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Effectiveness of XP-EndoFinisher, Ultrasonic and EndoActivator on Debris and Smear Layer Removal in Curved Root Canals: A Scanning Electron Microscope Study

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Abstract: ***The purpose of this study was to assess the efficacy of XP-Endo finisher in comparison to other irrigation regimens after biomechanical preparation, on debris and smear layer removal in curved root canals. Sixty freshly extracted mandibular molar teeth with the mesial root curvature more than 20 degree were used in this study. The mesial root was prepared by using Neo Endo Flex file and divide into four groups[n=15] according to the following irrigation techniques; control group, XP-Endo Finisher, Ultrasonic, EndoActivator. Root canals were split longitudinally and were evaluated by scanning electron microscopy. Five grade scoring criteria was used to assess the debris and smear layer at coronal, middle and apical third of the canals. Under the tested conditions it may be concluded that XP-Endo Finisher group is more effective in removing debris and smear layer compared to other groups except at apical third where it is same as effective as Ultrasonic group. Coronal region has less debris and smear layer at all groups except the control group where there is no significant difference between the apical and middle regions.***

Keywords: smear layer, debris, irrigants

1. Introduction

Adequate cleaning and shaping of the root canal is an important and crucial step in the success of root canal treatment procedure[1]. Smear layer which is produced during the root canal instrumentation compromises of dentin, pulp and bacterial remnants[2]. It causes the complete occlusion of the dentinal tubules thus compromises the root canal seal[3,4]. Several irrigants like NaOCL, EDTA, Calcium chelating agents have been used for removing the smear layer [5]. Among all these irrigating solutions preferably NaOCL has been commonly used due to its superior antibactericidal and tissue dissolving properties[6]. Alternative use of EDTA and Calcium chelating agent due to its antibacterial property helps in the disruption and dissolution of the smear layer[7]. Traditionally the irrigants which are delivered by the syringe irrigation method was ineffective for the complete cleaning of the root canal system because of the delivery of the solution upto 1mm beyond the needle tip[8,9] . This causes the inadequate penetration of the irrigants thus affects the quality and outcome of the treatment.

The EndoActivator system consists of portable handpiece and polymer based tips that do not cause any damage to the prepared dentinal walls[10].

Ultrasonic irrigation has been used to improve the penetration and effectiveness of irrigants. This irrigation is of two types in which first is it's combination with instrumentation, which has been discarded due to the excessive cutting of the dentin. Second type is passive ultrasonic irrigation which doesnot require instrumentation and works on the phenomenon of acoustic streaming and cavitation of the irrigating solutions[11,12]. The XP endo finisher file helps to treat and efficiently cleans the root canals with complex morphologies because of its dependency on the shape memory principle of NiTi alloy[13]. It has a small core size [ISO 25 diameter and zero taper] with magnificient flexibility thus causes flawless shaping of the root canal along with the preservation of the dentin[14].The objective of this study was to evaluate the efficacy of the XP-Endo finisher file, sonic and ultrasonic irrigation regimen after biomechanical preparation on the debris and smear layer removal in curved root canals.

2. Materials and Methods

Sixty freshly extracted human mandibular molar teeth with a mesial root angulation of 20 degree according to Scheinder method were used in this study. Teeth were stored in the formalin until use. Access cavity was prepared followed by the mesial and distal root separation using the diamond saw. The specimens were decoronated using the diamond saw under water to achieve a standardized root length of 15mm. The working length was determined by inserting size 10 K file to root canal terminus and subtracting 1mm from this measurement. The mesial root canals were mechanically prepared using the Neo Endo Flex rotary system under the constant irrigation with 3% NaOCL using a 30 gauge side vent needle. Canals were enlarged upto a #30/0.04 using Neo Endo Flex files upto the full working length. Then the root canals were irrigated thoroughly with 10 ml saline solution to prevent any harmful effects of NaOCL solution.[15]

- After biomechanical preparation of the mesial root canals these specimens were randomly divided into four groups of 15 teeth each.
- The groups were as follows;

Group 1 (n = 15): positive control; no final rinse and no additional agitation of the irrigant were performed

Group 2 [n = 15] ; EndoActivator ;17 percent EDTA was agitated with EndoActivator tip [25/0.04] at 10,000 cycles min for 60 sec.

Group 3[n = 15]; Ultrasonic file; 17 percent EDTA was agitated with ultrasonic file tips which advances upto the full working length.

