The Effect Of Final Irrigation Materials And Techniques On The Cleanliness Of The Smear Layer In The Apical Third Of The Root Canal

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ABSTRACT

Background: *17% EDTA is a chelating agent used to clean the smear layer. NSC is a new material with the same use, while 0.2% chitosan nanoparticles are a material that has been widely studied. The agitation technique is another factor that also influences the cleanliness of the smear layer. Sonic and ultrasonic agitation techniques has its own advantages and disadvantages. The research objective is to evaluate the effect of final irrigation materials, agitation techniques, and a combination of both on the cleanliness of the smear layer in the apical third of the root canal.*
Method: *45 premolars were prepared then randomly divided into 3 experimental groups (n=15). Group 1 using 17% EDTA irrigation material, group 2 using Novel Silver Citrate, and group 3 using 0.2% nanoparticle chitosan. Each group was divided into three subgroups (n=5) with subgroup A using manual agitation technique, subgroup B sonic agitation, and subgroup C ultrasonic agitation. The samples were sectioned and then examined under SEM with 5000x magnification to evaluate the cleanliness of the smear layer in the apical third of the root canal. The results from SEM were scored and then analyzed using the Chi-Square test*
Result: *Chi-Square test showed no significant differences in materials, techniques, and material-technique interactions in cleanliness of the smear layer in the apical third of the root canal (p>0,05).*
Conclusion: *This study concluded that the final irrigation material combined with agitation techniques resulted in the same cleanliness of the smear layer in the apical third of the root canal*

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INTRODUCTION

Smear layeris a layer of debris with a thickness of approximately 5-10 µm which, when viewed with a Scanning Electron Microscope (SEM), appears as an amorphous irregular layer, which is composed of organic and inorganic components, such as necrotic tissue, dentin, remaining pulp tissue, residual odontoblasts, and microorganisms.[1] The presence of a smear layer can cause contamination with microorganisms because the smear layer can become a substrate for bacteria to survive and grow, so that reinfection can occur. The smear layer can also hinder the adaptation of medicaments and obturation materials, as well as adhesion to the penetration of the sealer material into the dentin tubules because it is blocked by the smear layer. This can then be the cause of leaks both in the coronal and apical parts.[2]

Ethylenediaminetetraacetic Acid is an irrigation material which has properties as a chelating agent which functions to dissolve the inorganic part of the smear layer and is the gold standard used as a final irrigation material and functions to remove the smear layer. EDTA 17% has the disadvantage of having no or minimal antibacterial effect.[3] Another irrigation material wich has chelating effect is chitosan nanopartikel 0,2%. Chitosan has antimicrobial, biocompatible, non-toxic, biodegradable properties and has potential as an irrigation material.[4] Use of chitosan with a concentration of 0.2% for 3 minutes is efficient for removing the smear layer with minimal erosion effects, so that 0.2% chitosan can be an alternative to replace EDTA 17% and has almost the same effectiveness.[5]

In the other hand there are Novel silver citrateis one of the new irrigation materials on the market today. The composition of the novel citrate consists of silver ions produced by electrolysis (0.003%) in citric acid (4.846%). A novel silver citrate solution (BioAKT endo, New tech solution, Bresica) has been tested as an innovative biomaterial that can be used as a root canal irrigation material. The advantage of this irrigation material is due to the presence of a silver compound which has antibacterial properties which has long been used as a medical disinfection agent[6], while the citric acid contained in this solution is a weak organic acid with chelating properties that can be comparable to the chelating properties of has a 17% EDTA solution which is the gold standard used for final irrigation materials.[7]

Such irrigation measures must be carried out during and after instrumentation aimed at removing residual dentin tissue and microorganisms from the root canal. However, no single irrigation material can meet all these criteria, even with the use of methods such as lowering the pH, increasing the temperature, and even adding surfactants to increase the wetting effectiveness of the irrigation material. It is important to know that the irrigation material must be in direct contact with the entire surface of the root canal in order to act effectively, especially the apical third. Proper irrigation techniques aim to bring the irrigation material to the maximum within the working length. An irrigation material carrier system must have adequate flow and volume for the working length to effectively clean the root canal system without forcing fluid out into the periradicular tissue.[8]

Ultrasonic agitation is very effective in cleaning the smear layer even down to the apical third. Nurisawati et al.[9] researched that without dynamic agitation it was also possible to clean the apical third of the root canal well, even better than the semi-negative pressure agitation technique. Ultrasonic agitation technique is more effective in cleaning the smear layer than conventional agitation techniques and even negative pressure agitation techniques. On the other hand, the use of a sonic agitation tool is more recommended considering that the tip on the ultrasonic endoactivator uses metal which, even though it is non-cutting, can still cause deformity in the root canal walls.[10] Research from Khare et al.[11] stated that both methods have quite good smear

layer cleaning power in the lateral canal, where the push-pull movement of the technique without dynamic agitation tends to cause hydrodynamic flow in the root canal, compared to the ultrasonic agitation technique which produces acoustic flow and cavitation in the root canal. root canals, both of which have been proven to be effective in cleaning root canals.

