Original Article

Comparison of the Efficacy of CanalBrush, EndoActivator, and Passive Ultrasonic Irrigation on the Removal of Triple Antibiotic Paste from Root Canal Walls: An *In Vitro* Study

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ABSTRACT

Aim: The aim of this study was to compare the efficacy of CanalBrush (CB), EndoActivator (EA), and Passive Ultrasonic Irrigation (PUI) on the removal of triple antibiotic paste (TAP) from root canal walls. **Materials and Methods:** Thirty-six extracted human single-rooted teeth were prepared using ProTaper Universal rotary files (DentsplyMaillefer, Ballaigues, Switzerland) up to size F5. The root canals were filled with TAP, and after 21 days, roots were randomly assigned to three groups (n = 10) according to irrigation regimens used: CB, EA, and PUI. In three teeth, TAP was not removed (positive controls), and the other three teeth were not filled with TAP (negative controls). The roots were sectioned, and the amount of TAP remaining was evaluated at the mesial halves of each tooth at ×30 magnification under a stereomicroscope using a 4-grade scoring system. Data were evaluated using the Kruskal–Wallis and Mann–Whitney U tests. **Results:** There were significant differences among the experimental groups according to the different parts of the root canals ($P < 0.05$). At the apical and middle third, EA and PUI groups removed more TAP than CB group; however, there was a statistically significant difference only between CB and PUI groups (<0.01 at apical third and <0.05 at middle third). At the coronal third, there was no statistically significant difference between all the three groups ($P > 0.05$). **Conclusion:** PUI led to superior results compared to CB in the middle and apical thirds. There was no significant difference between EA and PUI techniques.

KEYWORDS: *CanalBrush, EndoActivator, ultrasonic irrigation*

INTRODUCTION

The root canal treatment involves the generation of an environment free of bacteria in the root canal space. This can be accomplished by chemo-mechanical preparation of the canal using various instruments and irrigating solutions.[1] Although it leads to decrease in bacterial count, it does not completely eliminate them from the root canal system.[2] The polymicrobial nature of root canal infection advocates the use of intracanal medicaments in the reduction of bacterial population. Calcium hydroxide (CH) is the most common intracanal medicament that has high alkalinity.[3] This high pH of CH changes the biologic properties of the lipopolysaccharide component in the cell wall of gram-negative species and inactivates the mechanisms of membrane transportation, which leads to bacterial cell death.[3] However, it is suggested that effect of CH is questionable due to various factors such as increased bacterial adhesion to dentin, buffering capacity of

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dentine, presence of biofilm, and necrotic tissue. Also, it is said to reduce the flexural strength of dentin.[4] Considering these shortcomings, finding an alternative intracanal medicament would be beneficial.

One of the most potent intracanal medicaments is a mixture of metronidazole, ciprofloxacin, and minocycline—the triple antibiotic paste (TAP) described by Hoshino *et al.*[5] Several studies have shown that TAP when applied to root canal walls leads to its efficient sterilization. Its antimicrobial and biocompatible properties create suitable environment for tissue revascularization.[6] TAP has also shown successful results when treatment with CH dressing failed to eliminate symptoms.[7] An *in vitro* study showed that compared to CH, the TAP is highly effective against *Enterococcus faecalis*.[8] These reports show the popularity of TAP as an intracanal medicament and in regenerative endodontic procedures.

Regenerative endodontic procedure includes disinfection of root canal space with TAP medicament, followed by its removal, and followed by placement of mineral trioxide aggregate. However, it has been proclaimed that TAP has a lethal effect on the stem cells derived from the apical papilla.[9] Also, it has been said to have an effect on sealer penetration and tooth discoloration.[10] Thus, this paste should be completely cleared away from the root canal walls to suppress its effects.

Conventionally, syringe irrigation with sodium hypochlorite solution has been used to remove TAP.[9,10] However, this does not lead to thorough cleaning of complex root canal anatomy. Devices for irrigation delivery to increase the flow and distribution have recently been recommended.

The CanalBrush (CB) (Roeko Canal Brush, Coltène/Whaledent, Langenau, Germany) is a highly flexible endodontic microbrush, which is molded entirely from polypropylene. It is used manually with a rotary action.[11]

The EA system (Dentsply, Tulsa, Oklahoma) is a cordless, battery-powered, sonically driven irrigant activation system. It is designed to produce vigorous agitation of intracanal solutions.[12]

Passive Ultrasonic Irrigation (PUI) (Acteon Group Ltd, Merignac, France) uses a stainless steel file to agitate the irrigating solution previously placed inside the canal. It is gently moved inside out not touching the canal walls.[13]

Background and Objectives

The objective of the study was to compare the efficacy of CB, EA, and PUI on the removal of TAP from root canal walls.

