefer) from S1to F3 (S1, SX, S1, S2, F1, F2, F3) instruments at 300 rpm and torque 3 N/cm. Each canal was irrigated with total 6ml of 5.25% sodium hypochlorite (NaOCl) solution during instrumentation. The files were frequently cleaned to remove debris from their flutes, and irrigating solutions were frequently replaced to maintain its effectiveness. 30G endodontic needles were allowed to reach the apical third.

All the specimens were flushed with saline and divided into three groups according to the final irrigation protocol.

- Group A: side vented needle 2mm shorter than the working length and 6ml of non-heated NaOCl was used followed by 17% EDTA for 1min.
- Group B **:** (extra canal heating at 50^0C): side vented endo needle 2mm shorter than the working length and 6ml of NaOCl at 50^0C was used , followed by 17% EDTA for 1min.
- Group C**:** (intracanal heating at 180^0C): endodontic needle 2mm shorter than the working length, and 6ml of NaOCl were used; fast pack (Orikam) heat source is set at 180^0C with fine tip (black- 40/0.25) at 3mm shorter and will be activated for 3-5sec and then nonactivated for 10sec; this activation procedure is repeated 5 times and NaOCl will be refreshed with new solution at each cycle, followed by 17% EDTA for 1min.

The root canals were finally flushed with saline ethanol for 30s and dried with paper points.

Scanning Electron Microscope (SEM) preparation and analysis

Two longitudinal grooves were prepared; each root was split into two equal halves.

The specimens were dried, and then placed in a vacuum chamber, and sputter coated with a gold layer. The specimens were then analyzed using SEM (EVO 40XVP, Zeiss) in high vacuum mode at 20Kv. The dentinal surfaces were observed at apical thirds with a magnification of ×1500 for the presence/absence of smear layer, pulpal debris, and inorganic debris. Photomicrographs (×1500) of these areas on apical thirds were taken (Figures 1-3). The scoring system used was proposed by Guttmann et al.[22] and the criteria for scoring were reported as follows.

Score	Smear Layer
1	Little or no smear layer, covering <25%, most tubules were visible and patent.
2	Little to moderate or patchy amounts of smear layer, covering 25-50%; many tubules visible and patent.
3	Moderate amount of scattered or aggregated smear layer; covering 50- 75%, minimal to no tubules visibility.
4	Homogeneous smear layer >75%, no tubules patent or visible.

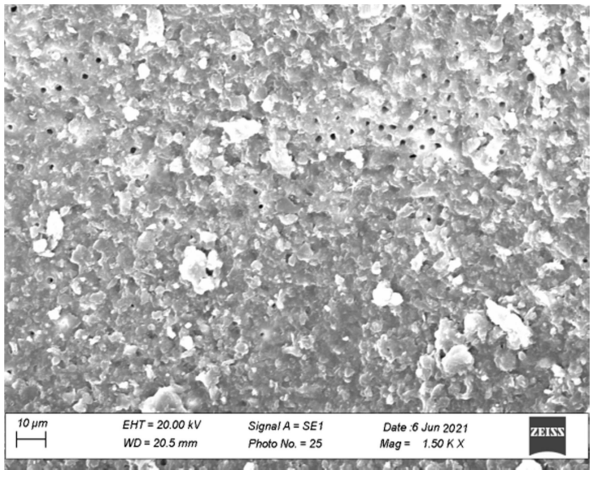


Figure-1. SEM representative image of apical third root canal surface after final irrigation with non-heated Sodium hypochlorite.

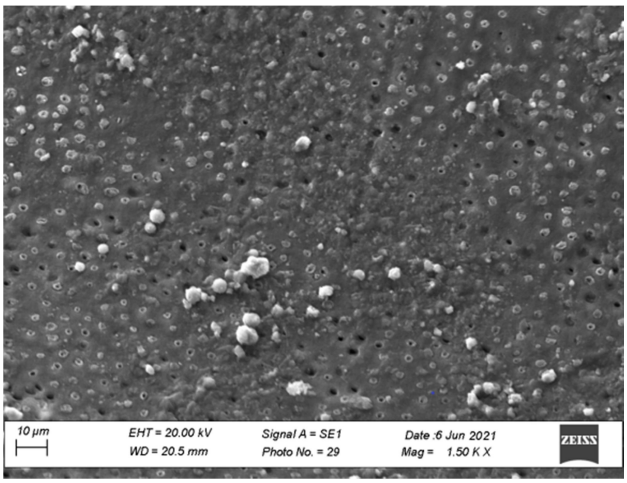


Figure-2. SEM representative image of apical third root canal surface after final irrigation with extra canal heated Sodium hypochlorite at 50^{o}C.

