Original Article

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Effect of irrigants using ultrasonics on intracanal calcium hydroxide removal – an *in vitro* comparative evaluation

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Abstract

Aim: To evaluate the efficacy of various irrigating solutions on calcium hydroxide (Apex cal and RC cal) removal with the use of ultrasonics. **Methods:** The root canals of 120 single-rooted maxillary central incisors were prepared using the stepback technique. The teeth were decoronated and split longitudinally. After filling, the two halves of roots were reassembled with sticky wax and each group was further divided into four subgroups according to the irrigating solution: Smear Clear, 10% citric acid, 5% EDTA and 3% NaOCl. Evaluation for cleanliness was done under a microscope with ×12.5 magnification. Statistical analysis was done with Kruskal Wallis and Mann Whitney tests at 5% level of significance. **Results:** There was no statistically significant difference ($p>0.05$) for calcium hydroxide (Apex Cal and RC Cal) removal by different irrigants. There were more residues in the apical groove than in the coronal groove ($p<0.05$). **Conclusions:** When the different irrigants were compared at coronal and apical levels, Smear Clear and citric acid were more effective in calcium hydroxide removal than EDTA and NaOCl.

Keywords: smear clear, calcium hydroxide, root canal irrigants.

Introduction

Calcium hydroxide was introduced by Herman in 1920. Its clinical success is due to its alkaline pH and ability to rapidly disassociate into hydroxyl ions and calcium ions[1]. Its clinical application includes use for root canal disinfection, induction of calcification response and promotion of apexification[2]. Because of its antimicrobial activity, it has been recommended as an intracanal medication between sessions to eliminate persistent microorganisms, particularly in teeth with pulp necrosis and periradicular bone loss[3]. In vitro studies have shown that calcium hydroxide remnants can prevent the penetration of sealers into dentinal tubules, hinder the bonding of resin sealer adhesion to dentin, markedly increase the apical leakage of endodontically treated teeth, and potentially interact with zinc oxide eugenol sealers and make them brittle and granular[1]. Removal of an intracanal dressing is usually performed by irrigation in combination with hand instrumentation up to working length. In straight root canals, recapitulation with the master apical file in combination with irrigation showed better removal of calcium hydroxide than an irrigant flush alone. Rotary NiTi instruments facilitated calcium hydroxide removal from curved root canals without changing root canal anatomy[4].

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Stomas et al. (1987)[5] compared cleanliness of canals and isthmuses prepared with hand, sonic, and ultrasonic instrumentation and concluded that the ultrasonic method provided better debridement than either the hand or sonic methods at 1 mm level. Lev et al. (1987)[6] compared the debridement achieved by hand instrumentation to the debridement achieved by using ultrasonics for 1 and 3 min following hand instrumentation. Their results indicated that both ultrasonic groups were cleaner that the hand-instrumented group and that 3 min were better than 1 min in removing debris.

The objective of the study was to evaluate the efficacy of removing calcium hydroxide with various root canal irrigating solutions in combination with ultrasonics.

Material and methods

One hundred and twenty single-rooted maxillary central incisors with a straight root were selected. After preparing the canals by the stepback technique the teeth were decoronated with a diamond disc leaving a root length of 13 mm. Apical enlargement was done to size 50 K file (Dentsply Maillefer, Tulsa, OK, USA). The specimens were split longitudinally into two halves allowing subsequent reassembling. Two standardized grooves were cut into root dentin with dimensions of 3.0 mm length, 0.5 mm width and 0.5 mm depth as checked with a caliper. One groove was placed coronally in one half and the other groove was placed apically in the other half (Figure 1). The teeth were assigned to two groups based on the calcium hydroxide pastes: Apex cal (calcium hydroxide, 400% Al; Ivoclar Vivadent, Andheri west, Mumbai, India) and RC cal (calcium hydroxide, barium sulfate; Prime dental products, Mumbai, Maharastra, India). After filling the grooves with the calcium hydroxide pastes with the aid of a spreader to ensure proper loading of the material in both grooves, the two halves were reassembled with sticky wax. The root canals were completely filled with calcium hydroxide paste and sealed coronally with Cavit Temporary Filling (3M ESPE, St. Paul, MN, USA). The teeth were incubated for 7 days at 37°C and 100% humidity. For removal of the calcium hydroxide paste, size #25 H file (Dentsply Maillefer, Ballaigues, Switzerland) was introduced into the root canal up to working length and fifteen up-and-down strokes were performed to loosen the medication. A #25 K ultrasonic file mounted on a piezoelectric handpiece was passively activated for 3 min with 10 mL of the respective solutions. The teeth were hand held at the time of ultrasonic irrigation. During the irrigation the #25 K ultrasonic file was moving in the root canal. Each group was further divided into four subgroups (n = 15) based on the solutions used during ultrasonic irrigation: Smear Clear (SybronEndo, Orange, CA, USA), 10% citric acid, 5% EDTA and 3% NaOCl. Ten milliliter of each solution was used (Figure 1). The root canals were dried with size 30 paper points and the roots were separated.

