Removal Efficiency of Calcium Hydroxide Intracanal Medicament With Two Calcium Chelators: Volumetric Analysis Using Spiral CT, An In Vitro Study

Suresh Nandini, BDS, Natanasabapathy Velmurugan, MDS, and Deivanayagam Kandaswamy, MDS

Abstract

The vehicles used to carry calcium hydroxide intracanal medicament are many and may affect the retrieval. Access cavities were prepared in 40 single rooted anterior teeth, cleaning and shaping was done and filled with either Metapex or pure calcium hydroxide powder in distilled water. After 7 days the calcium hydroxide was retrieved using either 17% EDTA or 10% citric acid in combination with ultrasonic agitation. Volume analysis was done using spiral computed tomography. The percentage difference was calculated and statistically analyzed using Kruskal-Wallis and Mann-Whitney U test. 10% citric acid showed better removal efficiency than 17% EDTA for Metapex (p = 0.003). The 17% EDTA showed excellent removal efficiency of powder form of calcium hydroxide in distilled water than Metapex (p < 0.001). Ten percent citric acid removed powder form of calcium hydroxide in distilled water better than Metapex (p = 0.05). (J Endod 2006;32: 1097–1101)

Key Words
Calcium chelators, retrieval, spiral computed tomography, vehicles

Hermann’s introduction of calcium hydroxide in 1930 started a new epoch in the field of dentistry (1). The clinical success with this material is mainly attributed to its alkaline pH and depends on its ability to rapidly disassociate into hydroxyl ions and calcium ions. Tronstad et al. demonstrated the diffusion of calcium ions through the dentin to the external surface (2). Calcium hydroxide has been used in various clinical situations and is kept inside the canal for different time periods ranging from 7 days for intracanal medication to 6 to 24 months for apexification (3). Calcium hydroxide as an intracanal medicament has been shown to reduce the pathogenic species associated with pulp necrosis (4). The antibacterial efficacy of calcium hydroxide may be dependent on the vehicle used (5). Calcium hydroxide placed inside the root canal has to be removed before obturating the canal with permanent obturating materials.

Ricucci and Langeland reported a case of a failed root canal treatment because of incomplete removal of calcium hydroxide from the root canal that was placed as intracanal medicament (6). In vitro studies have shown that remnant calcium hydroxide can hinder the penetration of sealers into the dentinal tubules (7), hinder the bonding of resin sealer adhesion to the dentin, markedly increase the apical leakage of root canal treated teeth (8), and potentially interact with zinc oxide eugenol sealers and make them brittle and granular (9). Thus, complete removal of calcium hydroxide from the root canal before obturation becomes mandatory.

Very few studies have been done to assess the efficiency of techniques in removal of calcium hydroxide. Calcium hydroxide removal before final obturation is routinely accomplished either by irrigating with NaOCl or saline or instrumentation in a reaming motion. Margelos et al., has shown that using 15% edihylenediaminetetraacetic acid (EDTA) solution or NaOCl alone, as irrigants does not remove calcium hydroxide from the root canal, but combining these two irrigants with hand instrumentation improves the removal efficiency (9).

Lambrianidis et al. have studied the removal efficiency of calcium hydroxide dressing in different vehicles from the root canal using normal saline, 3% NaOCl, 3% NaOCl + 17% EDTA as irrigants in combination with hand filing. They concluded that 45% surface area remained covered with calcium hydroxide. They inferred that amount of calcium hydroxide powder in the paste does not affect the removal but the vehicle used for making the paste can affect the retrieval (10). In 1982 Anthony et al. demonstrated that the vehicle used could affect the calcium hydroxide diffusion through the apical foramen and the consequent pH change (11). Simon in 1995 assessed the pH of calcium hydroxide and release of Ca2+ from various vehicles and found Ca2+ release to be more when distilled water was used as vehicle (12).

The aim of this in vitro study was to assess the efficiency of two calcium chelators namely 17% EDTA solution and 10% citric acid combined with ultrasonic agitation, in the removal of calcium hydroxide placed as an intracanal medicament using two different vehicles. The two vehicles used in this study were, the commercially available paste in silicone oil and freshly mixed calcium hydroxide powder in distilled water. The volume of calcium hydroxide removed was analyzed with spiral computed tomography (CT).

