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Calcium Hydroxide removal: Comparative evaluation of four different techniques, an *in vitro* study

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ABSTRACT

Calcium hydroxide is the most commonly used intracanal medicament. Complete removal is essential before obturation to improve the seal of the root canal filling. This study was done to compare the efficacy of conventional syringe irrigation, passive ultrasonic irrigation, Endoactivator system and Endovac method in removal of $Ca(OH)_2$. 48 extracted human mandibular premolars were used. Roots were decoronated to 1mm above CEJ and specimens were kept at 15mm standard length from root apex. Root canals were instrumented with NiTi rotary instruments upto F3. Teeth were randomly assigned into 4 groups. One-way analysis of variance with ANOVA test was used for statistical analysis ($p<0.001$) and showed removal of $Ca(OH)_2$with Endovac system was superior to other techniques. None of irrigation techniques was able to completely remove $Ca(OH)_2$ from root canal system. Highest degree of cleanliness resulted from use of Endovac system.

Introduction

Calcium hydroxide has been recommended for use as an intracanal medicament based on its antimicrobial, tissue dissolving and antiresorptive properties.[1] It has been used clinically to obtain microbial control, dissolve organic remnants, heal periapical inflammation, arrest inflammatory root resorption, stimulate hard tissue formation and serve as a temporary obturating material between appointments.[2] The most effective type of calcium hydroxide is an aqueous suspension. Despite its good antimicrobial effect, it exhibits poor handling properties, and its distribution throughout the canal is problematic.[1] Another challenge is its thorough removal.

Before final obturation of the root canal system, the dressing should be removed completely to improve the seal of the root canal filling. Remaining calcium hydroxide could be washed out by body fluids resulting in apical leakage and reduced bond-strength of AH plus sealer (Dentsply, Konstanz, Germany) [3]. Decrease of bond-strength of a resin-based sealer, or a silicone-based sealer to root dentin may be sequelae of residual intra-canal medicament.

Intracanal Ca(OH)2 is usually removed from the root canal by the use of copious irrigation with either NaOCl or saline, combined with instrumentation and a final rinse with 17% ethylene diamine tetraacetic acid (EDTA). However, none of the above techniques are efficient in removing all the material from the canal walls, leaving up to 45% of the root canal surface covered with remnants (Lambrianidis et al. 1999).

The EndoActivator system (Dentsply Tulsa Dental Specialties, Tulsa, OK, USA) is a sonically driven canal irrigation system that was introduced to improve the irrigation phase. Its activation generates vigorous intracanal fluid agitation.[4]

The EndoVac system (Discus Dental, Culver City, CA) uses suction to pull the irrigant down the root canal, and then up into the Hi-Vac suction unit. This is termed as "negative apical pressure," because EndoVac applies suction rather than forceful injection of irrigant.

The aim of this study was to compare the intra-canal medicament removal efficiency of conventional syringe irrigation, passive ultrasonic irrigation (PUI), Endoactivator system, and apical negative pressure irrigation (EndoVac) methods.

Methodology

Forty-eight extracted human first and second mandibular premolars were used in this in vitro study. Teeth with completely formed apices were chosen. None had visible root caries, fractures, or cracks on examination; No signs of internal or external resorption or calcification were seen. A # 10 Kfile was inserted into the canal and radiographs were taken to ensure that the degree of curvature determined by Schneider's method was mild (< 20°). Roots considered straight according to this method with same external size were selected to provide standardization. Teeth were stored in 2.5% NaOCl solution at room temperature to remove organic debris for 48 h. External root surfaces were debrided with ultrasonic scalers and washed under running water. The roots were decoronated to 1 mm above the cementoenamel junction using a carborundum disc and the specimens were kept at 15 mm standard length from the root apex. The pulp tissue was removed using Hedstorm-files( ). WL was established 1 mm above the apical foramen using RVG. All canals were prepared by a single operator. Cleaning and shaping of the root canal was done manually uptil #25 K-file. Following this, the root canals were instrumented with ProTaper NiTi rotary instruments (Dentsply Maillefer, Ballaigues, Switzerland) up to F3 (30 size,.06 taper). Root canals were irrigated with 5 mL of 2.5% NaOCl solution between instrumentations. A plastic syringe with a 26 gauge irrigation needle was inserted up to the WL for irrigation. A final rinse was carried out with 5 mL of 17% ethylenediaminetetraacetic acid (EDTA) and 5 mL of 2.5% NaOCl. Root canals were dried with multiple paper points.

