Effectiveness of four different techniques in removing intracanal medicament from the root canals: An *in vitro* study

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Abstract

Aim: To evaluate the effectiveness of different techniques in removing calcium hydroxide ($Ca(OH)_2$) from the root canal. **Materials and Methods:** Twenty-four freshly extracted mandibular premolars were instrumented using ProTaper rotary instruments. The teeth were longitudinally split into two halves, cleaned of debris. The two halves were then reassembled and filled with $Ca(OH)_2$ and were divided into four groups. In Group I, the teeth were irrigated with 5 mL of 2.5% sodium hypochlorite (NaOCl) and 5 mL of 17% of ethylenediaminetetraacetic acid. In Group II, the teeth were irrigated with 5 mL of 2.5% NaOCl and a rotary ProTaper F3 instrument was used. In Group III, the teeth were irrigated with 5 mL of 2.5% NaOCl and agitated using an ultrasonic unit. In Group IV, the teeth were irrigated with 5 mL of 2.5% NaOCl and a CanalBrush was used to remove $Ca(OH)_2$. The roots were disassembled, and photographs were taken. The amount of residual $Ca(OH)_2$ was calculated using an image analysis software as a percentage of the total canal surface area. The data were analyzed using one-way analysis of variance and *post-hoc* Tukey test. **Results:** CanalBrush and ultrasonic techniques showed significantly less residual $Ca(OH)_2$ than irrigants and rotary techniques. There was no significant difference between the rotary and irrigant techniques. **Conclusion:** None of the techniques used were completely able to remove $Ca(OH)_2$ from the root canals. But the CanalBrush and ultrasonic techniques were significantly better than the rotary instrument and irrigant groups.

Keywords: Calcium hydroxide, CanalBrush, rotary instrumentation, ultrasonic

Introduction

Calcium hydroxide ($Ca(OH)_2$) has been shown to be an effective intracanal medicament during endodontic therapy.[1] Various biological properties have been attributed to this substance, such as antimicrobial activity, high alkalinity, inhibition of tooth resorption, and tissue-dissolving ability. To be effective, it has to be adequately placed and condensed in the root canal space.[2]

Before root filling, the $Ca(OH)_2$ medicament that has been applied to the root canal should be removed. Any $Ca(OH)_2$ residue on the canal walls negatively affects the quality of the root filling.[3,4] *In vitro* studies have shown that remnant $Ca(OH)_2$ can hinder the penetration of sealers into the dentinal tubules,[5] hinder the bonding of resin sealer adhesion to the dentin, markedly increase the apical leakage of root canal treated teeth,[6] and potentially interact with zinc oxide-eugenol sealers and make them brittle and granular.[7] Thus, complete removal of $Ca(OH)_2$ from the root canal before obturation becomes mandatory. However, removing the $Ca(OH)_2$ residues from irregular canal walls is difficult.[8]

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Access this article online	
Quick Response Code:	Website: www.contempclindent.org
	DOI: 10.4103/0976-237X.161860

Several techniques have been proposed to remove the $Ca(OH)_2$ dressing from the root canal system, including the use of endodontic hand files,[9] sonic activation,[10] passive ultrasonic irrigation,[11] the CanalBrush System,[12] and nickel-titanium (NiTi) rotary instruments.[1,13] The most commonly described method for removing $Ca(OH)_2$ is instrumentation along with sodium hypochlorite (NaOCl) and ethylenediaminetetraacetic acid (EDTA) irrigant solutions combined with use of a "master apical file" at working length (WL).[14,15] However, there is still no consensus as to which is the best method for removal.

Removal of the dressing using hand files, with or without an irrigating solution, may be inefficient and tedious,[12] whereas the use of NiTi rotary instruments may enhance the removal procedure when compared to the techniques using hand files.[1] During root canal debridement and in order to reduce the amount of debris within the canal, a flexible microbrush (CanalBrush, Colte'ne Whaledent GmbH+ Co., KG, Langenau, Germany) made from polypropylene has been suggested. Debris removal from simulated canal irregularities in the apical part of the curved canals is more effective with CanalBrush, sonic, and ultrasonic irrigation techniques than syringe irrigation.[16] Tasdemir *et al*.[12] showed that the CanalBrush was effective in removing $Ca(OH)_2$ from the root canals than irrigant only techniques.

