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Efficacy of several techniques for the removal of calcium hydroxide medicament from root canals

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Abstract

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Aim To compare the efficacy of several techniques for the removal of calcium hydroxide ($Ca(OH)_2$) from root canals.

Methodology The root canals of 24 freshly extracted human mandibular premolars were prepared with ProTaper rotary instruments. The teeth were sectioned longitudinally along the length of the instrumented canals. The roots were subsequently reassembled with wires. After $Ca(OH)_2$ was placed into the canals, four techniques were used for its removal. In Group I, the teeth were irrigated with 5 mL of 2.5% NaOCl. Group II was treated in the same manner as Group I, but 5 mL of 17% EDTA was used in addition to NaOCl. In Group III, the teeth were irrigated with 5 mL of 2.5% NaOCl and agitated by an ultrasonic unit. In Group IV, the teeth were irrigated with 5 mL of 2.5% NaOCl and a CanalBrush was used to remove the $Ca(OH)_2$. The roots were disassembled and digital photographs were taken. Measurements of residual $Ca(OH)_2$ were performed as percentages of the overall canal surface area. The data was analysed with one-way ANOVA with *post hoc* Tukey test.

Results Significantly less residual material was obtained with a CanalBrush and passive ultrasonic agitation of NaOCl than the other groups ($P < 0.05$). There was no significant difference between syringe delivery of NaOCl and NaOCl + EDTA ($P > 0.05$).

Conclusions None of the techniques removed the $Ca(OH)_2$ dressing completely. CanalBrush and ultrasonic agitation of NaOCl were significantly more effective than irrigant-only techniques.

Keywords: calcium hydroxide removal, CanalBrush, passive ultrasonic agitation, root canal.

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Introduction

Intracanal medicaments are used in order to improve disinfection of the root canal. The most commonly used intracanal medicament is $Ca(OH)_2$ because it is effective against the majority of endodontic pathogens and is a biocompatible material (Athanassiadis *et al.* 2007). 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 (Caliskan *et al.* 1998, Barbizam *et al.* 2008). However, removing the $Ca(OH)_2$ residues from irregular canal walls is difficult (Ricucci & Langeland 1997). The most commonly described method for removing $Ca(OH)_2$ is instrumentation along with sodium hypochlorite (NaOCl) and EDTA irrigant solutions combined with use of a 'master apical file' at working length (Lambrianidis *et al.* 1999, 2006, Salgado *et al.* 2009).

Several studies have examined $Ca(OH)_2$ removal methods from the root canal. Using rotary NiTi-instruments (Kenee *et al.* 2006, Kuga *et al.* 2010), using an apical 'patency file' (Lambrianidis *et al.* 2006) and NaOCl with passive ultrasonic irrigation (Kenee *et al.* 2006, van der Sluis *et al.* 2007) have been found to remove more effectively $Ca(OH)_2$ from

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root canals. However, there is still no general consensus about which technique is best.

During root canal debridement and in order to reduce the amount of debris within the canal, a flexible microbrush (CanalBrush, Colténe 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 (Weise *et al.* 2007). Salman *et al.* (2010) reported that agitation with a sonic system in combination with a CanalBrush and 17% EDTA, especially in the apical third of the canal is more effective for the removal of debris and smear layer than NaOCl or NaOCl + EDTA. However, there is little or no information on whether the CanalBrush is efficient at removing $Ca(OH)_2$ medication. Thus, the aim of this study was to evaluate quantitatively the amount of $Ca(OH)_2$ remaining in single-rooted straight canals of mandibular premolars after removal was attempted with combinations of irrigation, passive ultrasonication or a CanalBrush.

Materials and methods

Twenty-four freshly extracted human mandibular premolar teeth with single root canal were used. 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 (KerrHawe SA, Bioggio, Switzerland) that was inserted into the canal to the WL. When instrumentation was complete, a final flash was applied using 5 mL 17% EDTA and 5 mL 2.5% NaOCl.