The null hypotheses were that the removal of TAP was not affected by the using the following:

Irrigation technique
Different parts of the root canal system.

Materials and Methods

Setting and design

Specimen preparation

Thirty-six single-rooted, non-carious human teeth with similar sizes and completed apices were selected. The sample size was calculated online using Raosoft software. Soft tissues and calculus were mechanically removed from the root surface with a periodontal scaler. Buccolingual and mesiodistal radiographs were taken to confirm the presence of a single canal, an intact apex and no signs of internal or external resorption. The teeth were stored in 4°C distilled water until use. The teeth were decorated 12 mm from the apex to standardize the root length using a diamond disk under water coolant.

The root canals were shaped with ProTaper Universal rotary files (DentsplyMaillefer, Ballaigues, Switzerland) up to F5 with 2 mL of 3% sodium hypochlorite (NaOCl) between each file. Prepared canals were irrigated with 5-mL NaOCl, followed by 5 mL of 17% EDTA to remove the smear layer. The canals were then dried with paper points (DentsplyMaillefer).

TAP was prepared by mixing equal proportions (1 g) of metronidazole, ciprofloxacin, and minocycline (Research-Lab Fine Chem Industries, Mumbai, India) with distilled water (1 mL) (powder:liquid ratio of 3:1) on a glass slab with a stainless steel spatula [Figure 1]. A Lentulo spiral was used to carry and spread the medicament in the canal space until it was in view at the apical foramen. The openings of the root canals were sealed momentarily with a cotton pellet and Cavit (ESPE, Seefeld, Germany). The teeth were stored in an incubator at 37°C with 100% humidity for 21 days.

Figure 1: Preparation of triple antibiotic paste

Experimental procedure

The specimens were split into three experimental groups (n = 10) and positive and negative control groups (n = 3) using a simple random sampling method. A lottery approach was made in which each specimen in the sample was numbered from 1 to 36 in a consequent manner. These specimens were mixed in a bowl and were randomly chosen to be divided into the experimental and control groups. This allocation and implementation of the randomization was carried out by an individual who was unaware of the groups and was not related to the field of dentistry. In the positive control group, no irrigation protocol was followed. In the negative control group, root canals were not filled with TAP.

Group 1: CB [Figure 2A]: A CB with a tip diameter of 0.30 mm in a handpiece set at 600 rpm was placed 1 mm from the working length. 10 mL of 3% NaOCl was agitated for 1 min in a gentle up and down motion.

Group 2: EndoActivator (EA) [Figure 2B]: An EA handpiece with a red (25/04) tip set at 10,000 cycles per minute was inserted 1 mm from the working length. 10 mL of 3% NaOCl was infused into the canal and agitated for 1 min.

Group 3: PUI [Figure 2C]: A size 15K, 0.02 taper ultrasonic file was connected to an adaptor of a Satelec P5 Newtron XS ultrasonic system handpiece (Acteon Group, Merignac, France) at power setting 6 and was inserted 1 mm deficient of working length without

