

The Effect of Peracetic Acid on Removing Calcium Hydroxide from the Root Canals: A SEM Study

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ABSTRACT

Objectives: Ca(OH)₂ is widely used as an intracanal medicament. Removal of Ca(OH)₂ dressing and the cleanliness of root canal walls before root canal filling are critical and can affect the outcome of the treatment. Aim of this study was to evaluate the efficiencies of Peracetic Acid (PAA) and other irrigating solutions in removal of Ca(OH)₂ from the root canal.

Methods: Twenty four freshly extracted maxillary incisors with straight roots and single canals were prepared with ProTaper system. The canals were filled with Ca(OH)₂ paste. Specimens were randomly divided into 3 experimental groups (n=6). Positive and negative control groups were used. Group 1 used 2.5 ml 17% EDTA, group 2 used 2.5 ml 2.5% NaOCl + 2.5 ml 17% EDTA and group 3 used 2.5 ml 1% PAA. The specimens were evaluated with scanning electron microscope analysis and scored. Kruskal-Wallis and Student Newman-Keuls post hoc tests were used for statistical analysis.

Results: In the apical and coronal thirds, 1% PAA was superior to the other groups (P<.05). In the middle thirds, no significant differences were found among the groups (P>.05).

Conclusion: According to findings of the present study, 1% PAA could be strongly recommended for the removal of Ca(OH)₂ from the root canals.

Keywords: Calcium Hydroxide, SEM Study, Peracetic Acid.

INTRODUCTION

A long standing endodontic infection allows bacteria to propagate the entire root canal system including the ramifications, isthmuses, apical deltas and dentinal tubules. In these locations, bacteria may remain present even after complete chemo-mechanical preparation of the root canal^(1,2). These remaining bacteria grow and multiply inside the

root canal system if no intracanal dressing is used between the appointments. Thus intracanal medications are a valuable adjunct to chemo-mechanical preparation in the disinfection of the root canal system, reducing the endodontic microbiota and therefore favouring periapical tissue repair⁽³⁾. Because of its antimicrobial potential⁽⁴⁾, organic tissue dissolution capability⁽⁵⁾, and anti-inflammatory effects⁽⁶⁾, calcium hydroxide

Received: Sept. 12, 2022; Accepted: Nov. 28, 2022

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(Ca(OH)₂) has been widely chosen as an intracanal medicament. It is used with mainly 3 types of vehicles: (1) Water-soluble substances like water, saline, local anaesthetic agent, and ringers solutions; (2) Viscous vehicles like glycerin, polyethylene glycol, and propylene glycol; and (3) Oil-based vehicles like olive oil, silicone oil, camphor, eugenol, metacresylate, etc⁽⁷⁾.

It has been reported that residual Ca(OH)₂ on the root canal walls influences the dentinal bond strength⁽⁸⁾ and the penetration of sealers into the dentinal tubules^(9,10). It is also suggested that the remnants could react chemically with the sealer to adversely affect its desired properties⁽¹¹⁾. Therefore, removal of the Ca(OH)₂ dressing and the cleanliness of the root canal walls before the root canal filling are critical and could affect the outcome of treatment⁽¹²⁾.

Peracetic acid (PAA) solutions have been used in the former German Democratic Republic as an endodontic irrigant⁽¹³⁾. However, with time, their potential usefulness in endodontics has somehow been forgotten. PAA is not inactivated in the presence of organic material⁽¹⁴⁾, does not leave residues, and does not produce byproducts harmful to the environment⁽¹⁵⁾. PAA has antibacterial, sporicidal, antifungal, and antiviral effects⁽¹⁶⁾. PAA has been used for the elimination of biofilm formation in different areas⁽¹⁷⁾. The acetic acid content is suggested to be responsible for the inorganic material dissolution. Acetic acid also bonds to calcium to form complexes that are easily soluble in water⁽¹⁸⁾. It has been shown that 2.25% PAA solution is comparable with 17% EDTA at removing the smear layer⁽¹⁵⁾. However, 2.25% PAA is reported to be relatively caustic when it is in contact with oral mucosa and is therefore recommended for use in lower concentrations^(18,13).

The aim of this study was to evaluate the efficiencies of PAA, EDTA and EDTA + NaOCl solutions in the removal of Ca(OH)₂ from root canals.