Materials and Methods

The calcium hydroxide formulations were selected on the basis of the vehicles used. Metapex is a commercially available product composed of calcium hydrox-
ide, silicone oil, and iodoform (Meta Dental Corp. Ltd., Elmburst, NY). The chemically pure (95%) calcium hydroxide powder (Merck India Ltd., Mumbai, India) was mixed with distilled water in 1:1 ratio and barium sulfate was added for radiopacity (13).

Forty extracted single rooted anterior teeth were selected. The teeth with fractures, cracks, or any other defects were excluded. Teeth were stored in normal saline solution that was changed daily till sufficient number of teeth was collected. Access was prepared and the root canals were subjected to chemomechanical preparation with the step-back technique using K-files. The master apical file was standardized to three times the size of the initial apical file and 5.25% NaOCl was used as an irrigant after each instrument. Recapitulation with smaller size files was done during chemomechanical preparation. Before the final rinse a 20-size file was passed 1 mm beyond the apex to remove any dentinal shaving plugs. The teeth were stored in normal saline in airtight bottles in between procedures.

The teeth were divided into two groups of 20 teeth each. Metapex was injected into the root canal until the material extruded through the apex (group A). Calcium hydroxide was placed into the canals with lentulo spiral until the material extruded through the apex (group B). The access cavities were temporarily sealed with a cotton pellet and IRM. The teeth were stored at 37°C and 100% relative humidity for 7 days (14). Then the teeth were mounted in a plastic stand using modeling wax for the purpose of taking spiral CT. After CT imaging, the volume of the filled material in each tooth were estimated using Siemens Emotion Duo model of Spiral CT with the aid of Syngo software (Fig. 1).

Figure 1. (A) Group A1, filled with Metapex. (B) Group A2, filled with Metapex. (C) Group B1, filled with calcium hydroxide powder + distilled water. (D) Group B2, filled with calcium hydroxide powder + distilled water.
Then the teeth in each group were further divided into two subgroups based on the chelators used for removal, thus giving four groups:

A1 and A2: Metapex retrieved with 1 ml of 17% EDTA solution/1 ml of 10% citric acid + ultrasonic agitation for 1 minute.

B1 and B2: Calcium hydroxide powder mixed with distilled water retrieved with 1 ml of 17% EDTA solution/1 ml of 10% citric acid + ultrasonic agitation for 1 minute. Even though Barium sulfate is not used clinically nowadays, it was added to the calcium hydroxide powder because the radiopacity of plain calcium hydroxide powder was not adequate enough to differentiate it from dentin accurately during CT imaging.

Citric acid (10%) was prepared just before the use. A second spiral CT was done and the volume of remaining material in each tooth was estimated as before (Fig. 2). The removal efficiency was calculated as \[ \frac{(a-b) \times 100}{a} \], where a was the volume of material packed in the root canal and b was the volume remaining after retrieval. The data was statistically analyzed using SPSS Version 10.0.5 software.

**Results**

There was significant difference between the groups when tested using Kruskal-Wallis (Kruskal-Wallis statistic \( H = 13.73, p = 0.0033 \)). Intergroup comparisons were done using Mann-Whitney U test assuming unequal variance. The removal efficiency for various groups was 72.8% (A1), 89.8% (A2), 99% (B1), and 96% (B2) (Fig. 3). The 10% citric acid showed better removal efficiency than 17% EDTA for Metapex (\( p = 0.003 \)). Powder form of calcium hydroxide in distilled water was removed efficiently by both the methods (\( p = 0.08 \)). The 17% EDTA showed much better removal efficiency of powder form of calcium hydroxide in distilled water than Metapex (\( p < 0.001 \)). The 10% citric

---

**Figure 2.** (A) Group A1, filled with Metapex + retrieved with 17% EDTA + ultrasonic agitation. (B) Group A2, filled with Metapex + retrieved with 10% citric acid + ultrasonic agitation. (C) Group B1, filled with calcium hydroxide powder + distilled water + retrieved with 17% EDTA + ultrasonic agitation. (D) Group B2, filled with calcium hydroxide powder + distilled water + retrieved with 10% citric acid + ultrasonic agitation.
acid removed the powder form of calcium hydroxide in distilled water better than Metapex (p = 0.04).