Group 4 [n = 15] ; XP-Endo finisher file ;17 percent EDTA was agitated with XP-Endo finisher file which sets at 800 rpm and advances upto the full working length.

After EDTA agitation group 2 ,3 and 4 were irrigated with 1ml 3 percent NaOCL for 1 minute followed by final rinse with the 5ml sterile saline solution. Root canals were dried with no 30 paper points.[16]

3. Scanning Electron Microscopy Analysis

The diamond disc was used to groove the roots through the buccal and lingual surfaces followed by splitting the roots longitudinally into two halves with chisel and mallet. For each specimen, half which has most visible part of the apex was selected for further analysis followed by discarding of the other half of the apex. Each specimen was grooved by diamond bur from the root apices to 3 levels i.e. coronal, middle and apical third. The specimens were dessicated by varying concentrations of ethyl alcohol[30 -100 %] followed by placing in the dessicator for 24 hrs. Each specimen was the plated with gold and then specimens were assess under a scanning electron microscopy.

The photomicrographs from the apical to coronal third of each roots were taken with 400x for debris and 1000x for smear layer. The photomicrographs were then evaluated by two endodontist who were blind to group status. [17]

The presence of debris was assessed using the following criteria;
Score 1 clean root canal wall with only few small debris particles,
Score 2; few small cluster of debris,
Score 3; cluster of debris covering less than 50 % of the root canal wall, score 4; cluster of debris covering more than 50 % of the root canal wall score 5; complete or nearly complete covered by the debris.

The presence or absence of smear layer was assessed using the following criteria;
Score 1 exposed dentinal tubules with absence of smear layer;
Score 2 small amount of dispersed smear layer with exposed dentinal tubules;
Score 3 thin smear layer with dentinal tubules partially exposed;
Score 4 ; partial covering with a thick smear layer ;
Score 5; total covering with a thick smear layer;

This scoring criteria was relevant to the coronal, middle and apical third of the canals. Before scoring the two examiners assessed the first twenty samples together for calibration purposes. The results were tabulated and submitted to statistical analysis.[18]

4. Statistical Analysis

Comparison between the groups were examined using the Kruskal–Wallis nonparametric analysis of variance and Mann–Whitney U tests. Statistical significance level was set at P <0.05

5. Results

Table 1 shows the mean and standard deviation results of SEM analysis of the root canal walls regarding debris and smear layer scores

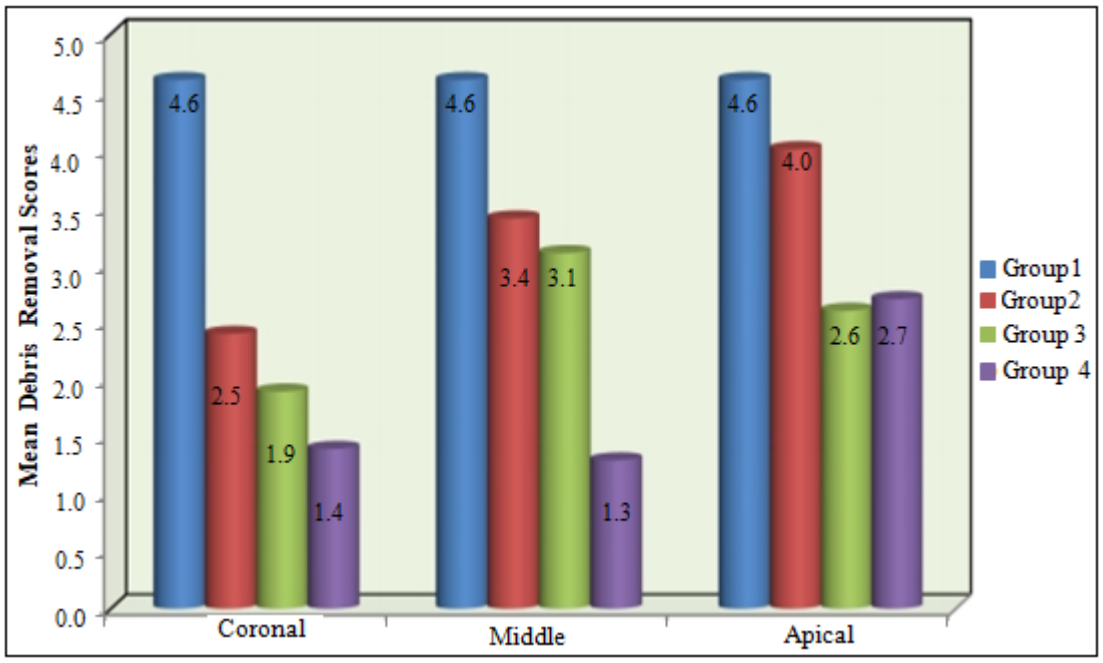
Comparison of mean debris removal scores between 04 groups at different areas of root canal using Kruskal Wallis Test usingKruskalWallisTest							
Areas	Groups	N	Mean	SD	Min	Max	P-Value
Coronal	Group1	10	4.6	0.5	4	5	<0.001*
	Group2	10	2.4	0.5	2	3	
	Group3	10	1.9	0.7	1	3	
	Group4	10	1.4	0.5	1	2	
Middle	Group1	10	4.6	0.5	4	5	<0.001*
	Group2	10	3.4	1.2	2	5	
	Group3	10	3.1	1	2	5	
	Group4	10	1.3	0.5	1	2	
Apical	Group1	10	4.6	0.5	4	5	<0.001*
	Group2	10	4	0.8	3	5	
	Group3	10	2.6	0.5	2	3	
	Group4	10	2.7	1.1	2	5	

