

The persistence of different calcium hydroxide paste medications in root canals: an SEM study

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ABSTRACT

Introduction: There is a possibility of intracanal medication remain in the root canal even after its removal prior to obturation. The present study aims to evaluate under scanning electron microscopy the persistence of residues in the root canal from calcium hydroxide medications prepared with different vehicles. **Methods:** Thirty-six bovine incisors had their crowns removed, the root canals prepared and were assigned randomly to six different experimental groups, according to the intracanal medication used. Group I (control) received no intracanal medication, whereas root canals of Group II were filled with P.A. calcium hydroxide. Group III received a mixture of $\text{Ca}(\text{OH})_2$ and saline solution, in Group IV glycerin was used as vehicle, and Groups V and VI received $\text{Ca}(\text{OH})_2$ mixed with propylene glycol or polyethylene glycol 400, respectively. After one week, medication was removed,

roots were split and the canals observed under the scanning electron microscope. Representative photomicrographs of the apical third of each experimental group were observed and analyzed quantitatively by means of a grid, with results expressed in percentage of canal walls covered by debris. **Results:** Statistical analysis (one-way ANOVA and Tukey's post hoc test, $\alpha=0.05$) revealed significant differences between groups, indicating higher amounts of $\text{Ca}(\text{OH})_2$ residues in the canals where propylene glycol or polyethylene glycol were used as vehicles. The dentinal walls of the canals that received pure P.A. calcium hydroxide or its association to glycerin presented amounts of debris similar to the control group. **Conclusions:** $\text{Ca}(\text{OH})_2$ P.A. based medications or its association to glycerin allows an easier removal from the root canal.

Keywords: Calcium hydroxide. Intracanal medication. Vehicles.

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Introduction

The elimination of microorganisms in the root canal environment prior to obturation is of paramount importance for predictable treatment of apical periodontitis, and literature demonstrates the necessity of using an intracanal dressing to achieve such goal¹⁻⁵.

Calcium hydroxide ($\text{Ca}(\text{OH})_2$) has been used successfully in endodontics as a microbicide agent, due to its ionic effect observed by chemical dissociation into calcium and hydroxyl ions. The last inhibits bacterial enzymes by acting on the cytoplasmic membrane of the bacteria, generating irreversible effects, while calcium activates tissue enzymes such as alkaline phosphatase, leading to a mineralizing effect.^{2,4}

The use of $\text{Ca}(\text{OH})_2$, however, is not limited to its microbicide action. Other uses of this substance include inhibition of tooth resorption^{4,6,7} and induction of repair by hard tissue formation,^{4,8,9} which makes its use recommended in many clinical situations.⁴ Currently, this chemical is considered the best medication to induce hard tissue deposition and promote healing of vital pulpal and periapical tissues.⁵

The vehicle used with $\text{Ca}(\text{OH})_2$ to create a paste grant chemical characteristics that will influence its clinical handling during application and rate of ionic dissociation and diffusion. Some authors believe that hydrosoluble vehicles have better biological behavior (antimicrobial qualities and induction of tissue repair), due to a higher ionic dissociation, whereas others advocate the use of viscous or oily vehicles, since the alkaline properties of such pastes will only be exhausted after a longer period.^{5,10,11,12}

Prior to obturation of the root canal system, though, calcium hydroxide must be completely removed in order to avoid failure of the treatment.¹³ Literature shows that this is a difficult, if not impossible, task. Margelos et al¹⁴ have shown that it is necessary to combine sodium hypochlorite (NaOCl) and ethylenediamine tetracetic acid (EDTA) as irrigants with hand instrumentation to improve the removal efficiency of $\text{Ca}(\text{OH})_2$ from root canal, but its complete elimination may not be achieved. Lambrianidis et al¹⁵ found that even after irrigation with NaOCl and EDTA, as well as reinstrumentation with a #25 file, a considerable amount of calcium hydroxide (25 to 45%) from intracanal dressings remained attached to the canal walls. Attempts of removing such

medication with nickel-titanium rotary instruments, sonic or ultrasonic irrigation or citric acid instead of EDTA also proved unsuccessful, given that $\text{Ca}(\text{OH})_2$ still remained in the root canal.¹⁶⁻¹⁹