MATERIALS AND METHOD

Twenty-four freshly extracted human maxillary central incisor teeth with straight roots and single canals were used in this study. After extraction, the teeth were scaled with ultrasonic

instruments, washed with distilled water, and immersed in 10% formalin solution until required. The crowns of the teeth were removed, and the roots were adjusted to 12 mm to standardize the length of the roots. The working length was established 1 mm short of the apical foramen. All canals were prepared by the same operator using the ProTaper NiTi Rotary System (Dentsply Maillefer, Baillagues, Switzerland) up to F5 as the master apical file according to the manufacturer's instructions. Irrigation was performed conventionally with 3 mL 2% NaOCl between each instrument. A final rinse with 5 mL 2% NaOCl, 5 mL 17% EDTA, and 10 mL distilled water was performed.

Root canals were dried with paper points. The canals were filled with Ca(OH)₂ paste (Metapex) using a lentulo spiral. The access cavities were sealed with a temporary filling material (Cavit, 3M ESPE). The teeth were stored for 1 week at 37°C in 100% relative humidity to simulate the clinical situation when Ca(OH)₂ is used as an inter-appointment root canal medicament.

The specimens were randomly divided into the following 3 experimental groups (n = 6) according to the final irrigating solution used for the removal of Ca(OH)₂ residues: (1) group 1: the root canals were flushed using 2.5 mL 17% EDTA with passive irrigation, (2) group 2: the root canals were flushed using 2.5 mL 2.5% NaOCl + 2.5 mL 17% EDTA with passive irrigation, (3) group 3: the root canals were flushed using 2.5 mL 1% PAA with passive irrigation. Six of the specimens were divided into negative and positive control groups. In the negative control group (n = 3), teeth were not filled with Ca(OH)₂. In the positive control group (n = 3), teeth were filled with Ca(OH)₂, but no removal procedure was applied.

The irrigant volume and application length were standardized for all groups. After the removal of the temporary fillings, a size 15# K file was introduced to the working length to loosen the Ca(OH)₂ and to create space for an irrigation needle. The needle tip (30-G [NaviTip; Ultradent, South Jordan, UT]) was placed 1 mm short of the working length without binding⁽¹⁹⁾. Irrigation was performed passively at a 3-mL/min flow rate. After the irrigation procedures, the canals were dried

with absorbent paper points. Grooves were prepared with a water-cooled diamond bur on the

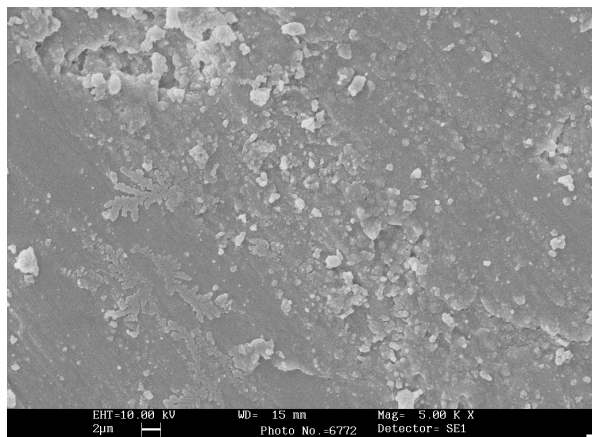


Fig 1: Scanning electron microscope image exhibiting relative absence of residues of Ca(OH)₂ in root canal wall. Dentinal tubules are covered with oil vehicle of used calcium.

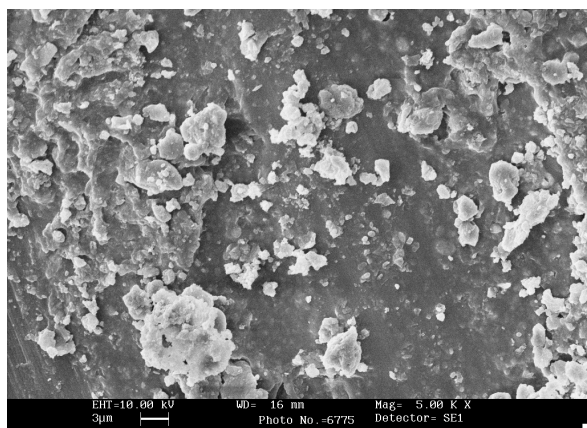


Fig 2: Scanning electron microscope image exhibiting small amount of residue of calcium hydroxide on root canal walls. (5000X).