*-Statistically Significant

Note: Group1-Control, Group2-Sonic, Group3-Ultrasonic, Group4- XP Endo Finisher

Multiple comparison of mean difference s in debris removal scores between 04 groups in different areas using Mann Whitney post hoc Analysis						
Areas	G1VsG2	G1VsG3	G1VsG4	G2VsG3	G2VsG4	G3VsG4
Coronal	<0.001*	<0.001*	<0.001*	0.11	0.002*	0.11
Middle	0.02*	0.002*	<0.001*	0.56	<0.001*	<0.001*
Apical	0.08	<0.001*	0.001*	0.001*	0.009*	0.74

Comparison of mean debris removal scores between 04 groups at different areas of root canal



Comparison of mean smear layer removal scores between 4 groups at different areas of canal using KruskalWallisTest

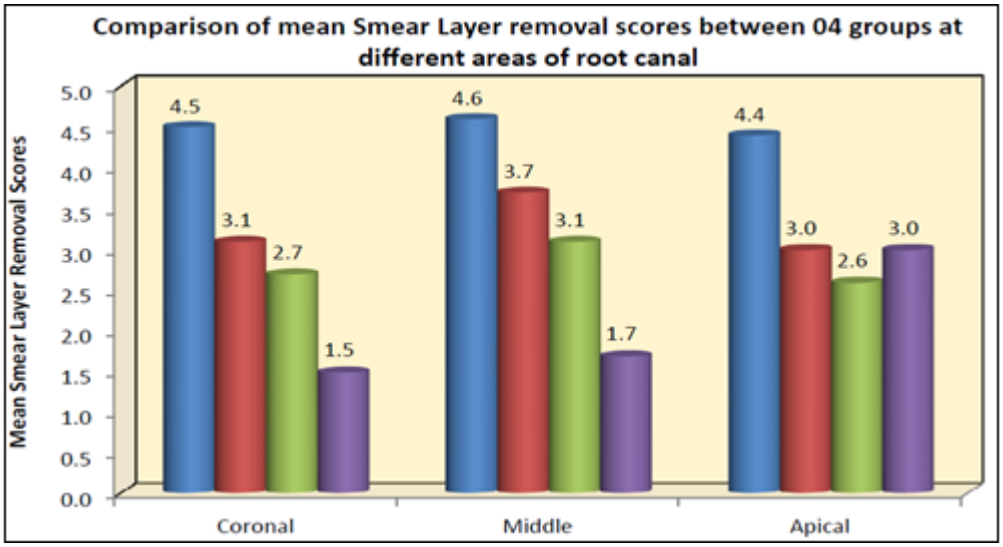
Areas	Groups	N	Mean	SD	Min	Max	P-Value
Coronal	Group1	10	4.5	0.5	4	5	<0.001*
	Group2	10	3.1	0.9	2	4	
	Group3	10	2.7	0.7	2	4	
	Group4	10	1.5	0.5	1	2	
Middle	Group1	10	4.6	0.5	4	5	<0.001*
	Group2	10	3.7	0.9	2	5	
	Group3	10	3.1	0.9	2	5	
	Group4	10	1.7	0.8	1	3	
Apical	Group1	10	4.4	0.7	3	5	0.002*
	Group2	10	3.0	0.8	2	4	
	Group3	10	2.6	0.5	2	3	
	Group4	10	3.0	1.2	2	5	

