Effect of 2% Chlorhexidine Gel Mixed with Calcium Hydroxide as an Intracanal Medication on Sealing Ability of Permanent Root Canal Filling: A 6-month Follow-up

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Abstract
The present study was conducted to determine the influence of 2 intracanal medicaments (calcium hydroxide, chlorhexidine gel 2%) when used either alone or combined on the short- and long-term sealing ability of permanent root canal fillings. Ninety human upper central incisors were divided into 4 experimental groups (n = 20). All root canals were instrumented in a step-back motion and then treated as follows: group I, root canal dressing with calcium hydroxide for 2 weeks and then obturation with laterally compacted gutta-percha and AH26 sealer; group II, chlorhexidine gel 2% for 2 weeks and obturation as in group I; group III, dressing with a new paste made by mixing calcium hydroxide plus chlorhexidine gel 2% for 2 weeks and obturation as described previously; group IV, immediately obturated with laterally compacted gutta-percha and AH26 sealer. Leakage along root canal fillings was measured using the transport fluid model. Short-term measurements were carried out for 3 hours after 24 hours equilibrium establishment. Leakage was measured again at 6 months after the initial measurement. At 3 hours, no significant differences were found among the 4 experimental groups. Long-term measurements showed that also at 6 months no significant differences were observed between the group IV and the other 3 experimental groups. Under the conditions of the present study, it could be supported that none of the medications used seemed to affect negatively neither the short- nor the long-term sealing ability of the tested obturation technique. On the basis of these results and because of its increased antimicrobial action as it is supported in the literature, the new paste made of calcium hydroxide plus chlorhexidine gel 2% can be proposed for use in clinical practice without affecting the sealing ability of root canal obturation. (J Endod 2008;34: 866–870)

Key Words
Calcium hydroxide, chlorhexidine gel, fluid transport model, leakage, root canal obturation, sealing ability

The adequate and 3-dimensional obturation of root canal system is of prime clinical importance for the long-term success of endodontic treatment (1). This seal is developed mainly to minimize the leakage along root canal fillings and to protect the periapical tissues from bacteria and their by-products (2, 3). Coronal leakage is a phenomenon implicated in all steps of endodontic therapy, and it might lead to treatment failure (4).

The use of intracanal medications for root canal system disinfection has been supported to improve the treatment outcome (5). Intracanal medications are mainly used to reduce or eliminate bacteria located inside the root canal system and to prevent their proliferation between therapy appointments (6, 7). Among the available intracanal dressings, calcium hydroxide is most indicated for use in clinical practice (8). Its antimicrobial action is related to its high pH, which results in the inactivation of bacterial membrane enzymes (9). However, calcium hydroxide has been found to be insufficient in the elimination of both facultative anaerobes and yeasts (10–13). On the other hand, chlorhexidine gluconate has been recommended as an irrigation solution and intracanal medication because of its strong antibacterial activity against gram-positive and gram-negative microorganisms as well as yeast, facultative anaerobes and aerobes (14, 15). Chlorhexidine was introduced to increase the antibacterial action of traditionally used intracanal medications and to eliminate microorganisms associated with persistent infections and treatment failure (16, 17). The mixture of these 2 aforementioned medicaments has been suggested in the literature to obtain a wide-spectrum antimicrobial action (14, 15, 18–20).

The influence on leakage of an obturated root canal system is an important factor for consideration when an intracanal medicament has been previously placed for root canal disinfection (21–27). In such cases, leakage along root canal fillings is mainly expected to occur between dentin and filling material (gutta-percha or sealer). This view seems reasonable because it is supported that residual medicament might compromise the adaptation of filling materials on root canal walls (28).

Contradictory results have been reported by dye leakage studies regarding the sealing ability of a root canal filling when a medication has been previously used for root canal disinfection (21–23, 25). However, when different, more reliable experimental models (fluid transport model, bacteria) were used, similar results were obtained. In these cases, no significant differences were found in terms of leakage between specimens that received an intracanal medication and those without any previous placement of medicament (23, 26, 27).

To date, only one study has investigated whether intracanal placement of 2% chlorhexidine gel affects the sealing ability of an obturated root canal system (26). Moreover, no study has been reported regarding the influence of a mixed intracanal medication containing calcium hydroxide powder and 2% chlorhexidine gel on sealing ability. The aim of the present in vitro study was to evaluate the short-term and long-term sealing abilities of permanent root canal fillings after the placement of calcium hydrox-
ide and 2% chlorhexidine gel when used either alone or combined with fluid transport model.