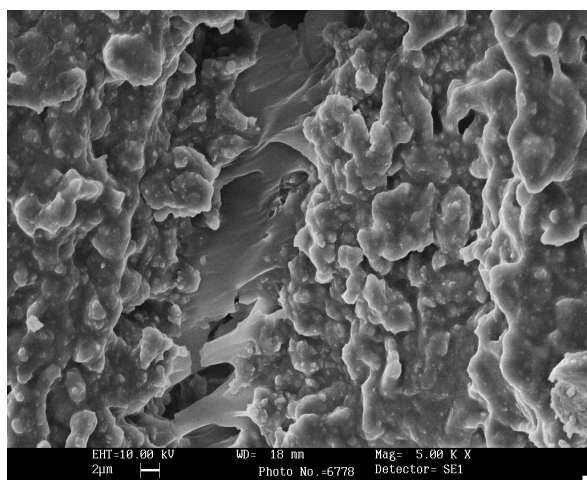


Fig 3: Scanning electron microscope image exhibiting moderate amount of residues of calcium hydroxide on root canal walls. (5000X).

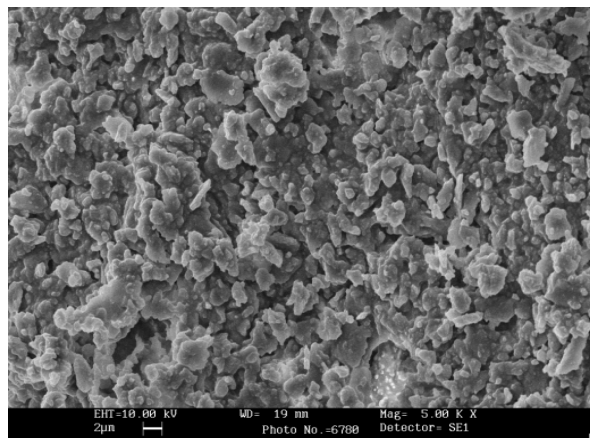


Fig 4: Scanning electron microscope image exhibiting large amount of residues of calcium hydroxide on root canal walls.

buccal and lingual surfaces, and the teeth were split along their long axis in a buccolingual direction using a diamond disk and a straight handpiece.

For scanning electron microscopic analysis, the samples were dehydrated and coated with gold-palladium particles (20 nm), and magnification range of X1,000 to X5,000 was used to evaluate the cleanliness of the canal walls at the apical, middle, and cervical root canal thirds⁽²⁰⁾. A scoring system that was used in the study of Kuga et al⁽²⁰⁾ was defined to assess the quantity of the remnants on the canal walls. The scores used were as follows:

Score 0	Absence of residues
Score 1	Small amount of residues (up to 20% of the surface covered)
Score 2	Moderate amount of residues (20%–60% of the surface covered)
Score 3	Large amount of residues (more than 60% of the surface covered)

A scanning electron microscopic image for each score is shown in Figure 1. After calibration with selected specimens, evaluation was performed in a blind manner. Data were subjected to statistical interpretation using Kruskal-Wallis and Student

Newman-Keuls post hoc tests at a 95% confidence level ($P < .05$).

Table 1: Shows the Effect of PAA in apical third, coronal third and coronal third.

Group	Median	Standard Error	25%- 75%	
Apical				Significant
1% PAA	1	0.307	0-1.25	a
EDTA+NaOCl	2.5	0.477	1.5-3	b
EDTA	2	0.365	1-3	b
Negative Control	0	0.000	0-0	
Positive Control	3	0.000	3-3	
Middle				
1% PAA	1.5	0.224	1-2	Not significant
EDTA+NaOCl	2	0.307	1-2.25	Not significant
EDTA	2	0.307	1-2.25	Not significant
Negative Control	0	0.000	0-0	
Positive Control	3	0.000	3-3	
Coronal				
1% PAA	1	0.211	0-1	a
EDTA+NaOCl	2	0.258	1.75-2.25	b
EDTA	2	0.447	1.5-3	b
Negative Control	0	0.000	0-0	
Positive Control	3	0.000	3-3	