*-Statistically Significant

Note: Group1-Control,Group2-Sonic,Group3-Ultrasonic,Group4-XPEndoFinisher

Multiple comparison of mean differences in debris removal scores between 04 Groups in different areas using Mann Whitney posthoc Analysis

Areas	G1VsG2	G1VsG3	G1VsG4	G2VsG3	G2VsG4	G3VsG4
Coronal	0.001*	<0.001*	<0.001*	0.28	0.001*	0.001*
Middle	0.02*	0.001*	<0.001*	0.13	0.001*	0.003*
Apical	0.002*	<0.001*	0.02*	0.25	0.75	0.74



The test results demonstrated stastistically significant difference in the mean debris and smear layer removal scores between 04 groups at different areas of root canal at P<0.001.

The XP –Endo Finisher revealed significantly debris and smear layer removal as compared to other groups at coronal, middle regions except at apical regions where there is no significant difference between XP-Endo finisher and Ultrasonic group [P=0.11]

Endoactivator shows relatively higher mean debris and smear layer score as compared to XP-Endo Finisher and Ultrasonic at all three levels[P<0.001]

A comparison between root canal regions shows apical regions has higher debris and smear layer scores compared to coronal regions except positive control group which shows no significant difference between the three regions of the root canal [P<0.001]

Figure 1 shows representative photomicrographs of smear layer of each group at the coronal, middle, and apical regions.

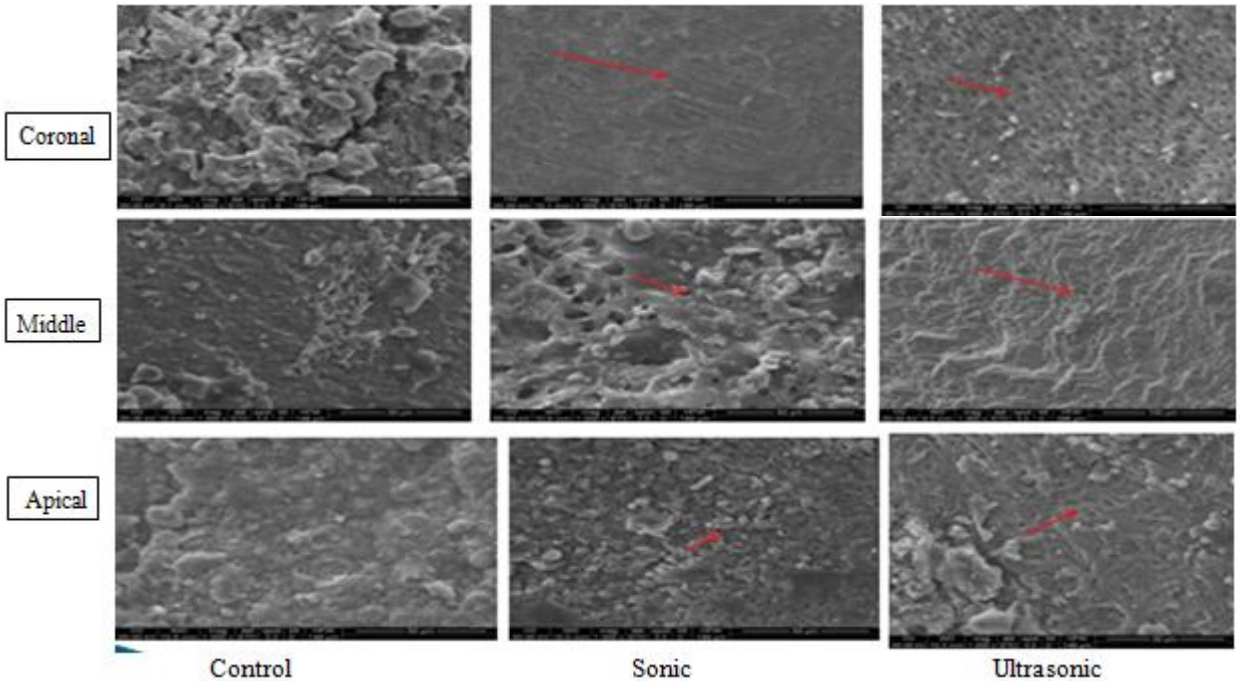


Figure 1: SEM micrograph images showing the smear layer [1000X] at coronal, middle, apical third in each group

