
Microscopic cleanliness evaluation of the apical root canal after using calcium hydroxide mixed with chlorhexidine, propylene glycol, or antibiotic paste

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This study evaluated cleaning of the dentinal wall after removal of different calcium hydroxide pastes. Sixty-eight single-rooted teeth were prepared using the step-back technique and randomly divided into 4 groups according to medication used: Ca(OH)₂ with 0.2% chlorhexidine solution (Group 1), Ca(OH)₂ with propylene glycol (Group 2), Ca(OH)₂ with antibiotic paste (ciprofloxacin, metronidazole) and distilled water (Group 3), and Ca(OH)₂ with antibiotic paste and propylene glycol (Group 4). The samples were stored at 37°C and 100% relative humidity for 21 days. The medicaments were removed using 5 mL 1% NaOCl, instrumentation with master apical file, 5 mL 1% NaOCl, patency with the K-file #10, ultrasonic instrumentation, and 10 mL 17% EDTA-T. The specimens were analyzed using scanning electron microscopy and chemical analysis. The Kruskal-Wallis ($\alpha = 5\%$) test showed that there were no differences between the experimental groups when comparing Ca(OH)₂ removal ($P = .0951$). The chi-square test ($\alpha = 5\%$) indicated a predominance of Ca(OH)₂ obstructing dental tubules in all groups. On the basis of the methodology applied, it was concluded that the apical dentine surface remained equally covered by Ca(OH)₂, regardless of the vehicle used. (*Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2011;111:260-264)

The ultimate goals of endodontic treatment are complete removal of bacteria, their by-products, and pulpal remnants from infected root canals, and the complete sealing of disinfected root canals. Intracanal medicaments have been thought to be an essential step in killing the bacteria in root canals; however, in modern endodontics, shaping and cleaning may assume greater importance as means of disinfecting root canals. Nevertheless, if multiple-visit endodontic treatment is chosen, the use of calcium hydroxide (Ca[OH]₂) as an intracanal medicament is recommended.¹

Calcium hydroxide is the most widely used medication because of its well-documented antibacterial activity²⁻⁴ and its capacity to promote apexification.^{5,6} Its main mechanism of action is to raise the pH sufficiently so that few microorganisms are able to survive.⁷ How-

ever, there are some strains that are resistant to the use of this drug.^{8,9} To improve its antimicrobial activity, Ca(OH)₂ has recently been used in association with chlorhexidine¹⁰⁻¹³ and with various combinations of antibiotics; one example is a mixture of ciprofloxacin and metronidazole.¹⁴⁻¹⁷ Ciprofloxacin is a bactericidal drug that acts by blocking bacterial DNA replication. Additionally, metronidazole has a specific selective toxicity for anaerobic bacteria as well as parasites.¹⁸

To achieve the best performance from the filling material, it is necessary to clean the dentin wall of smear layers and debris as well as intracanal medication.¹⁹ If this medication is not completely removed, its presence on the dentin wall could compromise the cleanliness and permeability achieved by the final flush after root canal instrumentation.^{20,21}

Ca(OH)₂ placed inside the root canal has to be removed before obturating the canal to obtain satisfactory sealing. The presence of Ca(OH)₂ on dentin walls can affect the penetration of sealers into the dentinal tubules.²²⁻²⁵

The most frequently described method for removal of Ca(OH)₂ from the root canal is instrumentation with the master apical file (MAF) in combination with copious irrigation with NaOCl and EDTA.²⁶ EDTA has the ability to chelate Ca(OH)₂ residues, which makes them easier to remove by irrigation.²³ EDTA plus sodium lauryl ether sulfate (EDTA-T) is widely used as the best irrigant for cleaning away the smear layer,

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mainly when it is associated with a cationic detergent, which allows better diffusion and effectiveness.^{19,27}

However, it has been reported that removal of $\text{Ca}(\text{OH})_2$ from the apical root canal wall is very difficult.^{23,28} This is because instrumentation and irrigation alone cannot completely clean the entire root canal wall.²⁹ When $\text{Ca}(\text{OH})_2$ is removed from the main canal with a file, remnants will remain in canal extensions or irregularities. It is only possible to remove the $\text{Ca}(\text{OH})_2$ from these canal extensions or irregularities by irrigation. Passive ultrasonic irrigation is more effective in debris removal from the root canal wall than syringe delivery of the irrigant.³⁰⁻³²

Assuming the importance of complete removal of $\text{Ca}(\text{OH})_2$ medication before filling the root canal, this study evaluated the cleanliness of apical dentine surfaces after the removal of different $\text{Ca}(\text{OH})_2$ pastes using scanning electron microscope analysis.