The persistence of $\text{Ca}(\text{OH})_2$ in the root canal prior to obturation may lead to failure of the endodontic treatment by creation of voids in the root canal that will not be properly filled, thus affecting apical seal.^{13,15,20,21} Even small amounts of $\text{Ca}(\text{OH})_2$ remaining in the root canal may obliterate dentinal tubules affecting sealer adhesion^{20,22,23} or cause adverse chemical reactions with the sealer, which may lead to an unpredictable prognosis.^{14,20}

Since the vehicle used during the preparation of the calcium hydroxide-based intracanal dressing may interfere with its removal capacity, the purpose of this study is to evaluate under the scanning electron microscope the persistence of residues in the root canal from calcium hydroxide medications prepared with saline solution, glycerin, propylene glycol 400 or polyethyleneglycol 400.

Material and Methods

Thirty-six bovine incisors with closed root apices had their crowns removed and root canals instrumented up to a #50 master apical file according to the step-back technique. Irrigation was performed using 1 ml of 2.5% sodium hypochlorite between files, with a final flush of 1 ml 15% EDTA for 1 minute followed by 10 ml of distilled water. Specimens were randomly assigned to six experimental groups, according to intracanal medication to be used, as follows: GI= no medication (control); GII= $\text{Ca}(\text{OH})_2$ P.A. powder (Synth, Diadema, SP, Brazil); GIII= $\text{Ca}(\text{OH})_2$ mixed with saline solution; GIV= $\text{Ca}(\text{OH})_2$ mixed with glycerin (Synth, Diadema, SP, Brazil); GV= $\text{Ca}(\text{OH})_2$ mixed with propylene glycol 400 (Synth, Diadema, SP, Brazil); GVI= $\text{Ca}(\text{OH})_2$ mixed with polyethylene glycol 400 (Synth, Diadema, SP, Brazil). A pediatric amalgam carrier was used in GII to place the $\text{Ca}(\text{OH})_2$ powder inside the root canal, following compaction using a #2 Paiva endodontic condenser. The other groups had the root canals filled with the aid of a Lentulo spiral bur (Maillefer, Ballaigues, Switzerland). Radiographs of the roots were obtained both in buccal-lingual and proximal views to assure that the medication was homogeneous and no voids

were produced during its introduction. The canal openings were then sealed with Coltosol® (Coltène, Whaledent, Switzerland).

After storage for seven days at 37°C, 100% humidity, samples were irrigated 1 mm short of working length with 5 ml of 2.5% sodium hypochlorite alternated with 5 ml of 15% EDTA, using the master apical file to reach the working length. A final irrigation with saline solution was performed and samples were processed for observation under the scanning electron microscope, at 500x magnification. Three representative photomicrographs of the apical third of each sample were obtained and analyzed quantitatively for debris, with the aid of a 10x10 grid. Results were recorded as percentage of debris covering the root canal walls, and statistical analysis was performed (one-way ANOVA and Tukey's post hoc test, $\alpha=0.05$).

Results

Table 1 presents the average of debris found in all experimental groups, according to SEM observations.

Statistical analysis (one-way ANOVA, $\alpha=0.05$) revealed statistical significant differences between groups ($p<0.001$). Tukey's post-test indicated lower amounts of debris found for groups I, II and IV, while higher amounts were found for groups V and VI. Group III (association with saline solution) presented intermediary amounts of debris.

Table 1. Mean amount of debris found in the apical third of the experimental groups, in percentage.

Group	amount of debris
I) no medication (control group)	1.6% ($\pm 0.55\%$) ^a
II) Ca(OH) ₂ powder	9.6% ($\pm 4.72\%$) ^a
III) Ca(OH) ₂ + saline solution	16.0% ($\pm 10.5\%$) ^b
IV) Ca(OH) ₂ + glycerin	10.8% ($\pm 2.86\%$) ^a
V) Ca(OH) ₂ + propylene glycol 400	28.0% ($\pm 11.8\%$) ^c
VI) Ca(OH) ₂ + polyethylene glycol 400	19.4% ($\pm 15.3\%$) ^c

Same letters indicate statistical similarity ($p>0.05$).

