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Removal Efficiency of Calcium Hydroxide Dressing from the Root Canal without Chemically Active Adjuvant

Lara Maalouf, Carla Zogheib, Alfred Naaman

ABSTRACT

Aim: Compare the efficiency in removing two calcium hydroxide [$Ca(OH)_2$] preparations from root canal and apical third using single use syringe, ultrasonics and RinsEndo® with saline solution.

Materials and methods: One hundred and eighty human single-rooted teeth were instrumented using ProTaper® rotary system, divided into two groups according to $Ca(OH)_2$ filling. A: Powder mixed with water, B: Pulpdent®. Each group was divided into three subgroups for the irrigation: A1, B1: Single use syringe; A2, B2: Ultrasonics; A3, B3: RinsEndo®.

Teeth were split longitudinally, photographed and imported into Adobe Photoshop. The percentage ratios of $Ca(OH)_2$ remaining in the canal and in the apical third were calculated. Data were statistically analyzed using 'ANOVA two-way' and 'univariate tests'.

Results: (a) Remnants of medicament were found in all teeth, (b) no statistically significant difference in the elimination of both $Ca(OH)_2$ from the entire canal ($p = 0.436$), however, mixed powder was better eliminated from the apical third ($p = 0.005$), (c) no statistically significant difference among the irrigation techniques in the whole canal ($p = 0.608$), though, RinsEndo® and ultrasonics were the most effective in cleaning the apical third ($p = 0.032$) when mixed powder was used.

Conclusion: None of the techniques removed completely $Ca(OH)_2$ from the canal. In the apical third, RinsEndo® and ultrasonics were the most effective when mixed powder was used.

Clinical significance: $Ca(OH)_2$, the most commonly used intracanal dressing, should be completely eliminated before the obturation to assure a good endodontic sealing. Based on the results of this study, RinsEndo® and ultrasonics were the most effective in removal of $Ca(OH)_2$ especially the powder mixed with water presentation.

Keywords: Clinical research, Single use syringe, Ultrasonics, RinsEndo®, Calcium hydroxide powder mixed with water, Pulpdent®.

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INTRODUCTION

In modern root canal therapy, calcium hydroxide [$Ca(OH)_2$] is the most commonly utilized intracanal dressing. It has been used clinically to obtain microbial control, dissolve organic remnants, heal periapical inflammation, arrest inflammatory resorption, stimulate hard tissue formation and serve as a temporary obturating material between appointments.[1]

$Ca(OH)_2$ removal before final obturation is routinely accomplished by instrumentation of the root canal with a small endodontic instrument or with the master apical file in combination with a copious irrigation of sodium hypochlorite (NaOCl) or saline, and a final rinse with 17% ethylenediaminetetraacetic acid (EDTA). According to Lee[2] ultrasonic irrigation, which is based on the transmission of energy from an ultrasonically oscillating instrument to the irrigant in the root canal,[3] is more effective in debris removal from the root canal extensions and irregularities than syringe delivery of the irrigant. However, these procedures have not been completely efficient in removing all the material from the canal walls, and the residual $Ca(OH)_2$ may compromise the endodontic sealing. In fact, Margelos[4] showed that an interaction occurs between $Ca(OH)_2$ and eugenol-based sealers, preventing a standard ZOE setting reaction, and consequently altering its sealing ability. Kim and Kim[5] also found that $Ca(OH)_2$ may increase apical leakage after obturation when the zinc oxide-eugenol sealer is used. Çalt and Serper[6] demonstrated that residual $Ca(OH)_2$ prevents penetration of sealer into dentinal tubules.

Most of the previous researches studied the elimination of $Ca(OH)_2$ from the root canal by means of irrigant solutions with chemical activity. The use of NaOCl can be a confounding factor because it is not clear whether the cleaning ability is improved by the chemical activity of the irrigant used or by the effect of the flush itself. Therefore, the aim of the present study is to compare the efficiency of the manual dynamic conventional irrigation with the single use syringe, the ultrasonic irrigation, and the automated dynamic irrigation with the RinsEndo® system (Dürr Dental, Bietigheim-Bissingen, Germany) in removing two different forms of $Ca(OH)_2$ from the entire canal and from the apical third specifically, using saline solution without chemically active adjuvant.

MATERIALS AND METHODS

One hundred and eighty freshly extracted human single-rooted teeth were used in this study. Following extraction the teeth were stored for 2 days at room temperature in 3% NaOCl to remove organic debris. Subsequently they were washed with distilled water and then immersed in 10% formalin solution until use.