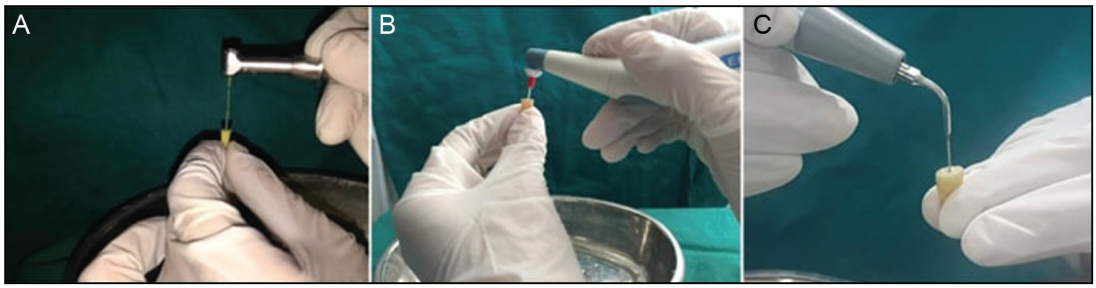


Figure 2: Irrigation techniques for removal of triple antibiotic paste

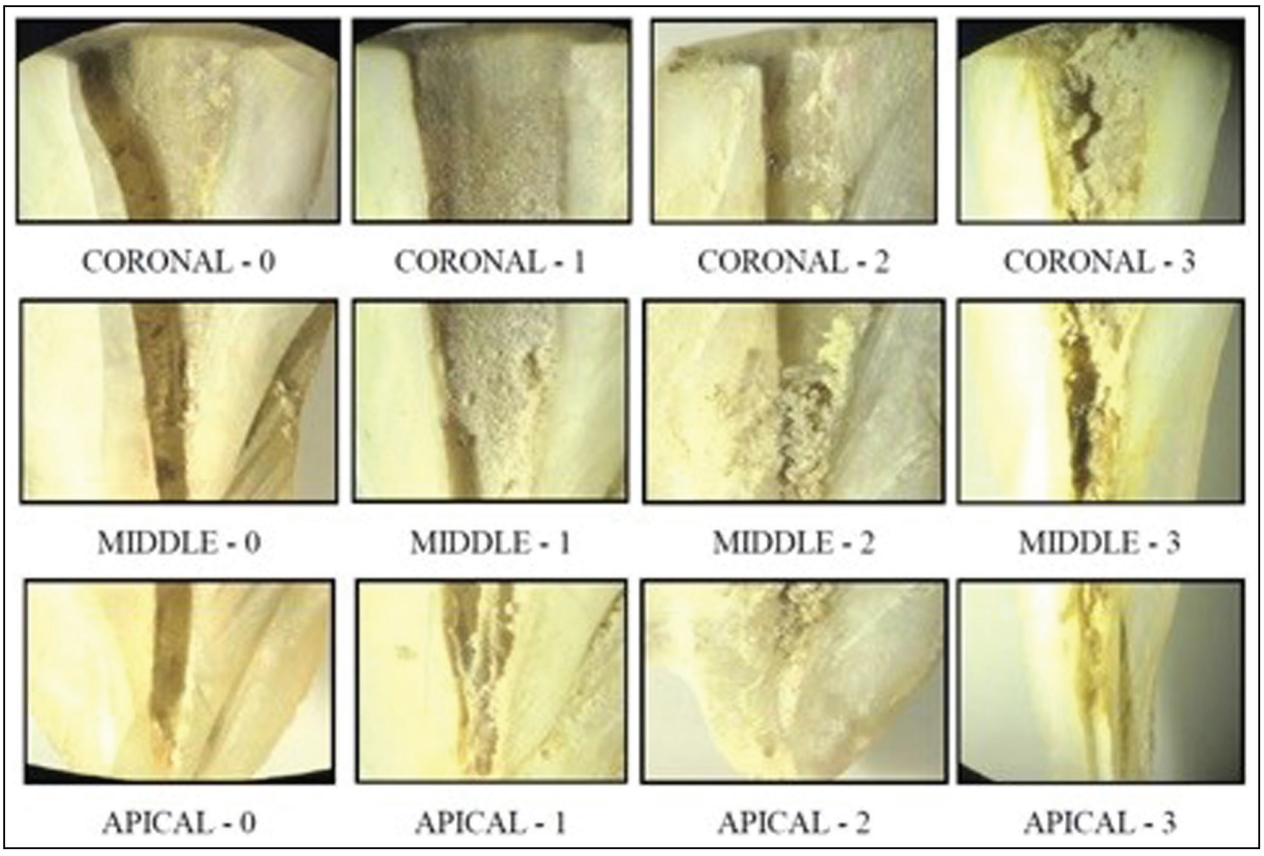


Figure 3: Representative images of score for triple antibiotic paste

brushing the walls, enabling it to vibrate freely. 10 mL of 3% NaOCl was passively agitated for 1 min.

After the final irrigation, 5-mL distilled water was used to flush away remaining NaOCl from the root canals which were then dried with paper points. Two longitudinal grooves were prepared on the buccal and lingual surfaces of each root using a fine diamond disc, avoiding penetration into root canal. The two halves of the root were separated using a hammer and chisel. Thus, 20 specimens were obtained from each group.