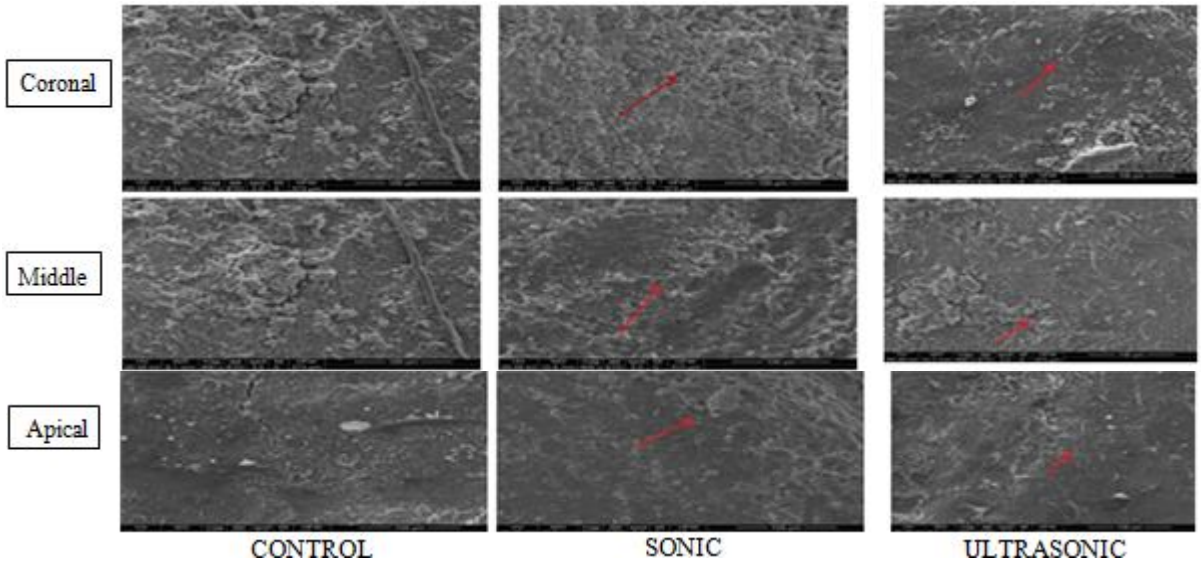
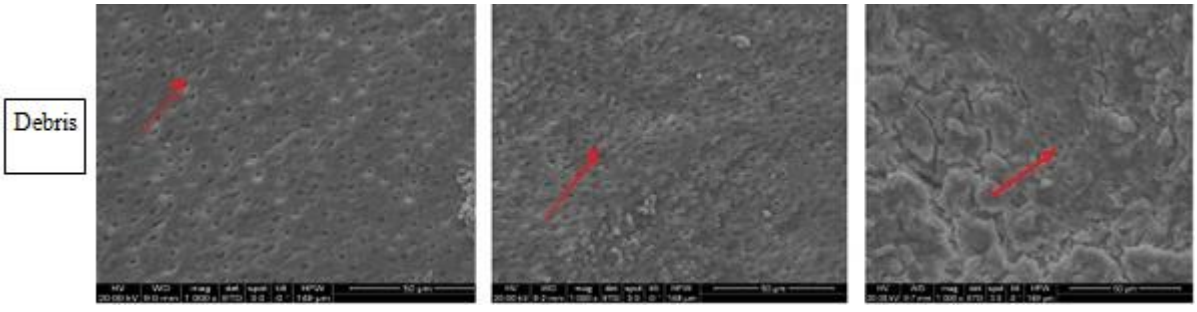


Figure 2: SEM micrograph images showing the debris layer [400X] at coronal,middle ,apical third in each group