MATERIAL AND METHODS

After the approval of the Ethics Committee (Number 065/078 CEP-CCS/UFPA) of the Federal University of Pará, 68 mandibular central incisors were used in this study. Following extraction, the teeth were stored at room temperature in saline solution. Mesiodistal and buccolingual radiographs were taken of each root to analyze the canal anatomy. The criteria for tooth selection included the following: a single root canal; no visible root caries, fractures, or cracks on examination with a 4-in. magnifying glass; no signs of internal or external resorption or calcification; and a completely formed apex. Roots with no greater than 5° of curvature were considered straight and were included in this study.

After access cavities were prepared, a size 10 K-file (Mailefer Instrumentos S/A/Dentsply Ind. e Com, Ltda, Petrópolis, RJ-Brazil) was introduced into the canal until it was visible at the apical foramen. The working length was determined by subtracting 1 mm from this measurement. This same file was used during preparation and it was introduced into the canal until it was visible at the apical foramen to ascertain patency at all times.

Subsequent root canal preparation was performed using the step-back technique with an MAF #40. The root canals were irrigated with 5 mL of 1% NaOCl, followed by a final rinse with 10 mL 17% EDTA-T. Irrigation was performed using 5-mL disposable plastic syringes with 27-gauge needle tips (Endo EZ; Ultradent Products, Inc., South Jordan, UT) placed passively into the canal.

The samples were randomly divided into 4 treatment groups ($n = 15$), on the basis of the calcium hydroxide paste. Group 1: 200 mg $\text{Ca}(\text{OH})_2$ with 0.2% chlorhexi-

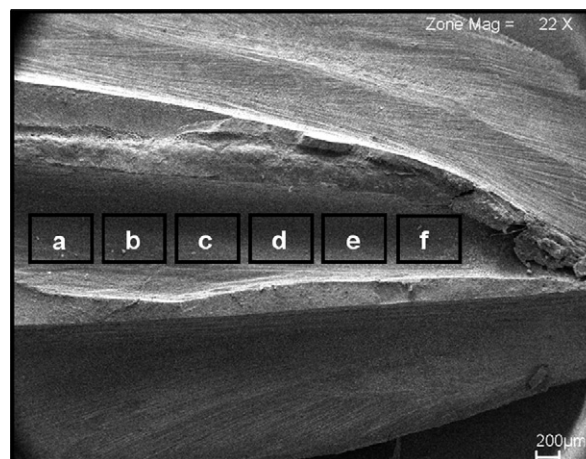


Fig. 1. Scanning electron image of the apical third. Each letter (a to f) represents 1 mm of the apical third.

dine solution (1:1.5, wt/vol); Group 2: 200 mg $\text{Ca}(\text{OH})_2$ with propylene glycol (1:1.5, wt/vol); Group 3: 100 mg $\text{Ca}(\text{OH})_2$ with 100 mg antibiotic paste (25% ciprofloxacin, 25% metronidazole) and distilled water (1:1.5, wt/vol); Group 4: 100 mg $\text{Ca}(\text{OH})_2$ with 100 mg antibiotic paste and propylene glycol (1:1.5, wt/vol). The negative control teeth ($n = 4$) were not filled with $\text{Ca}(\text{OH})_2$, and $\text{Ca}(\text{OH})_2$ was not removed from positive control teeth ($n = 4$). Radiographs were taken of each root to analyze them completely filled with $\text{Ca}(\text{OH})_2$. The samples were stored at 37°C and 100% relative humidity for 21 days. In all groups the medicaments were removed using the following: 5 mL 1% NaOCl irrigation, instrumentation using the MAF in a circumferential filing action, 5 mL 1% NaOCl; patency with the K-file #10, ultrasonic instrumentation with the K-file #15, and 10 mL 17% EDTA-T.