Thus, the purpose of this study was to evaluate the quantitative amount of $Ca(OH)_2$ remaining in the single rooted straight canals of mandibular premolars after attempted removal with a combinations of irrigants, rotary instrumentation, CanalBrush, or passive ultrasonics.

Materials and Methods

Twenty-four freshly extracted human mandibular premolar teeth with single root canal were used for this study. None of the teeth had visible root caries, fractures, or cracks on examination with a ×4 magnifying glass; no signs of internal or external resorption or calcification, all had a completely formed apex. Preoperative mesiodistal and buccolingual radiographs were exposed of each root to confirm the canal anatomy. The teeth were verified radiographically as having patent canals with curvatures of <10°. The crowns of the teeth were removed 14 mm from the apex to standardize their length. A size 10 K-file was placed in the canal until it was visible at the apical foramen. The WL was determined by subtracting 1 mm from this measurement. The root canals were instrumented with the ProTaper rotary system (Dentsply Maillefer, Ballaigues, Switzerland) to a size F3 (size 30, 9% taper) instrument as the master apical file. During the preparation, the root canal was irrigated with 2 mL of 2.5% NaOCl solution after each instrument. The irrigant was delivered via a 30 gauge endodontic irrigation needle that was inserted into the canal to the WL. When instrumentation was complete, a final flash was applied using 5 mL of 17% EDTA and 5 mL of 2.5% NaOCl.

The experimental design of splitting the teeth longitudinally was chosen to establish a baseline for measurements.[1,11] Longitudinal grooves were cut on the buccal and lingual root surfaces without damaging the inner layer of dentine around the canal. Roots were split longitudinally [Figure 1] using a chisel. Canals were gently cleaned of all extraneous debris remnants, and the two halves were then reapproximated. The roots were eliminated from the study if any openings emerged from the dentine remaining along the length of the canals. The teeth were randomly assigned into one experimental group ($n = 20$), while the remaining teeth served as positive ($n = 2$) and negative ($n = 2$) controls. The teeth were reassembled with wires, and the commercially available $Ca(OH)_2$ preparation (Apexcal, Ivoclar Vivadent) was placed into each canal via a lentulo spiral to the WL. After this procedure, the reassembled teeth were reinforced with sticky wax. These specimens were stored for 1-week at 37°C in 100% relative humidity. The $Ca(OH)_2$ medicament was removed with four different techniques. To provide standardization in terms of canal shape and size in all experimental groups,` same 20 teeth were used. In Group I, root canals were irrigated with 5 mL of 2.5% NaOCl, filed manually with a size F3 instrument, irrigated with 5 mL of 17% EDTA and received a final flush with 5 mL of 2.5% NaOCl followed. In Group II, the canals were irrigated with 5 mL of 2.5% NaOCl and a ProTaper F3 instrument was used in an electric motor (Endomate DT, NSK Nakanishi Inc., Tochigi, Japan) driven at 250 rpm and with a torque of 1.6 N/cm, and received a final flush with 5 mL of 2.5% NaOCl. In Group III, the root canals were irrigated with 5 mL of 2.5% NaOCl and a piezoelectronic unit (NSK Varios 750; Nakanishi, Inc., Tochigi, Japan) using a size 15 Varios U file (Nakanishi, Inc., Tochigi, Japan) was inserted to the WL and activated for 30 s in each canal. The final flush was with 5 mL of 2.5% NaOCl. In Group IV, root canals were irrigated with 5 mL of 2.5% NaOCl, and a medium-sized CanalBrush was placed in a slow-speed handpiece (600 rpm) and advanced to the WL. A circumferential motion was made with the CanalBrush for 30 s, and a final irrigation of 5 mL of 2.5% NaOCl was used. The negative control ($n = 2$) did not receive $Ca(OH)_2$ material, and the positive control ($n = 2$) received intracanal dressing, but no subsequent removal.

After each technique, the canals were dried with paper points. The roots were disassembled, and digital photographs were taken. Digital images were imported into Image Analyzer Software (Image Pro Plus Version 4.1.0.0) [Figure 2] and the amount of residual $Ca(OH)_2$ on the canal walls was measured in mm^2 and recorded as a percentage of the overall canal surface area. Between the different removal procedures, all residual $Ca(OH)_2$ was removed from the canals with brushes and air under high pressure with the aid of a dental operating microscope. This allowed the same teeth to be used multiple times. One-way analysis of variance with *post-hoc* Tukey test was used for statistical analysis for collected data at a 95% confidence level ($P < 0.001$).