The amount of remaining calcium hydroxide in the two longitudinal grooves was scored under the microscope with ×12.5 magnification using a scoring system described by van der Sluis et al (2007)[7]. Score 0: Cavity is empty; Score 1: Less than half of the cavity is filled with calcium hydroxide, Score 2: More than half of the cavity is filled with calcium hydroxide, Score 3: Cavity is completely filled with calcium hydroxide.

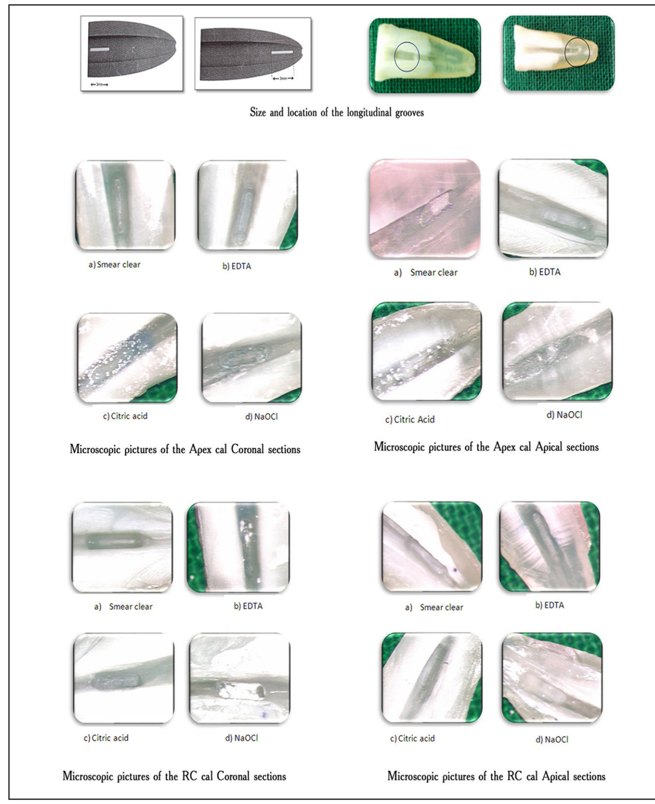

Fig. 1. Composite figure of grooves and apica/coronal sections. (i). Schematic presentation of size and location of grooves; (ii) Microscopic images of Apex cal coronal sections after irrigating with a) Smear clear, b) EDTA, c) Citric acid and d) NaOCl; (iii) Microscopic images of Apex cal apical sections after irrigating with a) Smear clear, b) EDTA, c) Citric acid and d) NaOCl; (iv) Microscopic images of RC cal coronal sections after irrigating with a) Smear clear, b) EDTA, c) Citric acid and d) NaOCl; (v) Microscopic images of RC cal apical sections after irrigating with a) Smear clear, b) EDTA, c) Citric acid and d) NaOCl.

Data were analyzed statistically by the Kruskal Wallis and Mann Whitney test at 5% level of significance. Pairwise comparison was performed separately for coronal and apical sections.

Results

The scores were tabulated, subjected to analysis and the results showed that there were more residues in the apical groove than in the coronal groove (Table 1 and 2). When the different irrigants were compared at coronal and apical levels, smear clear and citric acid were more effective in calcium hydroxide removal than EDTA and NaOCl (Table 1 and 2).

Discussion

Calcium hydroxide paste is used as an intracanal medication due to its antimicrobial efficacy. It can reduce canal permeability by promoting the formation of calcium

Table 1. Mean and standard deviations of apical sections of Apex cal and RC cal groups.

Irrigant	Mean	Standard deviation
5% EDTA	1.1333	0.50742
10% Citric acid	0.4333	0.62606
Smear Clear	0.3333	0.54667
3% NaOCl	2.2000	0.40684
Total	1.0250	0.91176

Table 2. Mean and standard deviations of coronal sections of Apex cal and RC cal groups.