The crowns were removed at the cemento-enamel junction with a diamond disk. The roots were grooved longitudinally from buccal and lingual directions at the maximum buccolingual width, without entering the root canal, and were split into halves with a pair of pliers.

The samples were coated with gold-palladium particles (20 nm) and examined using a scanning electron microscope at $\times 1000$ magnification (Leo 1430, Zeiss, Germany).

Remnants of $\text{Ca}(\text{OH})_2$ were evaluated in all apical thirds, each represented by 6 areas of 1 mm, equidistant from the lateral walls (Fig. 1). Only 1 section of each tooth was evaluated, included 6 scores per tooth in the statistic. A scoring system was defined to assess the quantity of the residue on the canal walls. The evaluation scales used were as follows: score 0 – no visible remnants of calcium hydroxide and dentinal tubules ex-

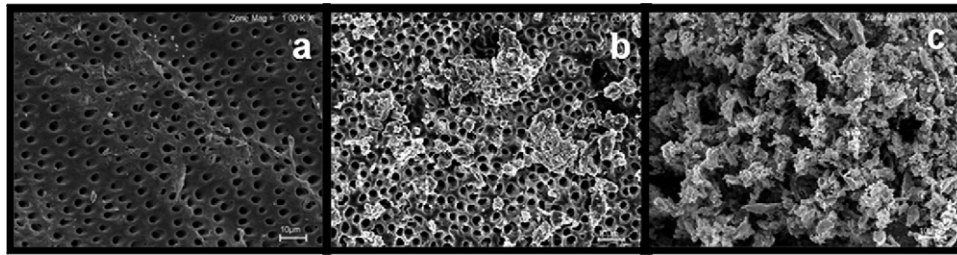


Fig. 2. Photomicrographs of root canal walls of apical thirds. **A**, Score 0 – no visible remnants of calcium hydroxide and dentinal tubules exposed; **B**, score 1 – scattered remnants of calcium hydroxide; **C**, score 2 – densely packed remnants of calcium hydroxide and dentinal tubules closed.

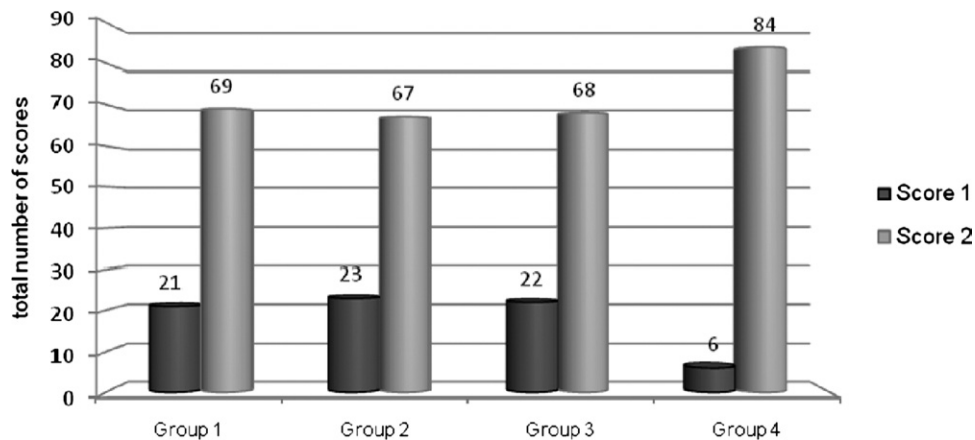


Fig. 3. Score distribution of different groups according to calcium hydroxide removal.

posed, score 1 – scattered remnants of calcium hydroxide and few dentinal tubules exposed, and score 2 – densely packed remnants of calcium hydroxide and dentinal tubules closed (Fig. 2). Following calibration with selected specimens, evaluation was performed by 2 investigators independently and in a blind manner.

Afterward, 3 points with 5 μm were evaluated on the canal walls by chemical analysis (energy dispersive X-ray microanalyzer [EDX]) to investigate the calcium ion remnants.

Data were subjected to statistical interpretation using Kruskal-Wallis, χ^2 , analysis of variance, and Tukey tests, at a 95% confidence level ($P < .05$).

