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

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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 (Ca^{2+}) 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.[4-7] 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.[8] 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 difficult[8,5,13] 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.

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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

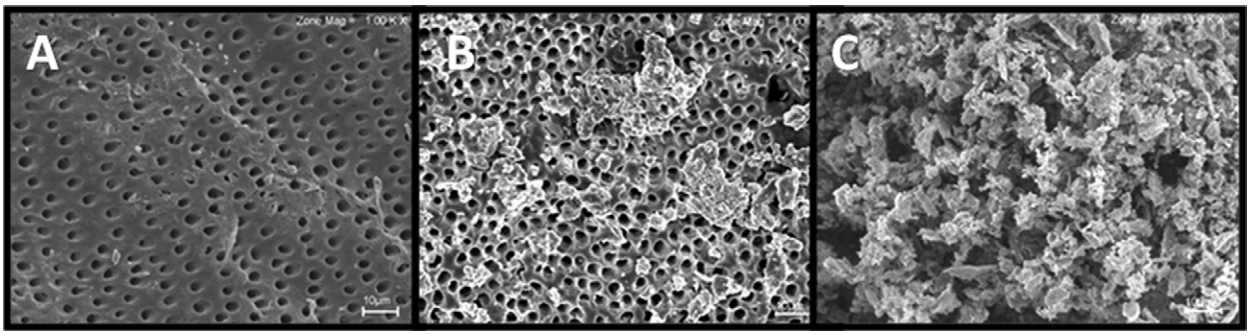

Fig. 1. Photomicrographs of root canal walls of apical third: **A,** score 0: no visible remnants of calcium hydroxide and dentinal tubules exposed, **B,** score 1: scattered remnants of calcium hydroxide; **C,** score 2: densely packed remnants of calcium hydroxide and dentinal tubules closed.

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 ± 1°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 few dentinal tubules exposed; 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