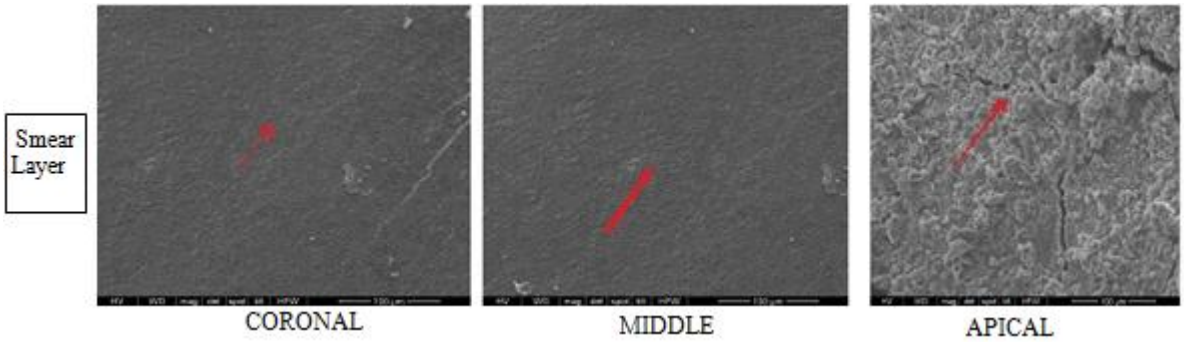


Figure 3: SEM Micrograph showing the debris and smear layer at coronal, middle and apical third of XP- Endo Finisher

Parameter Groups -Debris and Mean layer Score for the tested groups

	Positive Control	Sonic	Ultrasonic	XP-Endo Finisher
Debris Scores				
Coronal	5	3	1	1
Middle	5	4	3	2
Apical	5	4	2	2
Smear layer Scores				
Coronal	5	3	2	1
Middle	5	4	3	3
Apical	5	4	3	3

6. Discussion

Main aim of root canal treatment is to debride the canal by getting rid of microbes which will otherwise cause infection and hinders the apical healing[19]. To accomplish this, through the mechanical instrumentation root canals are cleaned by the help of various irrigating solutions.[20] Mechanical instrumentation of root canals produces a smear layer which will adversely affects the root canal seal and hinders the diffusion of sealers into the dentinal tubules[21].Thus the debridement of the canal by removing the smear layer at every aspect of canal is of major concern and challenge of this study.

The effectiveness of syringe irrigation in disinfecting the root canal has defused the success of endodontic treatment because of the difficulty in completely eliminating the remaining debris and smear layer especially in the apical third of the curved root canal due to its small size thus baffles the action of irrigating solutions [22,23] . Thus the main aim of this study is to compare the effectiveness of XP-Endo finisher with other irrigation regimens in removing the debris and smear layer by using SEM after biomechanical preparation.

Most commonly used irrigant is NaOCL due to its antibactericidal property thus helps in rendering canals free of debris and smear layer[24] In addition to NaOCL, the use of EDTA and chelating agent has also been commended to get rid of the smear layer[25] . The efficacy of EDTA in removing the smear layer at varying concentrations has proved to be effective in various studies in comparison to other irrigating solutions and it has shown the substantial amount of debris and smear layer removal in this study irrespective of the technique used[26]

XP –Endo Finisher and Ultrasonic groups are more effective in removing debris and smear layer than other groups. The finding in this study is attributed to the shape memory principle of NiTi alloy. In martenistic phase file is straight which is formed when it is cooled but when it comes in contact with the canal , it will convert to its sickle shape due to its shape memory principle to austenitic phase. This sickle shape allows to access and clean the areas with all variations of morphologies in the canal[13]

According to some studies ultrasonic irrigation is effective in removing debris and smear layer because of the phenomenon of acoustic streaming and cavitation. The acoustic stream can be defined as a rapid movement of the fluid in circular shape around the vibrating file. Cavitation is defined as the creation of stream bubbles or expansion, contraction of preexisting bubbles in a liquid[27]

Endoactivator group is more effective in removing debris and smear layer as compared to positive control group because of its polymer based tips that do not cause any damage to the canal wall. [28]

Except for the positive control groups, irrespective of the irrigation regimens used,coronal thirds were significantly cleaner than apical one-third due to the larger diameter in these areas thus helps in penetration of higher volume of irrigants to the dentin ,thus helps in effectively cleaning the debris and smear layer[29,30].

It has been reported that for the removal of smear layer root canal should be prepared to the apical diameter of minimum .30 mm thus last file used for the preparation of root canal was Neo Endo Flex #30/0.04[31]

7. Conclusion

Within the limitations of this study it can be concluded that irrigation of curved root canals using XP-Endo Finisher and Ultrasonic methods seems to be more effective in the removal of debris and smear layer as compared to other groups. Root canal at the coronal third region was significantly cleaner than apical root canal region. None of the irrigation regimens which were assessed in this study will completely remove the debris and smear layer.

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