Efficacy of sodium hypochlorite, ethylenediaminetetraacetic acid, citric acid and phosphoric acid in calcium hydroxide removal from the root canal: a microscopic cleanliness evaluation

Juliana Melo da Silva, MD, Amanda Silveira, Elizandra Santos, Lais Prado, and Oscar F. Pessoa, DDS, Belém, Brazil

DEPARTMENT OF ENDODONTICS, FEDERAL UNIVERSITY OF PARÁ

Rooted molars were subjected to standardized canal instrumentation to a master apical file (MAF). The samples were dressed with Ca(OH)₂, and after 7 days, teeth were reopened and Ca(OH)₂ medication was removed by 1 of 4 different experimental procedures: 2.5% sodium hypochlorite (NaOCl) (n = 10); 17% EDTA-T (n = 10); 10% citric acid (n = 10); or 37% phosphoric acid (n = 10). This was followed by reinstrumentation with MAF plus 15 mL saline solution. The roots were prepared for scanning electron microscopic analysis of the cervical, middle, and apical thirds. Statistical analysis was performed with the Kruskal-Wallis test. EDTA-T and phosphoric acid gave the best results in the apical third, with significant statistical differences compared with other groups. NaOCl gave the worst results. Irrigation with 17% EDTA-T and 37% phosphoric acid is more effective than sodium hypochlorite and citric acid in the removal of calcium hydroxide from the apical third. (Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;112:820-824)

To achieve the best adaptation of filling material, it is necessary to clean the smear layer and debris from the dentin wall as well as give intracanal medication.¹ Calcium hydroxide medication is frequently used, because <0.2% of the calcium hydroxide slurry dissociates at body temperature into calcium ions (Ca²⁺) and hydroxide ions (OH⁻), leaving most of the particles undissolved.² The size and shape of the calcium hydroxide particles may allow direct penetration into the open dentin tubules.³ If this medication is not completely removed, several studies have shown that the presence of calcium hydroxide on the dentin walls can affect the penetration of sealers into the dentinal tubules.⁴ The removal of calcium hydroxide has been investigated using various products and techniques, such as chelants to dissolve the inorganic particles in the smear layer, and intracanal medications.⁵ EDTA-T (EDTA plus sodium lauryl ether sulfate) is widely used as the best irrigant to clean the smear layer, mainly when it is associated with a cationic detergent, which allows better diffusion and effectiveness.⁹,¹⁰ Another efficient irrigant that is used for the same purpose is citric acid, which is used at various concentrations.¹¹,¹² 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.¹³ However, it has been reported that the removal of Ca(OH)₂ from the root canal wall is difficult⁸,⁵,¹³ because instrumentation and irrigation alone cannot completely clean the entire area.¹⁴ None of the above techniques is efficient at removing all the material from the canal walls, leaving up to 45% of the root canal surface covered with remnants.⁸ The aim of the present study was to evaluate the efficacy of 2.5% NaOCl, 17% EDTA-T, 10% citric acid, and 37% phosphoric acid in the removal of calcium hydroxide from the coronal, middle, and apical thirds of the human root canal system.

MATERIALS AND METHODS

Ethical clearance was obtained from the Ethical Committee (CEP-ICS/UFPA 190/08) of the Federal University of Belém, Pará, Brazil. Forty-eight distal and palatal rooted human molar teeth were used in this study. Preoperative mesiodistal and buccolingual radiographs were exposed for each root to confirm the canal anatomy.

The criteria for tooth selection included: a single root canal, no visible root caries, fractures, or cracks, no signs of internal or external resorption or calcification, and a completely formed apex. Roots with ≤5° of curvature were considered to be straight and were included in this study. The teeth were decoronated to
standardize the root length to 15 mm, and the working length was established by inserting a #10 K-file (Maillefer Instrumentos/Dentsply, Petrópolis, Brasil) into each root canal until it was just visible at the apical foramen (observed under magnifying loupes) and by subtracting 1 mm from this point. This same file was used during preparation and was introduced into the canal until it was visible at the apical foramen to ensure patency at all times.

The roots were subjected to standardized root canal instrumentation (step-back technique) using a #45 MAF and were irrigated with 2.5% NaOCl after each instrument, followed by 10 mL 17% EDTA-T as a final rinse. Irrigation was performed using 5-mL disposable plastic syringes with 27-gauge needle tips (Endo EZ; Ultradent Products, South Jordan, UT, USA) placed passively into the canal, up to 3 mm from the apical foramen without binding.

The samples were dried and filled with Ca(OH)₂ mixed with saline solution (1:1.5 w/v). Pastes were positioned with a size 35 lentulo paste carrier until the medicament was visible at the apical foramen. The access cavities were temporarily sealed with a cotton pellet and a filling (Cavit; Espe, Seefeld, Germany) to a depth of 3 mm. They were then stored at 37°C and 100% relative humidity for 7 days.

After 7 days, the teeth were reopened and the Ca(OH)₂ medication was initially removed using 10 mL saline solution and reinstrumentation with MAF (#45) using a circumferential filing action. The patency of the apical foramen was obtained by introducing a #10 K-file until it was visible at the apical foramen several times during the procedure.