Outcomes

Determination of the remaining triple antibiotic paste

The amount of TAP remaining was evaluated at mesial halves of each root (n = 10). The distal halves were discarded. Images of the coronal (8–12 mm from apex), middle (4–8 mm from apex), and apical (0–4 mm from apex) thirds of root canal surfaces were acquired using a digital camera mounted on a stereomicroscope (Zeiss Stemi 2000-C, Carl Zeiss MicroImaging, Göttingen, Germany) at ×30 magnification and transferred to the computer. The remaining medicament at each third of root canal was evaluated by two registered endodontists in a blind manner using a four-grade scoring system described by van der Sluis *et al.*[14] as follows [Figure 3]:

Score 0: The canal was empty
Score 1: TAP was present in less than half of the canal
Score 2: TAP covered more than half of the canal
Score 3: The canal was completely filled with TAP

Statistical analysis

The κ test was used to analyze interexaminer agreement. Statistical analysis was performed with the Kruskal–Wallis and Mann–Whitney U tests using Statistical Package for the Social Sciences (SPSS) software program (IBM SPSS, Chicago, Illinois). The level of statistical significance was set at 95% confidence ($P < 0.05$).

Results

The κ test showed that the interexaminer agreement was 92.7%. The positive control group showed that the canal walls were completely filled with TAP. The negative control group showed no TAP on the root canal walls. The score allotted to the amount of TAP removed at different parts of root canal system is shown in Tables 1 and 2. There were significant differences among the experimental groups according to the different parts of the root canals ($P < 0.05$) [Table 3].

At the apical third

There was a highly significant difference between CB and PUI groups ($P < 0.01$). In EA group, better results were obtained than CB group, but it was not statistically significant. Also, in PUI group better results were obtained than EA group, but it was not statistically significant.

At the middle third

There was a significant difference between CB and PUI group ($P < 0.05$). In EA group, better results were obtained than CB group, but it was not statistically significant. Also, in PUI group better results were

Table 1: Distribution of the triple antibiotic paste removal scores at different parts of the root canals (n = 10)

Scores		0	1	2	3	Median
Canalbrush	Apical	1	3	4	2	2
	Middle	2	5	3	0	1
	Coronal	5	5	0	0	0.5
Endoactivator	Apical	3	5	2	0	1
	Middle	5	5	0	0	0.5
	Coronal	7	3	0	0	0
Passive ultrasonic irrigation	Apical	5	5	0	0	0.5
	Middle	7	3	0	0	0
	Coronal	8	2	0	0	0

Table 2: Mean with standard deviation values for the removal of triple antibiotic paste

	Canalbrush	Endoactivator	Passive ultrasonic irrigation
Coronal	0.5 ± 0.52	0.3 ± 0.48	0.2 ± 0.42
Middle	1.1± 0.73	0.5 ± 0.52	0.3 ± 0.48
Apical	1.7 ± 0.9	0.9 ± 0.73	0.5 ± 0.52

Table 3: Kruskal–Wallis test ($P < 0.05$)

Third	CB vs EA			CB vs PUI			EA vs PUI		
	MRD	P Value		MRD	P Value		MRD	P Value	
Apical	6.800	>0.05	NS	10.900	<0.01	**	4.100	>0.05	NS
Middle	6.450	>0.05	NS	9.150	<0.05	*	2.700	>0.05	NS
Coronal	3.000	>0.05	NS	4.500	>0.05	NS	1.500	>0.05	NS
Overall	14.833	<0.05	*	22.917	<0.001	***	8.083	>0.05	NS

MRD: Mean Rank Difference

NS: Not Significant

*: Significant

**: Highly Significant

***: Very Highly Significant

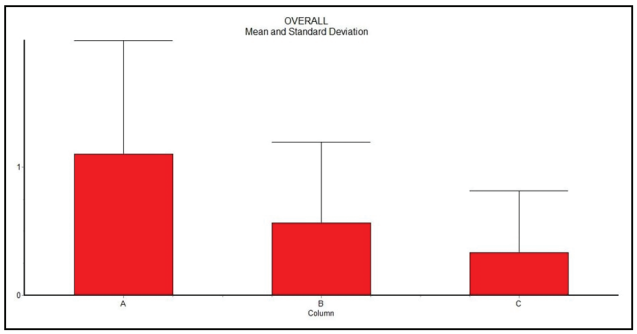
obtained than EA group, but it was not statistically significant.

At the coronal third

There was no significant difference between all three groups ($P > 0.05$).

Overall comparison of each group

There was a very highly significant difference between CB and PUI group ($P < 0.001$) and a significant difference between CB and EA group ($P < 0.05$). However, no significant difference was found between EA and PUI group [Graph 1].