Figure 1. Tooth sectioned longitudinally

The teeth were split longitudinally to establish a baseline for measurements. Longitudinal grooves were cut on the buccal and lingual root surfaces without damaging the inner layer of dentine around the canal. A chisel was used to split the roots longitudinally. 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 extended from the dentine remaining along the length of the canals. The teeth were randomly assigned into four experimental groups (n =

12) according to the following methods: Group A- Endoactivator system. Group B- apical negative pressure irrigation (EndoVac system). Group C- conventional syringe irrigation with NaCl. Group D- Ultrasonic irrigation.

The teeth were reassembled with ligature wire. The commercially available $Ca(OH)_2$ (Apexcal, Ivoclar Vivadent) was placed into each canal using a lentulo spiral. The specimens were stored for 7 days at a temperature of 37°C in 100% relative humidity. The $Ca(OH)_2$ medicament was removed using four different techniques.

In **Group A**, the Ca(OH) was removed using the Endoactivator system (Dentsply Tulsa Dental Specialties, Tulsa, OK, USA) using sonic irrigation at a speed of 10000cpm 1 minute using a 20/.04 tip, in a cyclic axial movement. In **Group B,** (EndoVac system Discus Dental, Culver City, CA, USA), a macro-irrigation cycle was conducted with 5 mL of 2.5% NaOCl for 30 seconds, followed by a micro-irrigation cycle for another 30 seconds . The microcannula alternated push-pull movement remaining 6 seconds at WL and 6 seconds 2 mm short of the WL for 30 seconds..The last cycle was performed with 5 mL of 2.5% NaOCl irrigation by using micro-cannula for 1 min. In **Group C**, root canals were irrigated with 5 mL of normal saline. In **Group D (Ultrasonic)**, 2 mL of 2.5% NaOCl solution and ultrasonic activation was delivered for 1 minute using the Endosuccess (Satelec, Acteon).

After each technique, the canals were dried with paper points. The roots were disassembled, and digital photographs were taken.

Digital images were imported into ImageJ software and the amount of residual $Ca(OH)_2$ on the canal walls was measured in mm and recorded as a percentage of the overall canal surface area.

Statistical analysis

One-way analysis of variance with ANOVA test was used for statistical analysis for collected data at a 95% confidence level ($P < 0.001$).

Results

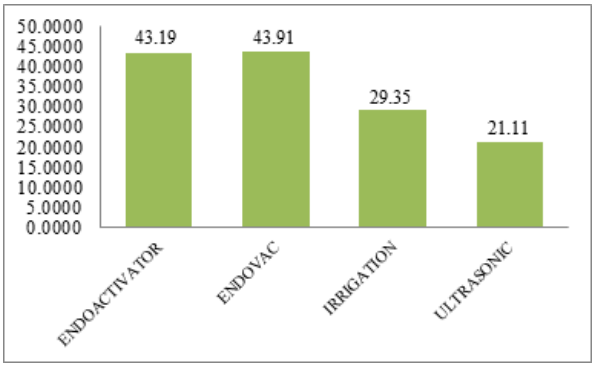

Table1: Percentage of residual calcium hydroxide after various removal techniques

The comparison of area of $Ca(OH)_2$ Presence using one-way ANOVA test showed that the mean value of ENDOVAC (35237.92) was highest followed by ENDOACTIVATOR (23616.5), IRRIGATION (23291.42), and least in ULTRASONIC (15893.75). This difference is statistically significant with a test value of 7.97 and p value of <0.001.