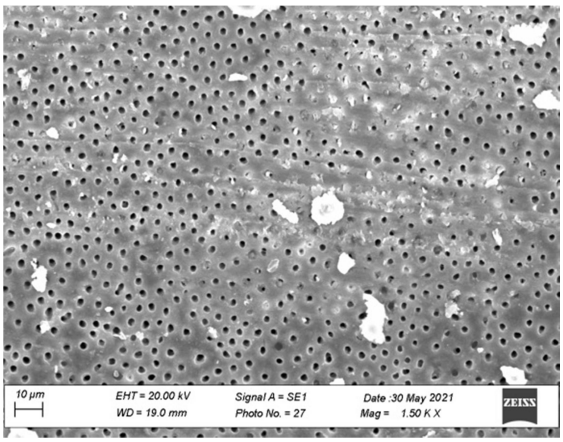


Figure-3. SEM representative image of apical third root dentine surface after final irrigation with intracanal heated Sodium hypochlorite at 180^{o}C.

Statistical Analysis

The collected data was entered in Microsoft Excel and subjected to statistical analysis using SPSS v19.0. The differences in the different groups were analyzed using the Kruskal–Wallis test (ANOVA) and subsequently with Mann-Whitney U test for comparison within the group was considered as significant. The significance level for all statistical analysis was set at $p<0.05$

Results

Kruskal–Wallis analysis of variance for smear layer showed significant difference among the different groups of heated NaOCl ($P< 0.05$) (Table-1). Mann- Whitney test confirmed that group C has higher smear layers removal compared to other two groups (Table-2). The

ANOVA confirmed that even with heating of NaOCl, higher quantity of smear layer still remains in apical third (Table-3).

Group	Scoring			
	Mean	SD	F- value	P- value
GROUP A	3.7	0.47	26.28	0.000*
GROUP B	3	0.64		
GROUP C	2.25	0.71		

Table: 1 The mean score was compared between group A, group B and group C.

Group	Scoring		
	Mean rank	Z	p- value
GROUP A	26.25	-3.91	0.000*
GROUP B	14.75		

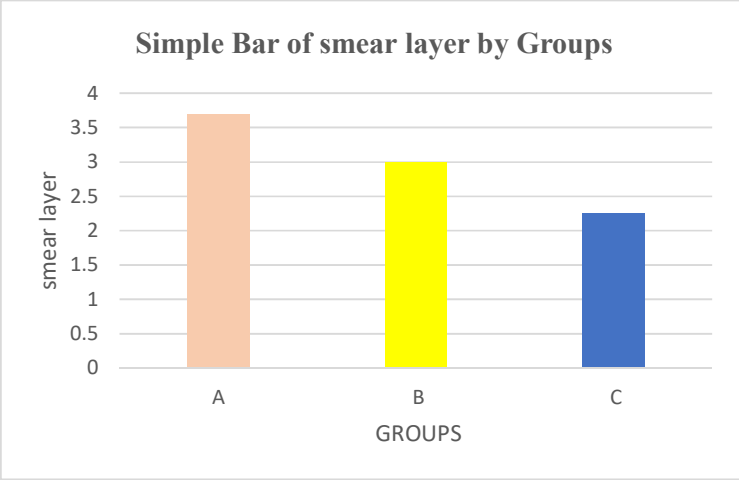
Table: 2 The comparison of mean scoring between GROUP A and GROUP B apically for the presence and absence of smear layer.

Group	Scoring		
	Mean rank	Z	p value
GROUP A	29.3	-6.14	0.000*
GROUP C	11.7		

Table: 3 The comparison of mean scoring between GROUP A and GROUP C apically for the presence and absence of smear layer.

Group	Scoring		
	Mean Rank	Z	p value
GROUP B	25.18	-2.06	0.019*
GROUP C	15.82		

Table: 4 The comparison of mean scoring between GROUP B and GROUP C apically was found to be statistically significant. ($P<0.05$).



Graph-1. Simple bar graph showing comparison of smear layer removal using NaOCl at non-heated, 50^0C (extra canal) , 180^0C(intracanal).