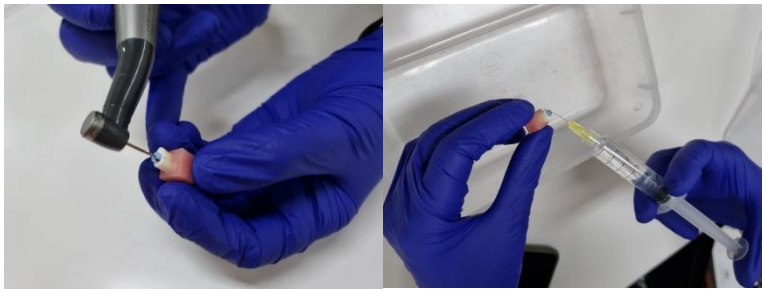
The apical third area is an area that is difficult to clean during preparation because the anatomy of this area is usually narrower than the coronal third area, the shape is curved with quite complex anatomy and root canal branching is often found.[12] Mechanical instrumentation is not sufficient to clean this quite complex anatomy, especially in the apical third of the root canal, therefore mechanical preparation must be supported by irrigation solutions that can clean the smear layer and have chemically active antibacterials.[13]

RESEARCH METHOD

This research is a laboratory experimental research. The sample used is:using fitheen mandibular first premolars with one canal. This research has been approved by the Faculty of Medicine's Dental Research Ethics Committee UGM Teeth (No75/UN1/KEP/FKG-rsgm/ec/2023). The chitosan solution is made from low-melecular sigma-aldrich chitosan which is made into a 0.2% nanoparticle preparation using the cross-linking method.

Forty-five mandibular premolars that met the requirements were confirmed radiographically to prove that the teeth had single, straight root canals. Evaluate with a periapical radiograph from the mesiodistal direction with the distal surface attached to the red wax. The teeth are washed with sterile distilled water and cleaned of debris and remaining tissue, then stored in a closed container containing 10% formalin solution for tooth disinfection for 7 days then transferred to sterile saline so that the teeth do not become dehydrated. Tooth cutting is carried out using a disc diamond bur attached to a low speed handpiece. The tooth was cut coronally leaving a 12 mm long root

Forty-five premolars were then prepared canalsroots with a crown down technique using rotary files (M3 Pro-Gold, United Dental) according to the working length in file order ending with a file measuring 30/.04. Root canal preparation is carried out using rotary files and endomotors sequentially according to the working length. Each set of files is used for 6 root canals. Every time the instrument is changed, the root canal is irrigated with 3 ml of 2.5% NaOCl and 3 ml of saline. The apical foramen of each tooth was covered with soft wax to prevent the irrigation solution from flowing through the apical foramen.



(A) (B)

Figure 1. (A) Root canal preparation of sample (B) Root canal irigation

Teeth thendivided into 3 groups randomly. Group 1 used 17% EDTA irrigation material, group 2 used Novel Silver Citrate, and group 3 used 0.2% chitosan nanoparticles. Each group was divided into three

subgroups (n=5) with subgroup A using manual agitation techniques, subgroup B using sonic agitation, and subgroup C using ultrasonic agitation. The root canal is dried with a paper point and then covered with gutta percha (M3 30/.04) so that root division debris does not enter the root canal when cutting the tooth into two grooves on the buccal and lingual sides of the tooth. It is made using a diamond disc bur without regarding root canals. Each root was split using a chisel. Samples were measured with a sliding caliper and cut at the apical third, namely 4 mm from the apical. The apical third was fixed with buffered formalin for 12 hours and dehydrated using 70%, 80%, 90% ethanol, respectively, for 15 minutes and 100% ethanol for 30 minutes.

(A) (B)

Figure 2. (A) Sonic agitation (B) Ultrasonic agitation

Root pieces were mounted on metal plates and coated with gold to provide electrical conduction on the surface and observed under SEM with a magnification of 5000 times. The cleanliness of the smear layer on the surface of the root canal or in the dentinal tubules was scored using Paul's criteria as shown in Table 1.