Post-hoc Tukey test showed that the difference between ENDOACTIVATOR and ENDOVAC is statistically significant with a mean difference of -11621.417* and p value of 0.028. The difference between ENDOACTIVATOR and IRRIGATION is not statistically significant with a mean difference of 325.083 and p value of 1. The difference between ENDOACTIVATOR and ULTRASONIC is NOT statistically significant with a mean difference of 7722.75 and p value of 0.231. The difference between ENDOVAC and IRRIGATION is statstically significant with a mean difference of 11946.500* and p value of 0.023. The difference between ENDOVAC and ULTRASONIC is statistically significant with a mean difference of 19344.167* and p value of <0.001. The difference between IRRIGATION and ULTRASONIC is NOT statistically significant with a mean difference of 7397.667 and p value of 0.265.

Discussion

Calcium hydroxide ($Ca(OH)_2$) is known to be an effective intracanal medicament in endodontic therapy.[5] Various 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 must be adequately placed and condensed in the root canal space.[6] Before root filling, the $Ca(OH)_2$ medicament should be removed. Any $Ca(OH)_2$ residue on the canal walls adversely affects the quality of the root filling.[7] An influence of the consistency of the carrier material of $Ca(OH)_2$ paste has been reported: mixtures with oily or viscous substances were removed significantly worse compared to mixtures with aqueous solutions. In vitro studies have shown that residual $Ca(OH)_2$ can hinder the penetration of sealers into the dentinal tubules,[8] interfere with the bonding of resin sealer adhesion to the dentin, markedly increase the apical leakage of root canal treated teeth,[9] and potentially interact with zinc oxide eugenol sealers to make them brittle and granular.[10] Kim and Kim[11] recommended the use of a sealer cement that binds to the root canal wall when $Ca(OH)_2$ is used as an intracanal medicament. Resilon and AH Plus bind to the root canal wall.[12,13]

Thus, complete removal of $Ca(OH)_2$ from the root canal before obturation is mandatory. However, removing the $Ca(OH)_2$ residue from irregular canal walls is difficult.[14]

In previous studies, the amount of Ca(OH) in the canal was calculated by measuring the surface area of the residues on the canal walls in terms of mm ,[5, 15, 16,] using a scoring method,[17] using a scanning electron microscopy,[18] or a volumetric analysis by spiral computed tomography.[7] 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.[15] 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.

In the present study, removal of $Ca(OH)_2$ with the EndoVac system was superior to the other techniques. The present study revealed poor removal of Ca(OH) with ultrasonic method. Removal of residual $Ca(OH)_2$ with NaCl irrigation was marginally better than that with Ultrasonic irrigation. Rödig et al.[19] explained this result because NaOCl has limited ability to dissolve inorganic substances such as calcium.

Regarding the efficiency of the EndoActivator, controversial results have been published. Ma et al. [20] did not detect significant differences between PUI and the EndoActivator when used for calcium hydroxide removal from C-shaped root canals. Syringe and EndoActivator removed similar amounts of different intracanal paste medicaments, among these Ledermix (Riemser, Riems, Germany) and Pulpdent (ADS, Vaterstetten, Germany)[21]

EndoVac system's effectiveness may be attributed to the use of apical negative pressure irrigation concept. During microdebridement, placement of the microcannula directly at the apical end of the root canal provides more irrigant volume and flow than other techniques in the apical region.

Although the EndoVac system in the present study showed the best results, a potential benefit of the EndoActivator could be its

non-invasive mode of action which especially in curved root canals could prevent ledging.

Conclusion

Complete removal of calcium hydroxide from the root canal could not be accomplished with any of the techniques tested. The highest degree of cleanliness resulted from the use of the EndoVac system followed by Endoactivator system.

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