RESULTS

Remnants of the medications were found in all the experimental teeth regardless of the material used. The positive control teeth in all groups showed densely packed remnants in all thirds as opposed to the negative control. The evaluation scales demonstrated no difference among the experimental groups when $\text{Ca}(\text{OH})_2$ removal was compared ($P = .0951$). Regarding score distribution, score 2 was more evident than score 1, and score 0 did not appear in any of the tested groups (Fig. 3).

Quantitative element analysis (EDX) showed a statistically significant difference ($P < .01$) in the remnants between Group 1, which used $\text{Ca}(\text{OH})_2$ with 0.2% chlorhexidine solution (29.57), and Group 4, $\text{Ca}(\text{OH})_2$ with antibiotic paste and propylene glycol (18.69), probably because a lower quantity of $\text{Ca}(\text{OH})_2$ was used in Group 4 (Table I).

DISCUSSION

Several studies have shown that the presence of calcium hydroxide on dentin walls can affect the penetration of sealers into the dentinal tubules.^{22-24,25} In routine root canal treatment $\text{Ca}(\text{OH})_2$ is removed by instrumentation and by irrigating the canal with NaOCl solution before obturation, but the development of a space in the root canal after obturation can be the result of dissolution of $\text{Ca}(\text{OH})_2$ left in the canal because of incomplete removal. Clinically, it is impossible to verify that all the $\text{Ca}(\text{OH})_2$ has been removed from the canal wall. The presence of $\text{Ca}(\text{OH})_2$ remaining in the canal was not recognized radiographically because this material has the same radiopacity as that of dentin.²²

None of $\text{Ca}(\text{OH})_2$ medicaments were entirely removed from the root canal walls, leaving remnants

Table 1. Element content in wt% (\pm SD) in canal walls of the different tested groups

	Group 1	Group 2	Group 3	Group 4	Negative control	Positive control
Ca	29.57 \pm 8.66	23.55 \pm 3.74	22.05 \pm 4.53	19.57 \pm 3.79	16.69 \pm 0.13	42.65 \pm 8.73

mostly in the apical thirds. The procedure used in this study for the removal of the intracanal medicament was used as standard in other studies.^{22,31}

The length of time that Ca(OH)₂ is left in the root canal can affect its effectiveness depending on its ability to rapidly disassociate into hydroxyl ions and calcium ions. In the present research, the medication was left in the root canal for 21 days because some clinical situations have indicated the presence of this medication in the root canal for several days, well beyond a reasonable period of penetration and disassociation into hydroxyl ions and calcium ions.²⁶

Regardless of the medication used in the present study, remnants were found in the apical regions. All groups demonstrated densely packed remnants (score 2). The observation that none of the tested groups presented a score of 0 provides evidence that the apical dentine surface was equally covered by Ca(OH)₂.

Chemical analysis (EDX), indicated a significant difference when comparing calcium in Groups 1 and 4. The use of a watery vehicle in Group 1 (Ca[OH]₂ with 0.2% chlorhexidine solution) provided the means for a greater speed of dissociation and diffusion, represented by a larger amount of calcium in this group. Also, it is known that viscous vehicles slow down the dissociation of calcium hydroxide, probably because of its high molecular mass, which could have been represented by the lower amount of calcium remaining in Group 4 (Ca[OH]₂ with antibiotic paste and propylene glycol). Furthermore, a lower quantity of Ca(OH)₂ was used in Group 4 because of its association with antibiotics.

The calcium content in the positive control group (42.65%) revealed the presence of calcium hydroxide after 21 days in the root canal. This result was similar to that of a previous study,³³ which identified higher levels of calcium after calcium hydroxide was used as the intracanal medication.

According to the results of this study, the different Ca(OH)₂ associations did not differ in the amounts of remnants left behind, as shown by the scoring system analysis. Therefore, the choice of medication to be used in association with Ca(OH)₂ will have to depend on its antibacterial efficacy. It is believed that remnants of calcium hydroxide may interfere with the sealing process; the results of this study showed the need for the development of new instrumentation techniques coupled to irrigation to increase the success of intracanal medication removal. Further investigations are neces-

sary to elucidate the role of this widely used intracanal medication in the persistence of debris.

CONCLUSIONS

The different medications used in this study did not contribute to a better removal of the interappointment root canal medication. The apical third of the straight canals used in this study remained equally covered by Ca(OH)₂.

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