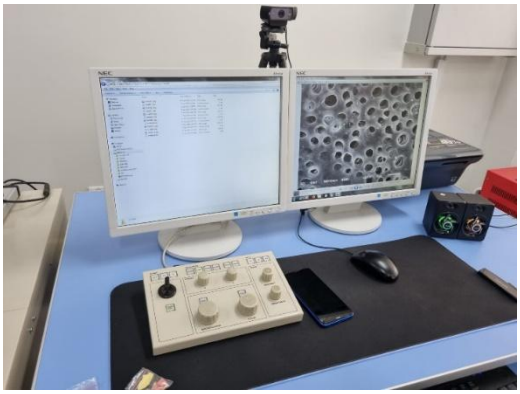


Figure 3. Scanning Electron Microscope Test

Table1. Paul smear layer cleanliness criteria

Score	Information
1	There is no smear layer at all, with clean and open tubules
2	There is minimal smear layer and debris with most tubules clean and open
3	There is a smear layer and debris covering almost the entire surface with some exposed tubules
4	There is a smear layer and debris covering the entire surface

RESULTS

In vitro research regarding the effect of three final irrigation materials, namely the novel silver citrate solution, EDTA solution and 0.2% chitosan nanoparticle solution using three different agitation methods has been carried out and obtained results in the form of SEM images which were then scored to determine the cleanliness of the smear layer on apical third of the tooth root canal.

Specimen measurements were carried out using the smear layer scoring method on the surface of the root canal walls. Observations were carried out by three observers to validate the scoring results. Images from observations using a scanning electron microscope (SEM) with a magnification of 5000X for each group. The following are some SEM results from the research sample

1. Observation of SEM Results

a) Manual-agitation

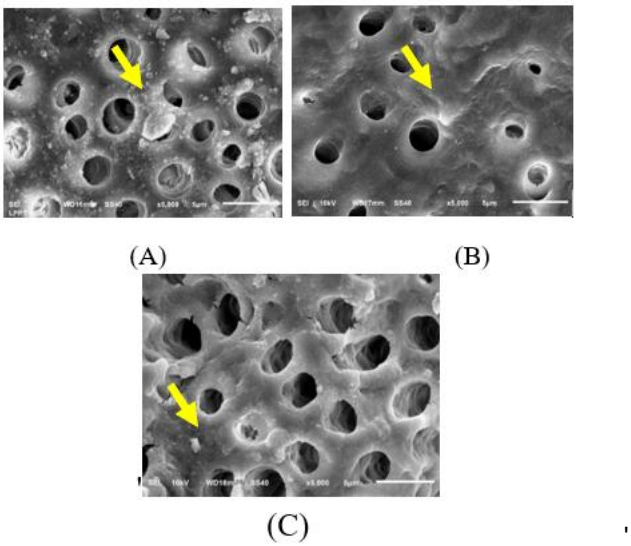


Figure 4. SEM image (magnification 5000X) manual agitation in group (A) EDTA solution shows the dentin tubules are open and there is still have smear layer in the observation area (B) Novel silver citrate solution shows the dentin tubules are partial open and there is still have debris. (C) 0.2% chitosan nanoparticle solution shows an image of open dentin tubules and no smear layer in the observation area.

b) Sonic agitation

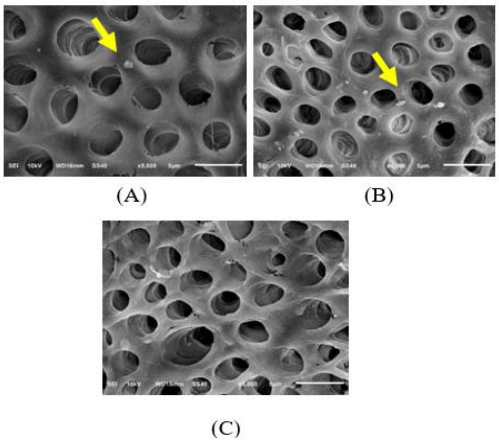


Figure 5. SEM image (magnification 5000X) sonic agitation in group (A) EDTA solution shows the dentin tubules are open and there is still no smear layer in the observation area (B) Novel silver citrate solution shows the dentin tubules are completely open and there is still debris. (C) 0.2% chitosan nanoparticle solution shows an image of open dentin tubules and no smear layer in the observation area.