Irrigant	Mean	Standard deviation
5% EDTA	0.7667	0.62606
10% Citric acid	0.2000	0.40684
Smear clear	0.2000	0.40684
3% NaOCl	1.2000	0.40684
Total	0.5917	0.62840

carbonate particles and interfering with the sealing ability of endodontic sealer. Therefore, several root canal irrigants have been tested for the complete removal of calcium hydroxide from root canals[2].

Numerous solutions have been used as root canal irrigants. In the present study, the efficacy of commonly used irrigating solutions such as citric acid, EDTA, NaOCl and smear clear was compared. There are many studies reporting on the activity of Smear Clear on smear layer removal but only few studies are available on removal of calcium hydroxide.

According to Gutarts et al.[8] (2005), the use of the ultrasonic needle after hand/rotary instrumentation resulted in significantly cleaner canals and isthmuses in the mesial roots of mandibular molars. Ultrasonic irrigation was also more effective than syringe irrigation in removing artificially created dentin debris[9]. According to Cameron et al.[10] (1983), 1 min of ultrasound removed the superficial smear layer but left the dentinal tubules sealed off; 3 min of ultrasound removed the entire superficial smear layer and most of the dentinal tubule plug layer, and 5 min of ultrasound removed all debris in instrumented and uninstrumented areas except for a few dentin chips.

The surface tension of an irrigating solution can be reduced with the addition of surfactants. Smear clear is a 17% EDTA solution with 2 additional proprietary surfactants. The reason for the better efficacy of Smear Clear was that the reduction of surface tension of an endodontic irrigating solution by addition of surfactants should improve its efficacy in the narrow apical region of root canal. Reducing surface tension of endodontic solutions improves their dentin wettability[9].

Smear Clear and citric acid were significantly more effective than NaOCl and EDTA. The results for the coronal groove were superior to those for the apical groove in terms of cleanliness because there could be a large number of chelating molecules in coronal root canal that were able to bind calcium ions. According to Sen et al.[11], lower concentrations of 5% EDTA can be recommended for clinical use to avoid excessive erosion of root canal dentin. Few authors reported a decreased efficacy of EDTA and citric acid at the apical level owing to the reduced quantity of solution contained in a smaller canal volume[11-13]. The groove model has an advantage of standardized size and location of the grooves which allows a standardized evaluation. The major disadvantage of this model is that it does not reproduce the complexity of a natural root canal system. Hence, the removal of calcium hydroxide from artificial grooves may be easier than from isthmuses or oval extensions in vivo. Digital imaging has been used for evaluation of calcium hydroxide removal but the main disadvantage is that only superficial layer of the calcium hydroxide could be quantified. Evaluation of cleanliness is performed under the microscope allowing a three dimensional view of variations in depth of focus[4].

The basis for the passive ultrasonic irrigation is the transmission of energy from an ultrasonically oscillating instrument to the irrigant inside the root canal. It showed that an irrigating solution in addition with ultrasonic vibration is directly associated with the removal of organic or inorganic debris from the root canal walls[14]. Comparing the root canal thirds, the results on the apical third are typically worse than the coronal third, proving the difficulty of cleaning this region[15].

Calcium hydroxide when interacts with eugenol inhibits zinc oxide eugenol chelates formation. The interaction between calcium hydroxide and eugenol is rapid and kinetically dependent, leading to residual eugenol in the set product. The set zinc oxide eugenol cement and zinc oxide eugenol sealers in contact with calcium hydroxide are brittle in consistency and granular in structure[13]. When calcium hydroxide and zinc oxide eugenol sealer are mixed, a calcium hydroxide-eugenol compound is reported to be produced, with more solubility, less sealing ability, thicker film and higher water absorption value than the original sealer[16]. In another study, it was reported that calcium hydroxide and zinc oxide eugenol reacts to form calcium eugenol or calcium bonds to eugenol by an ionic bond which can be broken when water is present[17].

Ultrasonic instrumentation of the root canals has been widely advocated as an effective modality for cleaning pulpal remnants and dentinal debris from canals and isthmuses. The mechanical agitation provided by ultrasonic instrumentation or a rotary file in conjunction with irrigation may also enhance removal of calcium hydroxide[18].

In conclusion, there were more calcium hydroxide residues in the apical groove than in the coronal groove. Smear Clear and citric acid performed better than EDTA and NaOCl in both coronal and apical grooves. In the coronal groove, NaOCl had the worst result. Limitations for this study are that none of the irrigants were able to completely remove the calcium hydroxide. Further development of new irrigants for the complete removal of calcium hydroxide is needed.

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