Criteria for tooth selection included: A single root canal, no visible root caries, fractures or cracks on examination with a X4–magnifying glass, with a completely formed apex. Roots with not >5° of curvature according to Schneider[7] were considered straight and were included in this study. Preoperative buccolingual and mesiodistal radiographs were exposed for each tooth to confirm the canal anatomy. Only root canals in which the first file that snug at the apex was size 20 were included in this study.

After preparing a conventional access cavity for each tooth, crowns were sectioned with a diamond disk (Intensiv, Switzerland) to obtain the same length of 18 mm for all teeth.

A size 10 k-file (Dentsply-Maillefer®, Ballaigues, Suisse) was introduced into the canal until it was visible at the apical foramen. The working length was determined but subtracting 1 mm from this measurement.

Each canal was instrumented by the same operator to a size 20 using K-file in a solution of RC-Prep (Premier Products Company). The coronal flaring was assured with size 2 and 3 Gates-Glidden drills (Dentsply-Maillefer®, Ballaigues, Suisse). The finition of the preparation was done with the ProTaper® rotary system (Dentsply-Maillefer®, Ballaigues, Suisse) in a crown-down technique. The apical foramen of each tooth was enlarged to a size 30, taper 0.09 (ProTaper F3). Between each instrument, irrigation with 5.25% NaOCl was performed using 5 ml disposable plastic syringes with 27-gauge needle tips (Ultradent Products, Inc., South Jordan, UT, USA) placed passively into the canal, up to 3 mm from the apical foramen without binding.

The teeth were randomly divided into two groups of 90 each, groups A and B. In group A, the teeth were filled with $Ca(OH)_2$ powder mixed with water, and in group B with Pulpdent® paste (Pulpdent Corp, Watertown, MA) using a lentulo paste carriers n°3 (Dentsply-Maillefer®, Ballaigues, Suisse) until the dressing was detected through the apex.[8] The access openings were temporarily sealed with Cavit G (Espe, Seefeld, Germany). The roots were then placed in a natural water saturated sponge and stored in 100% relative humidity at 37°C for 7 days.

The teeth were taken out of the incubator and the Cavit G was eliminated. Each group was divided into three subgroups of 30 teeth each: A1, A2, A3 and B1, B2, B3.

Subgroup A1: $Ca(OH)_2$ was removed using 15 ml of saline solution delivered with a disposable 5 ml syringe and 27 gauge needles (Ultradent Products, Inc), agitated into the canal up to 2 mm from the apical foramen without binding. After each injection of 5 ml of the irrigant, a 20 K-file was inserted to the working length with a filing movement on the canal walls.

Subgroup A2: $Ca(OH)_2$ was removed using a 15 ultrasonic K-file mounted on piezoelectric handpiece: The Suprasson (Pmax, Satelec, Mérignac, France) and agitated for 30 seconds in the canal up to 2 mm from the apical foramen without binding and with continuous saline irrigation. A filing movement of a 20 K-file on the canal walls was done till the working length, and again a 15 ultrasonic K-file was activated for thirty seconds with continuous saline irrigation.

Subgroup A3: $Ca(OH)_2$ was removed using 15 ml of saline solution delivered with the RinsEndo® system which works on the basis of pressure-suction technology: The irrigant is automatically drawn from the attached 5 ml syringe and aspirated into the canal. During the suction phase, used solution is aspirated back.

After each injection of 5 ml of the irrigant, a filing movement of a 20 K-file on the canal walls was done till the working length.

The same irrigation techniques were used respectively for the subgroups B1, B2 and B3.

With a diamond-coated disk (Intensiv, Switzerland), the roots were grooved buccally and lingually without penetrating into the canal space, and then split in half by placing a cement spatula in the grooves and applying pressure. The fractured halves of each root were digitally photographed (Sony DSC-T200) according to the following criteria (Fig. 1):

- 8 mega-pixels image
- Optic enlargement ×4.0
- Macro-option activated
- No flash
- Standardized lighting conditions
- File format TIFF (no compression).

The photographed sections were then imported into Adobe Photoshop to calculate the percentage ratios of $Ca(OH)_2$-coated surface area to the canal surface area, once in the entire canal and once in the apical third alone.