Discussion

Effective cleaning of the canal system requires the use of irrigation solution, which serves a variety of purposes including antibacterial action, tissue dissolution, chelating and removal of smear layer.[3]

Irrigation is a crucial step in, during and after instrumentation for effective root canal cleaning.[7] Sodium hypochlorite is the most widely used irrigant. Although NaOCl is efficient in dissolving organic components of smear layer, its ability to remove inorganic tissue is limited.[8,11] Therefore, for effective removal of smear layer, judicious use of chelating agents is of paramount importance, such as EDTA. The combination of these two irrigants complements the cleaning of the root canal, especially in area of difficult access, such as dentinal tubules and lateral canals.[12,13]

In this present study, 5.25% OF NaOCl and 5ml of 17% EDTA (pH 7) for 1min was used to make valid comparisons.

Current literature suggests various techniques to improve the effectiveness of sodium hypochlorite as an irrigating solution. For instance, the use of greater amount of irrigant and preheating of irrigant.[13,14]

Preheated NaOCl solution has greater ability to dissolve pulp tissue and cleanse the canal wall.[14] Heating of NaOCl to 50°C–60°C is highly recommended.[25]Previous studies have shown that, the systemic toxicity of preheated NaOCl irrigants, once they have reached body temperature, is lower than non-heated counterparts with similar efficacy in root canal.[18,24]

Woodmansey found that NaOCl at boiling temperatures could disintegrate the pulp tissue at a speed of 210 times higher than the same irrigant at room temperature. For this reason, he suggested the use of intracanal heating of NaOCl, as extraoral technique was ineffective in maintaining the temperature of the preheated NaOCl inside the root canal.[16,21,26]

In the present study, apical third of the root was taken into consideration to evaluate the removal of smear layer. Because lateral canals and apical ramifications are most commonly present in apical third of the root.[3] Seventy percent of cases of refractory apical periodontitis had significant apical ramifications in the apical third of the root apex of teeth.[5]

In this present study, temperature controlled water bath is used to heat the NaOCl extracanally at 50^0C and Fast Pack (Orikam, Eighteen) heat carrier was used, which has a similar function with system B heat source. The system is able to produce and maintain precisely controlled, preselected temperature. The heating tip must remain passive and not be wedged against the canal walls. The tips should be heated in 3-8sec bursts and not continuously activated. Precautions must be exercised to prevent overheating of the tooth periodontal ligament. Although, studies have demonstrated negligible increases in temperature of root surface while using heat source.

At Intracanal heating of NaOCl at 180^0C, the results of SEM showed more than 75% of the dentinal tubules open and free of smear layer and better than preheated NaOCl which corresponds to the study done by Alfredo I et al[27] of intra-canal heating of NaOCl at 180°C proved to be more effective in obtaining clean canal walls. On the other hand, extra-canal heating at 50°C of NaOCl left a higher quantity of debris and the smear layer was widely represented. The body can rapidly buffer the NaOCl, thus mitigating its advantages. Thus, it is beneficial to heat NaOCl using heat carriers, after placement of the irrigant into the root canal.[19,28]

The increased efficacy of intracanal heating of NaOCl can be attributed to the study done by Iandolo et al, i.e., NaOCl preheated to 50^oC, 60^oC & 70^oC stabilized in a few seconds to body temperature. Furthermore, the apical third, the most critical area, was never able to reach 40

^{o}C. While with the intracanal technique using heat carrier, the higher temperature can be maintained for longer time span for 57s.[28]

Our results are consistent with the findings of Iandolo et al who reported, intracanal heating of NaOCl was significantly better than pre-heated and unheated NaOCl in removing hard tissue debris from the main root canal space. However, it was also reported that none of the groups were able to completely remove debris from the apical third of the root canal.[29]

Within the limitation of this in vitro study, the following conclusions were drawn. None of the root canal irrigation was able to completely remove the Smear Layer in apical third of root canals. Intracanal heating of NaOCl at 180^{0}C could effectively, but not completely, remove the smear layer.

Conclusion

Within the limitation of the study, following conclusions were drawn: Amongst all the groups, intracanal heating of NaOCl at 180^{0}C showed significantly less amount of smear layer followed by extra canal heating of NaOCl at 50^{0}C and nonheated NaOCl. None of the technique was able to completely remove smear layer and debris from the surface in apical 3rd of the root canal walls.

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