The experimental design of splitting the teeth longitudinally was chosen to establish a baseline for measurements (Kenee *et al.* 2006, van der Sluis *et al.* 2007). 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 using a chisel. Canals were gently cleaned of all extraneous debris remnants and the two halves were than 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 (Calcicur, Voco, Cuxhaven, Germany) was placed into each canal via a lentulo spiral to the working length. 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 and received a final flush with 5 mL of 2.5% NaOCl. In Group II, 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 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 working length 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 working length. 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 analyser software (Comef 4.3; OEG Messtechnik, Frankfurt, Germany), 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 (Fig. 1). 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 ANOVA with *post hoc* Tukey test was used for statistical analysis for collected data at a 95% confidence level ($P < 0.05$).

Results

The percentage of residual $Ca(OH)_2$ material on the canal walls is shown in Table 1. Groups III and IV, while not different from each other ($P > 0.05$), removed significantly more $Ca(OH)_2$ than the other two techniques ($P < 0.05$). There is no significant difference between Groups I and II ($P > 0.05$). 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

Many additives are included in $Ca(OH)_2$ intracanal medicaments, and many different formulations are used for root canal sealers. The combination of $Ca(OH)_2$ and sealer thus presumably affects their physical properties and apical sealing ability (Hosoya *et al.* 2004). It has been reported that residual $Ca(OH)_2$ on the root canal walls interacts with zinc oxide-eugenol-based sealers and produced calcium eugenolate (Margelos *et al.* 1997). The remnants could also influence the penetration of sealers into dentinal tubules (Çalt & Serper 1999), markedly compromising the quality of the seal provided by the root filling (Caliskan *et al.* 1998, Kim & Kim 2002). Intracanal $Ca(OH)_2$ material should therefore be removed as much as possible prior to root filling (Hosoya *et al.* 2004).

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 (Lambrianidis *et al.* 1999, Kenee *et al.* 2006, Balvedi *et al.* 2010), by using a scoring method (van der Sluis *et al.* 2007, Rödig *et al.* 2010), by using a scanning electron microscopy (Salgado *et al.* 2009, Kuga *et al.* 2010) or a volumetric analysis by spiral CT (Nandini *et al.* 2006). 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 analysed 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.* (2006) 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

Table 1 Percentage of residual $Ca(OH)_2$ remaining in the canal [mean and standard deviation (SD)]. Mean with same letter is not significantly different at the $P = 0.05$ level

Groups	Mean	SD
Group I (NaOCl only)	50.99^a	20.14
Group II (NaOCl + EDTA)	41.96^a	22.04
Group III (NaOCl + PUI)	25.45^b	17.14
Group IV (NaOCl + Canalbrush)	24.09^b	18.83

Figure 1 Images of $Ca(OH)_2$ remaining on the root canal walls and the calculation of the area of $Ca(OH)_2$ using an imaging programme.

of the canals was attained through their repeated use, thus eliminating the variables of canal morphology.

In the present study, Calcicur (with 45% calcium hydroxide) water-based calcium hydroxide paste was used. Lambrianidis *et al.* (1999) revealed that the calcium hydroxide content does not influence the removal efficiency from the root canal walls.

The data for the present study shows that, though none of the methods completely removed all of the material from the walls, the use of the CanalBrush or passive ultrasonication to agitate NaOCl for 30 s improved its removal. Both techniques produced superior results compared with other irrigant-only techniques ($P < 0.05$). 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 (Kenee *et al.* 2006, van der Sluis *et al.* 2007). However, Balvedi *et al.* (2010) 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 (Kenee *et al.* 2006, Salgado *et al.* 2009, Rödig *et al.* 2010). Rödig *et al.* (2010) 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.* (2010), 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.* (2009) 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, .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 (Garip *et al.* 2010). However, CanalBrush activation improved the removal of debris from simulated canal extensions and irregularities in the apical portions of curved root canals (Weise *et al.* 2007). In an another study, irrigation by agitation with the Sonicare/CanalBrush improved root canal debridement in the apical thirds of the root canal (Salman *et al.* 2010).

Conclusions

No technique completely removed $Ca(OH)_2$ medicament from root canals. The CanalBrush and ultrasonic agitation of NaOCl left significantly less $Ca(OH)_2$ than an irrigant flush alone.

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