Fig. 1: Example of longitudinally split extracted tooth

The apical third was defined after dividing the total canal length into three equal parts using the ruler option in Adobe Photoshop.

Repeated calculations on the same image by the same operator were performed 1 week later to assess intraobserver reliability, which were 98% after careful calibration.

The images were examined by the same operator to decrease subjective color assessment.

STATISTICAL ANALYSIS

Data were subjected to statistical interpretation using 'two-way ANOVA' and 'univariate tests', with Bonferroni correction, at 95% confidence level ($p < 0.05$).

RESULTS

Remnants of medicament were found in the entire canal, and in the apical third of all experimental teeth regardless of $Ca(OH)_2$ preparation and irrigation techniques used.

When comparing both preparations, no statistically significant difference was found between the remaining percentage of $Ca(OH)_2$ powder mixed with water (16.73%), and Pulpdent® (15.71%) in the entire canal (p = 0.436), regardless of the irrigation techniques, however, the residual of $Ca(OH)_2$ powder mixed with water (19.69%) was less than Pulpdent® residual (25.66%) in the apical third (p = 0.005) (Tables 1 and 2).

Concerning the irrigation techniques, no statistically significant difference was found among the three techniques tested in the entire canal (p = 0.608) (Syringe: 16.8%, Ultrasonics: 15.3%, RinseEndo®: 16.55%) regardless of $Ca(OH)_2$ preparation, however, RinsEndo® (16.15%) and ultrasonics (17.62%) were the most effective in cleaning the apical third when $Ca(OH)_2$ powder mixed with water was used (p = 0.032).

DISCUSSION

The results indicate that none of the three techniques used in this study removed the $Ca(OH)_2$ effectively from the entire canal. However, in the apical third, RinsEndo® and ultrasonics were the most effective when $Ca(OH)_2$ powder mixed with water was used.

The removal of $Ca(OH)_2$ is usually accomplished through several irrigant rinses in conjunction with hand instrumentation and/or ultrasonics. However, in the endodontic literature, there is not a well defined irrigation protocol to adopt for the elimination of $Ca(OH)_2$ by chemical action. In the present experiment, we chose to compare three different mechanical techniques: Single use syringe, ultrasonics and RinsEndo® using saline water to encounter the major inconvenience of the RinsEndo® which is apical extrusion of the irrigant.[9] A 5 ml single use syringe was

Table 1: The percentage of $Ca(OH)_2$ remaining in the canal

	Physiological saline solution + syringe (%)	*Physiological saline solution + ultrasonics(%)*	*Physiological saline solution + RinsEndo® (%)*	*Total (%)*	*p-value*
$Ca(OH)_2$ chemical pure	17.39 ± 11.48	15.16 ± 7.32	14.57 ± 8.14	15.71 ± 9.14	0.422
$Ca(OH)_2$ pulpdent	16.20 ± 8.64	15.45 ± 8.4	18.52 ± 7.88	16.73 ± 8.33	0.369
Total	16.8 ± 10.09	15.3 ± 7.81	16.55 ± 8.195	–	0.608
p-value	0.6	0.899	0.082	0.436	–

Table 2: The percentage of $Ca(OH)_2$ remaining in the apical third

	Physiological saline solution + syringe (%)	*Physiological saline solution + ultrasonics (%)*	*Physiological saline solution + RinsEndo® (%)*	*Total (%)*	*p-value*
$Ca(OH)_2$ chemical pure	25.27 ± 21.09	17.62 ± 11.26	16.15 ± 8.66	19.69 ± 15.07	0.032*
$Ca(OH)_2$ pulpdent	27.00 ± 15.69	22.77 ± 11.02	27.19 ± 12.7	25.66 ± 13.28	0.398
Total	26.14 ± 18.45	20.15 ± 11.35	21.77 ± 12.16	–	0.061
p-value	0.637	0.160	0.003*	0.005*	–

*Mean with the same letter is significantly different at the p = 0.005

adopted as the one provided by the manufacturer with the RinsEndo® device to have the same volume of irrigant in both techniques. Concerning the ultrasonics, because we found that it is difficult to clinically control the total volume of the continuous saline irrigation, we preferred to set a limited working time.