RESULTS

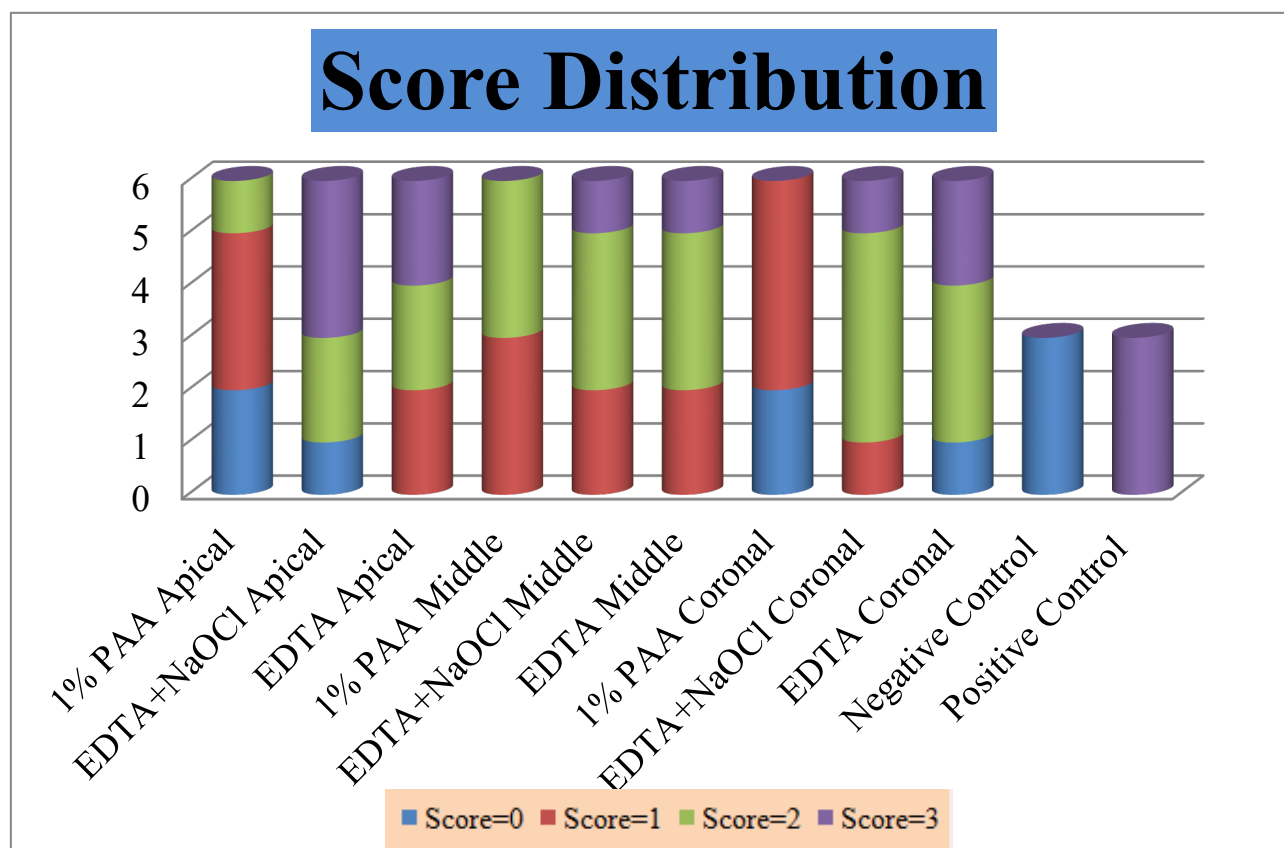
In the apical third of the canals, 1% PAA was superior to the other groups ($P < .05$); however, there were no significant differences among the other groups. In the middle third, there were no statistically significant differences among the groups ($P > .05$). In the coronal third, 1% PAA was superior to the other groups ($P < .05$). There were no significant differences among the other groups.

DISCUSSION

Ca(OH)_2 is one of the most frequently preferred intracanal medicament in endodontics. It has been reported that intracanal medication must be easily removed from the root canals entirely⁽²¹⁾. Several authors declared the negative effects of the Ca(OH)_2 residues on the penetration of sealers into

the dentinal tubules^(9,10) and stated that this might reduce the sealing ability^(10,22).

Graph 1: Showing score distribution of all three groups.



For removal of Ca(OH)_2 the most frequently described method is instrumentation of the root canal with the master apical file (MAF) in combination with copious irrigation by sodium hypochlorite (NaOCl) and EDTA⁽²³⁾. However, it has been reported that the removal of Ca(OH)_2 from the root canal wall is difficult, because instrumentation and irrigation alone cannot completely clean the entire area⁽²³⁾.

A number of factors can influence the efficiency of irrigants in removing the Ca(OH)_2 , such as final apical instrument size, the size of the needle used for irrigant delivery, the length of time devoted to irrigation, and the volume of irrigant used⁽²⁴⁾.