After this, the samples were divided into 4 different experimental groups: group 1: 5 mL 2.5% NaOCl (n = 10); group 2: 5 mL 17% EDTA-T for 3 minutes (n = 10); group 3: 5 mL 10% citric acid for 30 seconds (n = 10); and group 4: 5 mL 37% phosphoric acid for 30 seconds (n = 10). A final flush was performed using 5 mL saline solution. Irrigation was performed under the same conditions as in the instrumentation phase. The negative control teeth (n = 4) were not filled with Ca(OH)₂, whereas the Ca(OH)₂ was not removed from the positive control teeth (n = 4).

Longitudinal grooves were then prepared on the buccal and lingual surfaces of each root with the use of a diamond disk at a slow speed without penetrating the canal. The roots were then split into 2 halves with the use of a chisel and stored in deionized water at 37°C until scanning electron microscope (SEM) analysis. The samples were then mounted on metallic stubs, gold sputtered using an ion sputterer, and examined under a scanning electron microscope.

The selected dentinal surfaces of the cervical, middle, and apical thirds (9, 6, and 3 mm from the apex, respectively), equidistant from the lateral walls, were observed by SEM at ×1,000 magnification. Three calibrated examiners analyzed, independently and in a blind manner, the removal of calcium hydroxide and the cleanliness of the dentinal walls with the use of a graded scale. The scale used was: score 0, no visible remnants of calcium hydroxide and dentinal tubules exposed; score 1, scattered remnants of calcium hydroxide; and score 2, densely packed remnants of calcium hydroxide and dentinal tubules closed (Fig. 1).

The interexaminer reliability was verified using the kappa test. Statistical analysis was performed using the Kruskal-Wallis test at the 5% level of significance.

**RESULTS**

The kappa test results showed that there was no statistically significant difference between the 3 examiners’ values for scoring the calcium hydroxide in the coronal, middle, and apical thirds in each group. All irrigation regimens left debris on the canal walls. The
NaOCl group gave the worst results, with significant differences in the cervical and middle thirds compared with the other groups. EDTA-T and phosphoric acid gave the best results in the apical third, with significant differences compared with the other groups (Table I).

**DISCUSSION**

Given that remnants of calcium hydroxide may interfere with the sealing ability of endodontic cement,4–7 several studies have tried to determine the best protocol to remove all calcium hydroxide medication before root canal filling. Besides antimicrobial and tissue-dissolving properties, the chemical substances used as irrigants during biomechanical preparation should also have the ability to lubricate and clean the root canal walls, allowing better action of the intracanal medication and proper adherence of the obturation material to the dentinal walls.15

The most common irrigant used to dissolve organic tissues is NaOCl, in concentrations ranging from 0.5%–
However, its capacity to remove the smear layer from the instrumented root canal walls has been found to be lacking. The conclusion reached by many authors is that the use of NaOCl during or after instrumentation produces superficially clean canal walls with the smear layer remaining. In routine root canal treatment, the Ca(OH)$_2$ is removed by instrumentation and irrigating the canal with NaOCl solution before obturation. The present study showed the worst results for calcium hydroxide removal in the NaOCl group, with significant differences compared with all of the other groups. Similar results were found by other authors.

The most common chelating solutions are based on EDTA, which reacts with the calcium ions in dentine and forms soluble calcium chelates. It is worth mentioning that the use of 10% citric acid and 17% EDTA-T for final irrigation has shown good results in terms of smear layer removal, owing to its efficacy against calcium ions, compared with other substances, such as sodium hypochlorite. In the present study, the efficacy of the chelating agents 10% citric acid and 17% EDTA-T did not differ significantly in the coronal and middle thirds except for the apical third where 10% citric acid was statistically less efficient, according to other studies.

To remove the inorganic component of root dentin, phosphoric acid can be used at different concentrations and applied in different ways. No earlier studies have used phosphoric acid as a chemical substance to remove the calcium hydroxide from the root canal. Irrigation with 17% EDTA-T and 37% phosphoric acid is more efficient than sodium hypochlorite and citric acid in the removal of calcium hydroxide.

In the apical third, which is a crucial area for disinfection, 17% EDTA-T and 37% phosphoric acid showed significantly better Ca(OH)$_2$-removing ability than 2.5% NaOCl and 10% citric acid.

The complete removal of calcium hydroxide can improve the adaptation of filling materials to the root canal. Further studies should be conducted to evaluate the effects of remnants of calcium hydroxide on the bond strength of endodontic sealers to root dentin and on the apical and coronal microleakage that occurs with most sealers currently used for canal filling.

CONCLUSION

According to this methodology and the limitations of this study, NaOCl gave the worst results for calcium hydroxide removal, with statistical differences in the cervical and middle thirds compared with the other groups. Irrigation with 17% EDTA-T and 37% phosphoric acid was more efficient than 2.5% sodium hypochlorite and 10% citric acid in the removal of calcium hydroxide from the apical root canal. Independently of the irrigator solution used, all experimental groups left remnants of Ca(OH)$_2$.

REFERENCES


Reprint requests:
Juliana Melo da Silva
Rua Cônego Jerônimo Pimentel nº 900, apt° 1202
Umarizal, Belém, PA
Brazil
CEP: 66055-000
melo_juliana@yahoo.com.br