**Discussion**

In previous studies the teeth were sectioned longitudinally and photos taken, which were analyzed with digital image processing to measure the surface area covered with calcium hydroxide after removal (9, 10). In our study volume analysis was done with spiral CT. Volume analysis gives a more accurate measure than surface area measurement. Three-dimensional volume analysis is used in the field of medicine in a variety of applications (e.g. thoracic and abdominal aneurysm, intracranial aneurysm etc), which have proved that the accuracy is equal to that of conventional techniques like angiograms (15). With spiral CT, three-dimensional volume measurements are possible without sectioning the specimens and thus avoiding the loss of material during sectioning. The amount of calcium hydroxide packed in the canal should be measured; only then the amount removed can be compared and an accurate value be obtained. This was not done in previous studies. Specimen mounting was done in modeling wax because even a slight change in the position of the tooth in between the two spiral CT scans will not affect the measurement of volume.

Literature search shows that hand filing with saline or NaOCl irrigation does not remove calcium hydroxide completely from the canal. Whereas, EDTA and hand filing improved the removal efficiency. In our study two commonly used calcium chelators (17% EDTA solution, 10% citric acid) were used with ultrasonic agitation.

Lambrianidis et al. in their study have revealed that the calcium hydroxide content does not influence the removal efficiency from the root canal walls, but methyl cellulose vehicle resisted removal from the root canal when retrieved with 17% EDTA. This was probably because of the interactions between methylcellulose and EDTA (10). The result of the present study also emphasizes the fact that vehicle used to mix calcium hydroxide paste is important for complete retrieval. The powder form in distilled water was removed by 96% to 99% in comparison to silicone oil, which was removed by 73% to 89%. The particulate form of calcium hydroxide in distilled water was easily removed, but silicone oil resists dissolution in water and hence was retained in the canal. Both the chelators efficiently removed powder form of calcium hydroxide in distilled water. The 10% citric acid performed better in comparison to 17% EDTA solution in removal of Metapex. This probably could be because of the reason that EDTA chelates calcium ions in water, but citric acid is able to penetrate the silicone oil better in comparison to EDTA and chelates the calcium ions.

The remaining calcium hydroxide was found to be packed mainly in the apical thirds of about 2 to 3 mm. Specimens filled with Metapex, which was removed with 17% EDTA showed smears of calcium hydroxide on the root canal walls also.

Failure of root canal treatment of a maxillary central incisor has been reported and attributed to incomplete removal of a calcium hydroxide medicament and subsequent resorption of the material from the apical portion of the root canal. Removal of the remnants calcium hydroxide followed by permanent obturation with gutta-percha and sealer showed complete periradicular bone healing (6). It is also quoted that depending on the smoothness of the canal wall the removal of calcium hydroxide may be accomplished to varying degrees (16) Kim and Kim (8) gave a controversial report to that of Porkaew et al. (17) and Holland et al. (18) who have reported that leakage was less in teeth that received calcium hydroxide as intracanal medicament in comparison to that of nonmedicated teeth. They have pointed out that the residual calcium hydroxide was incorporated into the sealer during obturation, which caused a decrease in the permeability of the sealer itself or that the calcium hydroxide was mechanically pushed into the dentinal tubules blocking them off and decreasing the dentin permeability. However, it is not likely that a decrease in the dentin permeability will lead to decrease in the apical leakage. Leakage at the apex occurs between the root canal wall and the sealer, between the sealer and the gutta-percha, or within the sealer itself. Kim and Kim showed more leakage when a calcium hydroxide packed tooth was permanently obturated with gutta-percha and zinc oxide eugenol sealer.

Figure 3. Comparison of calcium hydroxide retrieved using both chelators.
Zinc oxide eugenol becomes more granular and brittle when it interacts with calcium hydroxide, thus the solubility increases (9, 19, 20).

**Conclusion**

The vehicle used to prepare calcium hydroxide paste is important for its retrieval. Oil based calcium hydroxide is more difficult to remove than powder form calcium hydroxide mixed with distilled water. Both 17% EDTA and 10% citric acid were found to remove the powder form of calcium hydroxide in distilled water efficiently, whereas 10% citric acid was found to perform better than EDTA in removing oil based calcium hydroxide.

**Acknowledgments**

The authors thank Dr. Senthil, MD (Radiologist), Aarthi Scans, Chennai.

**References**