Concerning the preparation of the teeth for the evaluation of the $Ca(OH)_2$ remnants, some authors as Kenee,[10] and Van der Sluis[11] suggest to use the same teeth for the different techniques in test. On one hand, standardization of canals was attained through their repeated use of the same tooth, controling thus, the variables of canal shape and curvature. On the other hand, the risk of additive elimination of $Ca(OH)_2$ by the technique of section was decreased. In this study, intact teeth were used for each group to avoid a possible leakage between the joint of the two halves, and therefore a leak of the irrigant and remnants at this level, which does not reproduce anymore the clinical situation where remnants are eliminated only coronally. Furthermore, the fact of using again the same tooth after passage of the cleaning instruments particularly an ultrasound file combined to a chemical solution, may alter the dentinal surface, and afterward entail bias in the experiment.

For the overall root canal wall cleanliness, the results of this study did not corroborate those of previous reports[10,12] which found that ultrasonic irrigation is more effective than syringe irrigation. This could be a result of the mandibular mesial canals used in Kenee's[10] experiment, canals presenting in general an increased curvature, thus restricting the depth of the needle's penetration. Another explanation can be correlated to the choice of the irrigant. In fact, the extra capacity to remove materials from the root canal of passive ultrasonic irrigation with NaOCl as irrigant does not occur when saline water is used. This can be due to the difference in the physical properties of these solutions;[11] NaOCl is a salt water suspension. Bubbles formed in salt water tend to be more numerous, particularly the smallest bubbles, and are less prone to coalesce than bubbles in fresh water.[13] Because the smallest bubbles are more numerous, the acoustic microstreaming will be different and could perhaps be more powerful.

It is also possible that the fact of reutilizing the same teeth for the different groups in the study of Kenee[10] (1: Syringe + NaOCl, 2: Syringe + NaOCl + EDTA, 3: Profile, 4: Ultrasonics) could have altered the results, principally since syringe irrigation was the first one used, and ultrasonic irrigation was the last, knowing that EDTA and profile instruments can modify the dentinal surfaces.

The remaining quantity of $Ca(OH)_2$ in the apical third was also estimated given the difference of the distribution of the dressing in the canal. In fact, a statistically significant difference was found among pure $Ca(OH)_2$ (group A), and Pulpdent® paste (group B) which demonstrated higher retention capacity. This is in agreement with the results of Lambrianidis.[14] Probably methylcellulose, contained in Pulpdent® to increase its handling properties, resists dissolution and removal of $Ca(OH)_2$ by the aqueous irrigation solutions.

When using the Pulpdent® paste, no statistical significant difference was found among the various irrigation techniques. However, when $Ca(OH)_2$ powder mixed with water was used, RinsEndo® and ultrasonics were the most effective. We can notice that the elimination of $Ca(OH)_2$ powder mixed with water can be affected by the mechanical action of instruments. However, with the Pulpdent® paste, a chemical dissolution can be more efficient. The improvement of hydrodynamic rinsing over the conventional methods was also demonstrated by Hauser,[9] and by Pouch[15] who found in their study that the apical third was best cleaned by RinsEndo®. These findings are different from those of Vivan[16] who found that there was no difference between RinsEndo® and conventional irrigation. In fact, this device, which represents an automated irrigation technique, offers a pulsed movement of the irrigant making the jet more targeted and more effective at the level of a narrow space. This would explain the lack of difference found in our study between RinsEndo® and the other techniques in the entire canal.

CONCLUSION

None of the three techniques used in this study removed the $Ca(OH)_2$ completely from the entire canal, with no statistically difference between. However, in the apical third, RinsEndo® and ultrasonics were the most effective when $Ca(OH)_2$ powder mixed with water was used. More investigations are recommended on the mechanical means that will effectively remove $Ca(OH)_2$ before final obturation of the root canal to reduce side effects and optimize the benefits of this interappointment medicament in endodontic treatment.

CLINICAL SIGNIFICANCE

$Ca(OH)_2$, the most commonly used intracanal dressing, should be completely eliminated before the obturation to assure a good endodontic sealing. Based on the results of this study, RinsEndo® and ultrasonics were the most effective in removal $Ca(OH)_2$ especially the powder mixed with water presentation.

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ABOUT THE AUTHORS

Lara Maalouf (Corresponding Author)

Assistant, Department of Endodontics, Saint Joseph University, Beirut Lebanon, e-mail: laramaalouf@hotmail.com

Carla Zogheib

Assistant Professor, Department of Endodontics, Saint Joseph University, Beirut, Lebanon

Alfred Naaman

Professor and Head, Department of Endodontics, Saint Joseph University, Beirut, Lebanon