Graph 1: Overall comparison between each group

Discussion

Remnants of intracranial medicaments left on the dentinal walls could reduce the sealing ability of the root canal sealers.[15] The amount of residue left can be evaluated using various methods such as digital photographs, stereomicroscope, scanning electron microscope, micro-computed tomographic imaging, and spiral computed tomographic imaging.[16] In this study, a stereomicroscope was used at ×30 magnification, and the remnants were evaluated using a 4-grade scoring system similar to that used in previous study.[14] Based on the results, the amount of TAP removed was significantly affected by both the irrigation techniques used and the different parts of the root canal system. Thus, both the null hypotheses were rejected.

Microorganisms play a significant role in the development of pulpoperiapical lesions. Various instrumentation techniques, irrigation protocols, and intracanal medicaments have been used to reduce the bacterial count. Due to the polymicrobial nature of the infection, different antibiotic combinations have been used to treat the diverse flora. A mixture of metronidazole, ciprofloxacin, and minocycline appears to be promising. Metronidazole is of nitroimidazole group. It has a broad spectrum of activity against protozoa and is toxic to anaerobic bacteria. Ciprofloxacin is a synthetic fluoroquinolone having bactericidal activity.[17] In addition, metronidazole and ciprofloxacin can generate fibroblasts.[18] Minocycline is a tetracycline derivative, which inhibits collagenases and matrix metalloproteinases[19] and increases the level of interleukin-10, an anti-inflammatory cytokine.[20]

In previous studies, TAP has been used successfully for the treatment of large periapical lesions.[7] TAP has a significant potential to eradicate bacterial biofilm, which is a critical step in regenerative endodontics. When used in low concentrations such as 1, 0.1, or 0.01 mg/mL, it possesses the ability to eradicate *E. faecalis* colonies with no side effect on the viability of the stem cells in the apical papilla. Also, as an intracanal medicament, it has led to an increase in dentin thickness and root length.[21]

TAP has been left in the root canal up to 21 days in the previous studies.[22] To simulate a similar clinical condition, in this study, TAP was left into the root canal up to 21 days. Discoloration due to presence of minocycline in TAP has been reported.[10,23] Minocycline chelates calcium ions to form insoluble complexes that remain in calcifying tissues.[24] This report was confirmed in this study as TAP containing minocycline discolored the root canal walls.

In the apical and middle third, PUI was more effective than CB in removing TAP. PUI relies on an ultrasonically oscillating instrument, which transfers energy to the irrigation solution inside the root canal which results in acoustic streaming or cavitation.[25] This micro streaming causes more dentine debris to be removed from canal walls.[26] Probably the same mechanism is responsible for effective removal of TAP. PUI is said to generate higher velocity of irrigant flow.[27] Reports have shown that fresh irrigant replacement also improves its efficacy.[28] The smaller tip used for PUI allowed free movement in the apical region, with consequent increase in hydrodynamic flow.

It is believed that a brush-covered irrigation needle will aid in removing debris from the root canal because it is flexible and the bristles may extend into the uninstrumented canal irregularities, into fins, cul-de-sacs, and isthmuses and remove the trapped tissue and debris. However, studies have evaluated the effectiveness of CB in removing antibiotic paste from root canal system and found antibiotic remnants to be packed mainly in the apical third of the root canal in nearly all specimens.[29,30] Grischke *et al.*[31] reported from their investigation that PUI is more effective than CB. A similar situation was noticed in this study.

It has been suggested that the use of PUI for 3–5 min with NaOCl concentrations of 3% or 5% is sufficient for the complete removal of the smear layer in instrumented root canals.[32] Wiseman *et al.*[16] found that PUI repeated three times with 20 s intervals was more effective than sonic irrigation. This result could be due to the fact that sonic frequency ranges are much lower than ultrasonic irrigation, and therefore the acoustic microstreaming would be lower, as would be the cleaning efficacy.[33] This study's results were inconsistent with the above findings, may be because a different irrigation duration, and regime was applied.

Conclusion

According to the findings of this study, it can be concluded that the different irrigation protocols significantly influence the removal of TAP from the root canal walls. Within limitations of the study, PUI led to superior results compared to CB in the middle and apical thirds. There was no significant difference between EA and PUI techniques.

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Conflicts of interest

There are no conflicts of interest.

Author contributions

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Ethical policy and institutional review board statement

Not applicable.

Patient declaration of consent

Not applicable.

Data availability statement

Not applicable.

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