c) Ultrasonic agitation

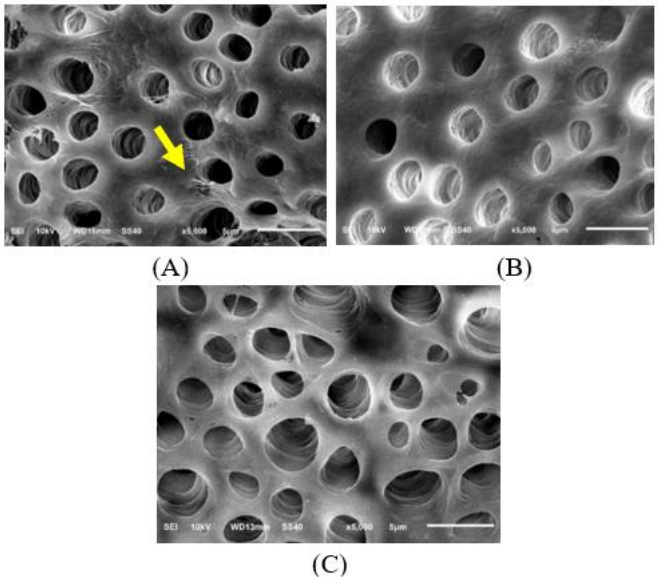


Figure 6. SEM image (magnification 5000X) ultrasonic agitation in group (A) EDTA solution shows the dentin tubules are open and there is no smear layer in the observation area (B) Novel silver citrate solution shows the dentin tubules are completely open and there is no smear layer and debris (C) 0.2% chitosan nanoparticle solution showed an image of open dentin tubules and no smear layer in the observation area.

2. Kappa Test

Before data analysis was carried out, the results of the assessment by three observers were tested to see their consistency using the kappa test.This test resulted in a kappa value of 0.88 so it was included in the very good category.

3. Chi Square Test

The Chi Square test was carried out to determine differences in the use of each material, technique and combination of the two. The following is a table of Chi Square test results including tests on materials (Table 2), techniques (Table 3) and a combination of both (Table 4).

Table2. Chi Square Test Results for EDTA, NSC and Chitosan Nanoparticles 0.2%

			SCORE					p
			1	2	3	4	Total	
MATERIAL	EDTA	Amount	6	7	2	0	15	0.314
		Percentage	25.0%	38.9%	66.7%	0%	33.3%	
	NSC	Amount	7	7	1	0	15	
		Percentage	29.2%	38.9%	33.3%	0%	33.3%	
	Chitosan	Amount	11	4	0	0	15	
		Percentage	45.8%	22.2%	0.0%	0%	33.3%	

The results of the Chi Square test using the three irrigation materials showed that the p value was 0.314 (p> 0.05), so it can be concluded that the differences in materials in this study did not have a significant influence in producing cleanliness scores in the apical third of the root canal.

Table 3. Chi Square Test Results Manual, Sonic and Ultrasonic Agitation Techniques

			SCORE					p
			1	2	3	4	Total	
TECHNIQUE	Manuals	Amount	3	9	3	0	15	0.011
		Percentage	12.5%	50.0%	100.0%	0%	33.3%	
	Sonic	Amount	10	5	0	0	15	
		Percentage	41.7%	27.8%	0.0%	0%	33.3%	
	Ultrasonic	Amount	11	4	0	0	15	
		Percentage	45.8%	22.2%	0.0%	0%	33.3%	

The results of the Chi Square test using the three agitation techniques showed that the p value was 0.011 (p < 0.05) so it can be concluded that the different agitation techniques in this study had a significant influence in producing cleanliness scores in the apical third of the root canal. The Chi Square test results showed that the percentage of samples with a score of 1 (highest cleanliness) was the highest in the ultrasonic agitation technique.

Table 4. Chi Square Test Results Combination of Use of Materials and Agitation Techniques

			SCORE				
			1	2	3	4	Total
INTERACTION	EDTA_Manual	Amount	0	3	2	0	5
		Percentage	0.0%	16.7%	66.7%	0%	11.1%
	EDTA_Sonic	Amount	3	2	0	0	5
		Percentage	12.5%	11.1%	0.0%	0%	11.1%
	EDTA_Ultra	Amount	3	2	0	0	5
		Percentage	12.5%	11.1%	0.0%	0%	11.1%
	NSC_Manual	Amount	0	4	1	0	5
		Percentage	0.0%	22.2%	33.3%	0%	11.1%
	NSC_Sonic	Amount	4	1	0	0	5
		Percentage	16.7%	5.6%	0.0%	0%	11.1%
	NSC_Ultra	Amount	3	2	0	0	5
		Percentage	12.5%	11.1%	0.0%	0%	11.1%
	Chitosan_Manual	Amount	3	2	0	0	5
		Percentage	12.5%	11.1%	0.0%	0%	11.1%
	Chitosan_Sonic	Amount	3	2	0	0	5
		Percentage	12.5%	11.1%	0.0%	0%	11.1%
	Chitosan_Ultra	Amount	5	0	0	0	5
		Percentage	20.8%	0.0%	0.0%	0%	11.1%
p			0.066				

The Chi Square test results obtained a significance value of 0.066 (sig. 0.066 > 0.05) which means that there is no significant difference in the score results in the combination of agitation techniques and the irrigation materials used.