Results

The percentage of residual $Ca(OH)_2$ on the root canal walls is shown in Table 1 and Figure 3. The mean amount of $Ca(OH)_2$ remaining was highest with respect to Group I followed by Group II and Group III. The lowest was seen with Group IV. Groups III and IV, while not different from each other, removed significantly more $Ca(OH)_2$ than the other two techniques. There is no significant difference between Groups I and II. Positive controls showed complete coverage of the canal walls with $Ca(OH)_2$ densely packed remnants in the canals as opposed to the negative controls.

Discussion

Several studies have shown that the presence of $Ca(OH)_2$ on dentin walls can affect endodontic treatment success.[7,8,17] It

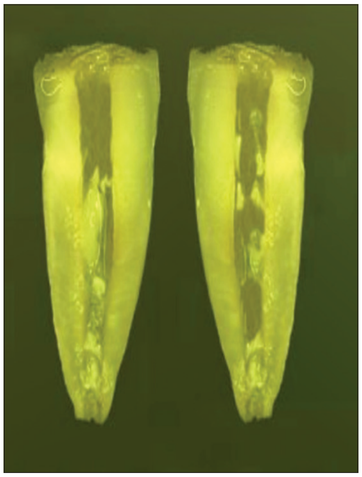

Figure 1: Longitudinal sectioning of the roots showing residual calcium hydroxide

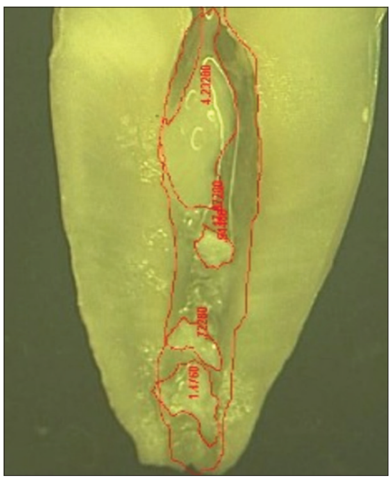

Figure 2: Image analysis software used to calculate residual calcium hydroxide

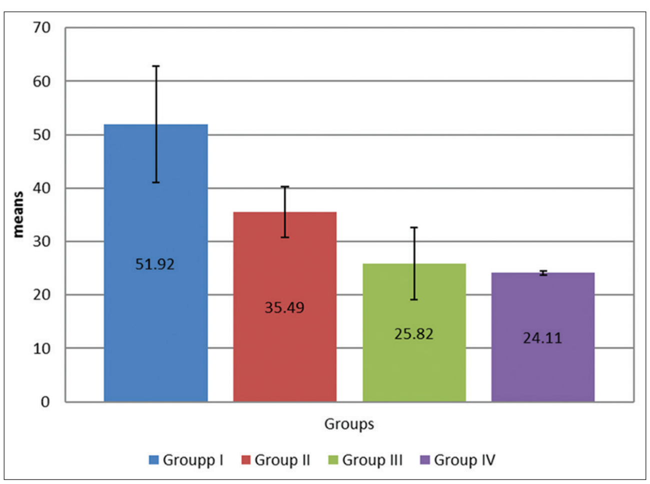

Figure 3: Means and standard deviations of the percentage of residual calcium hydroxide after various removal techniques

has been reported that residual $Ca(OH)_2$ interacts with zinc oxide-eugenol sealers to produce calcium eugenolate.[7] The residues could also influence the adhesion of sealers to the root canal walls,[4,5] compromising the quality of the seal provided by the root filling.[6,18] In the present study, a paste of $Ca(OH)_2$ with polyethylene glycol was used. According to the related literature, the paste composition does not influence the efficiency of mechanical and/or chemical methods in removing residues from root canal walls.[9,19]

Table 1: Percentage of $Ca(OH)_2$ remaining in the root canals

Group	Number of samples (*n*)	Mean±SD	*P*
Group I (NaOCl EDTA)	20	51.92±10.9[a]	<0.001**
Group II (ProTaper)	20	35.49±4.73[a]	
Group III (ultrasonic)	20	25.82±6.72[b]	
Group IV (CanalBrush)	20	24.11±0.4[b]	