Discussion

Calcium hydroxide-based medications are routinely used in endodontics to eradicate microorganisms from the root canal system, which due to its complex anatomy may lodge such pathogens even after careful instrumentation and irrigation, leading to failure.¹⁻⁴ Various vehicles associated to Ca(OH)₂ have been proposed, and a consensus seems still far from being reached.⁵

Most authors agree that such medication must be removed from the root canal prior to filling since it may interfere with the quality of the obturation, especially the apical seal,¹³⁻²³ while other studies indicate that the persistence of Ca(OH)₂ does not promote a higher apical leakage.^{24,25} However, Kim and Kim²⁰ point out that these studies also noted that when calcium hydroxide dressing was retained in the canal, apical leakage increased with time. The fact that methylene blue dye may suffer discoloration when in contact with Ca(OH)₂ may also lead to false positive results, which might invalidate some of the previous findings.^{26,27}

The complete removal of Ca(OH)₂ prior to obturation by the clinician is impossible to verify, since this material has the same radiographic aspect as that of dentin.²³ According to previous studies, even minute concentrations of Ca(OH)₂ covering the root canal walls may interfere with the setting of zinc oxide-eugenol based sealers.^{13,20} Resin-based sealers also may suffer adverse effects from such intracanal medication.²¹

The present study evaluated the persistence of Ca(OH)₂ medication in the root canal walls at a microscopic level. The choice of using bovine incisors was due to their wide root canal, which would provide a standardized, generous space for irrigation, thus creating the most favorable conditions possible for the medication removal. Anatomical complexities would retain mechanically more intracanal medication,¹⁹ which might lead to biased results. The choice of using NaOCl and EDTA as irrigants and the master apical file at the working length also constitutes an attempt to remove as much medication as possible from the root canal walls.

Results indicate that, despite such favorable conditions, Ca(OH)₂ still persists inside the canal after its removal attempts. This is in agreement with previous

studies that found the removal of calcium hydroxide-based dressings extremely difficult or even impossible.^{13-21,23}

The use of pure Ca(OH)_2 as intracanal dressing, although reported in some studies,^{18,28} seem to be both impractical clinically in narrow canals and not desirable, since ionic diffusion would be minimal. In the present study, it was used merely as a control, to allow comparison with other formulations. Although the lower persistence in the root canal system reported in the results, the use of such medication without a vehicle does not seem to be suitable or desirable clinically.

Propylene glycol or polyethylene glycol used as vehicles provide a viscous consistency to the paste, which facilitates the insertion in the root canal, leading some authors to prefer this formulation. The slow release of ions and resorption by the surrounding tissues are also among the qualities advocated.^{5,11,12} However, results suggest that removal of viscous pastes may be more difficult than other formulations, causing an excess of medication remaining at the apical level of the root canal. Similar findings were found

by Lambrianidis et al¹⁵ and Nandini et al,¹⁸ but using commercially available pastes based on methylcellulose or silicone oil, respectively. Other authors found no differences regarding Ca(OH)_2 medication persistence associated to different vehicles.^{23,28}

Association of Ca(OH)_2 with saline solution showed to be easier to remove from the root canals than propylene or polyethylene glycol, but still persisted in greater amounts when compared to glycerin used as vehicle. Other studies may be necessary to understand the reasons of the lower amounts of Ca(OH)_2 found on the Ca(OH)_2 + glycerin group (GIV).

Conclusions

1. Pure calcium hydroxide based medications or its association to glycerin allows an easier removal from the root canal.
2. The association of Ca(OH)_2 with polyethylene glycol or propylene glycol 400 determines a higher persistence of the medication inside the canal prior to obturation.
3. None of the intracanal medications could be totally removed from the root canals.

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