DISCUSSION

Statistical testing shows that atThe combination of using the agitation technique with the irrigation material used did not have a significant difference in producing a clean smear layer in one third of the root canal. Statistical testing on The use of the three agitation techniques shows that different materials have the same effect in cleaning the smear layer in the apical third of the tooth root canal. Statistical testing on the use of different agitation techniques on the three irrigation materials has a significant effect and ultrasonic agitation is the technique that produces the highest cleanliness. This is related to the mechanism by which the three materials used require contact with the root canal surface. Root canal surface contact is influenced by the penetration ability of the irrigant. Chitosan nanoparticles 0.2% have deeper penetration capabilities compared to EDTA and Novel silver Citrate which are subjected to manual agitation[14]

Solubility silver citrate novelto eliminatesmear layer due to the presence of citric acid in this solution. The citric acid in the novel silver citrate is a weak organic acid that can dissolve minerals in root canal dentin so it can be used as a chelating agent[15]. On the other hand, EDTA has a chelation method of action by demineralizing dentin which occurs due to the binding of calcium ions from the tooth structure. EDTA then binds Ca2+ ions from the smear layer and forms a complex salt that is easily soluble.[16] Irrigation techniques can affect the cleanliness of the smear layer, because the irrigation material must be in contact with the entire surface of the root canal so that it can react effectively, especially in the third apical root canal.[8] There a way to maximize the work of irrigation materials in cleaning root canals is to maximize the contact of irrigation materials as much as possible on the root canal system.[17,18]

Chitosan nanoparticles 0.2% are able to remove the smear layer from the dentin surface. The mechanism of action of chitosan nanoparticles in removing the smear layer on the dentin surface is related to the presence of amino groups that bind to metal ions and then chelation occurs on the calcium ions in the dentin, causing the loss of inorganic substances in the smear layer.[5] Mechanism chitosan as a chelation agent is also supported by the hydrophilic properties of chitosan so that it is easily adsorbed by the surface walls of the roots so that interaction occurs between calcium and chelation agents.[19]

Ability of EDTA and Novel silver citrate in smear layer cleaningin root canals in this study was equally good with 0.2% chitosan nanoparticles which were either sonic or ultrasonic agitated. This happens because the use of both sonic and ultrasonic agitation methods can increase the penetration of the irrigation material. These two materials also have less penetration without the agitation method because these two materials have higher viscosity and surface tension. In contrast to chitosan, it has an adsorption mechanism that facilitates better attachment to the root canal walls even without using any agitation techniques.[14,15]

The ultrasonic agitation technique from the results of this research is known to have the highest cleanliness. This happened becauseUltrasonic agitation technique has a higher vibration frequency than the sonic agitation system which then creates higher acoustic and cavitation flows so that the penetration of the irrigation material becomes more adequate so that the irrigation material can contact the dentin surface in the root canal more optimally.[21]

The use of the ultrasonic agitation method is also known to increase the temperature of the irrigation solution in the root canal, where this increase will reduce the viscosity of various irrigation fluids which can then maximize fluid penetration in the root canal. The use of ultrasonic agitation techniques will increase the temperature of the irrigation material in contact with the agitation tip. The intracanal temperature rises from 37º

to 45°C near the tip of the instrument when irrigation is activated ultrasonically for 30 seconds.[22] and thera are a research reported that increasing the temperature of 17% EDTA irrigation material could reduce the viscosity of the liquid.[23] The increase in temperature when using the ultrasonic agitation technique does not cause pathological effects on the periodontal ligament, however, the disadvantage of the ultrasonic agitation technique is that it cuts the dentin at the metal tip. Fragments of these pieces of dentin can be a problem in root canal treatment, resulting in the root canal filling not being hermetic.[16]

CONCLUSION

The final irrigation materials EDTA 17%, Novel Silver Citrate and Chitosan Nanoparticles 0.2% produced the same smear layer cleanliness in the apical third of the root canal. The ultrasonic agitation technique produces a higher smear layer cleanliness compared to the sonic agitation technique and manual agitation in the apical third of the root canal. The combination of the use of final irrigation material and the agitation technique produces the same smear layer cleanliness in the apical third of the root canal.

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