**P<0.001 highly significant differences using one-way ANOVA followed by Tukey's *post-hoc* test. Groups with the same letter are not significantly different. SD: Standard deviation; NaOCl: Sodium hypochlorite; EDTA: Ethylenediaminetetraacetic acid; $Ca(OH)_2$: Calcium hydroxide

In previous studies, the amount of $Ca(OH)_2$ in the canal was calculated by measuring the surface area of the residues on the canal walls in terms of mm^2,[1,15,19] using a scoring method,[11] using a scanning electron microscopy,[14] or a volumetric analysis by spiral computed tomography.[20] In the surface area measurement method, the teeth are sectioned longitudinally, the canals are cleaned of all extraneous debris remnants and the two halves are reapproximated. After each removal technique, the roots are disassembled, and photos are taken, which are analyzed with digital image processing to measure the surface area covered with residual materials. In the present study, a similar method was used. Kenee *et al*.[1] reported that longitudinal sectioning might more accurately allow for the measurement of the complete canal area. By splitting the roots in this way, the canals were confirmed to be free of debris before each removal technique was applied.

Standardization of the canals was attained through their repeated use, thus eliminating the variables of canal morphology.[12] To date, few studies have evaluated the influence of rotary instruments on dressing removal. Kenee *et al*.[1] evaluated the amount of $Ca(OH)_2$ remaining in mesial canals of molars after removal with NaOCl and EDTA irrigation, hand files (size 35), rotary instrumentation (Profile System, instrument size 35, 0.04 taper), or ultrasonics (using a size 15 file). They found that rotary and ultrasonic techniques removed significantly more residues than the hand file and irrigating solution techniques. Kuga *et al*.[2] compared the efficacy of three rotary systems (K3, ProTaper and Twisted File systems) to remove $Ca(OH)_2$ from the root canal and found no significant difference between the three systems.

In the present study, removal of $Ca(OH)_2$ with ultrasonics was superior than irrigant only techniques. These data are in agreement with several previous studies. $Ca(OH)_2$ medicament removal was superior with ultrasonic agitation of NaOCl compared to the irrigant only techniques.[1,11]. However, Balvedi *et al*.[19] reported that there was no significant difference between syringe irrigation and passive ultrasonic irrigation methods in the apical third of root canals. The present study revealed poor removal of $Ca(OH)_2$ with NaOCl. Similar results were obtained by other authors.[1,14,21] Rödig *et al*.[21] explained this result because NaOCl has limited ability to dissolve inorganic substances such as calcium. Additionally, in agreement with the results of Kuga *et al*.,[22] the 17% EDTA solution had a similar effect to 2.5% NaOCl for the removal of $Ca(OH)_2$ in the present study.

Limited comparable data are available with the use of the CanalBrush for $Ca(OH)_2$ medicament removal. Kozak *et al*.[23] compared cleaning efficiency of five different cleaning techniques to remove artificially placed $Ca(OH)_2$/chlorhexidine paste from simulated apical grooves and depressions within wide root canals (prepared to a size 80, 0.02 taper). They reported that all tested cleaning methods were similar, though the Sonicare/CanalBrush had a slightly higher cleaning efficiency compared with the other cleaning procedures. This result can be explained by the over prepared to a large diameter of the canals in this study. Whereas the CanalBrush was more effective in terms of debris removal in the narrower parts of the root canal where it was in better contact with the root canal surface.[24] Also, Tasdemir *et al*.[12] compared the CanalBrush with ultrasonic and irrigant only techniques for $Ca(OH)_2$ removal and found that the CanalBrush and ultrasonic were better than irrigant only techniques for removal of $Ca(OH)_2$ from the root canal.

Conclusion

None of the techniques used was completely able to remove $Ca(OH)_2$ from the root canals. But the CanalBrush and ultrasonic were significantly better than the rotary instrument and irrigant groups.

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How to cite this article: Bhuyan AC, Seal M, Pendharkar K. Effectiveness of four different techniques in removing intracanal medicament from the root canals: An *in vitro* study. Contemp Clin Dent 2015;6:309-12.

Source of Support: Nil. **Conflict of Interest:** None declared.