The vehicle used to mix calcium hydroxide paste has an influencing factor in the complete retrieval of it⁽²⁵⁾. The differences in velocity of ionic dissolution is directly related to the vehicle; the lower the viscosity, higher the ionic dissolution⁽²⁶⁾. The aqueous vehicles promote a high degree of

solubility when in contact with tissue and tissue fluids. Viscous vehicles like polyethylene glycol, propylene glycol and glycerin promote a lower solubility of the paste when compared with aqueous vehicles, probably because of their high molecular weight, which minimizes the dispersion of calcium hydroxide into the tissues⁽²⁷⁾.

The surface tension of the vehicle used in the medicament should be low to allow better penetration into inaccessible areas. The surface tension of any vehicle decreased significantly with addition of calcium hydroxide powder. Water has surface tension of 70.5 dynes/cm, which decreased to 66.5 dynes/cm with addition of calcium hydroxide⁽²⁸⁾. Silicone oil is hydrophobic as it contains many methyl groups and has surface tension of 19 dynes/cm, which will provide better wetting and water-resistant properties⁽²⁹⁾. Thus, in the present study, the medicament with distilled water would have been easy to remove. Metapex is

Ca(OH)₂ used with oil-based vehicle containing silicone oil, so it is more difficult to remove.

Oily vehicles are non-water soluble substances that promote the lowest solubility of the paste within the tissues, and pastes containing this kind of vehicle may remain within the root canal for a longer period than the pastes containing aqueous or viscous vehicles⁽³⁰⁾.

Silicone oil-based vehicles are more difficult to remove than polyethylene glycol and distilled water-based mixtures of calcium hydroxide⁽³¹⁾.

In this study, because we aimed to evaluate the efficiency of different irrigation solutions in the removal of Ca(OH)₂ from root canals, we did not use any agitation techniques and only used passive irrigation.

The calcium present in the hydroxyapatite crystals is one of the main inorganic elements in dentine. The chelating agents have been advocated for their direct action on calcium ions⁽³²⁾. One of the most preferred chelating agents in endodontics is EDTA. It is used in combination with NaOCl for the removal of the smear layer. Also, it demineralizes dentine, opens the dentinal tubules, and facilitates an easy preparation.

Peracetic acid (PAA) is one of the strongest disinfectants known. Currently, PAA solutions are frequently used in veterinary medicine, water treatment, the food industry, and the decontamination and sterilization of thermosensitive medical and hospital equipment and devices⁽³³⁾. Its action mechanism is caused by the release of free oxygen and hydroxyl radicals decomposing in oxygen, water, and acetic acid^(15,34). It is indicated that PAA in high concentrations is comparatively cytotoxic⁽³⁵⁾. It is found that 1% PAA did not irritate oral mucosa⁽¹³⁾.

In the current study, 1% PAA solutions were used in which the main purpose was to compare Ca(OH)₂ removal capability of EDTA, EDTA + NaOCl, and PAA solutions without using any instrument and agitation technique to evaluate the irrigants' efficiencies. No previous study has been encountered in the literature that evaluated the efficiency of PAA on the removal of Ca(OH)₂ from the root canals. Literature shows that NaOCl alone is

inadequate for the removal of Ca(OH)₂ from the root canals because of its limited ability to dissolve inorganic materials^(10,36). Therefore, this study does not involve an NaOCl-only group. In this study, 3 different irrigation protocols were used for the removal of Ca(OH)₂. In the apical thirds, intergroup comparisons revealed that 1% PAA is superior to the other groups. There were no significant differences among the other groups. This could be because of the sclerotic structure of dentinal tubules in the apical third. There was no significant difference among the groups in the middle thirds ($P > .05$). This might be because of the flushing of the middle thirds of the root canals with higher amounts of irrigating solutions. In the coronal thirds, 1% PAA groups had a better removal effect from the EDTA and EDTA + NaOCl groups. This could be a result of different decalcification dynamics of EDTA and acetic acid⁽¹⁵⁾. Because of the acidity of PAA, calcium ions stay in the solution and do not reprecipitate. The high scores of coronal thirds in the EDTA and EDTA + NaOCl groups could be related to the wider root canal space of coronal thirds, which reserves a high amount of Ca(OH)₂ paste. Ca(OH)₂ was found in all groups regardless of the irrigation solutions used.

CONCLUSION

According to the findings of the present study, 1% PAA was satisfactory for the removal of Ca(OH)₂ from the root canals. However, before recommending PAA as an alternative irrigation solution to replace EDTA and NaOCl, studies concerning the cytotoxicity, irritation potential, and dentinal erosion of 1% PAA should be performed.

CONFLICT OF INTEREST

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

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