Materials and Methods

Specimen Preparation

A total of 96 single-rooted human teeth (upper central incisors) were used in the present study. The teeth were kept in normal saline solution at 4°C until use. Initially, the teeth were immersed in 5% sodium hypochlorite (NaOCl) for 10 minutes to remove any organic components from the root surfaces. The crowns were removed with a diamond disk (Komet; Brasseler GmbH, Lemgo, Germany) so that the length of the roots was standardized at 10 mm. An operating microscope (Protégé plus; Global Surgical Inc) was used to examine the roots for cracks under magnification of 19.2×. A #10 K-file (Dentsply-Maillefer, Ballaigues, Switzerland) was inserted to the root canal to establish the working length 1 mm short of the apical foramen. The working length was established at 9 mm. The same K-file was passed through the apical foramen of the canals during and after instrumentation to ensure apical patency.

Mechanical instrumentation of the root canals was carried out serially to a size 40 K-file as master apical file (MAF). A step-back technique was used for the subsequent 4 file sizes larger (No. 60) than the MAF. The coronal 4 mm of root canals was instrumented by using Gates-Glidden drills (Dentsply-Maillefer) No. 2 at 4 mm, No. 3 at 2 mm, and No. 4 at 1 mm. A total of 5 mL of 2.5% NaOCl was used for irrigation of the canals between instruments with a syringe and a 27-gauge needle (Endo-Eze; Ultradent Products, Salt Lake City, UT). Five milliliters of 17% ethylenediaminetetraacetic acid (EDTA) (Vista Dental Products, Racine, WI) was used after the completion of instrumentation with K-files and Gates-Glidden drills, respectively, to remove the smear layer. Final irrigation of all root canals was performed with 5 mL of NaOCl 2.5% per specimen, and the canals were finally dried with sterile absorbent paper points. The prepared roots were randomly divided into 4 experimental groups of 20 roots each and 2 control groups of 5 roots each and treated as follows.

In group I, the root canals of this group were filled with chemically pure calcium hydroxide paste placed for 2 weeks. Powder of calcium hydroxide (Henry Schein Company, Melville, NY) was mixed with distilled water at a powder to liquid ratio of 6:4. The paste was introduced with a size #35 lentulo spiral filler (Antaeos; Vereinigte Dentalwerke & Co, Munich, Germany) and packed with a plugger (Schilder plugger, 0.7 mm; Dentsply-Maillefer) into the prepared root canals until the medicament was extruded beyond the apical foramen. Three millimeters of calcium hydroxide was then removed from the coronal part of each root canal.

In group II, chlorhexidine gel 2% (Ultradent Products) was placed into the root canals of this group with an Ultradent Capillary Tip (Ultradent Products). Gel was packed with the use of a cotton pellet until the medicament was visible at the apical foramen.

In group III, powder of chemically pure calcium hydroxide was mixed with 2% chlorhexidine gel to a creamy consistency on a glass plate (2 g calcium hydroxide powder was used per mL of 2% chlorhexidine gel) (15). This new paste was introduced with a lentulo spiral filler (ISO size No. 35) and packed with a plugger until the paste was extruded beyond the apical foramen. Three millimeters of this new paste was then removed from the coronal part of each root canal.

All root canals of the 3 above groups were sealed with a 1-mm cotton pellet and a 2-mm layer of temporary filling material (Cavit G; 3M ESPE AG, Seefeld, Germany). After that, the roots were stored at 37°C and 100% relative humidity for 14 days. At that time, the temporary material was removed with a slow-speed #2 round bur. Each canal was initially irrigated with 2 mL of NaOCl 2.5%. The medicaments were removed with the MAF at the working length in a circumferential filing motion. A second irrigation with 5 mL of NaOCl 2.5% took place followed by irrigation with 5 mL of EDTA 17% for 3 minutes and then final rinse with 5 mL of NaOCl 2.5%. Each canal was dried with 6 absorbent paper points per specimen.

Two additional roots of the first 3 groups were grooved longitudinally from buccal and lingual directions at the maximum buccolingual diameter without entering the root canal and were split into halves with a pair of pliers. Sections were cleaned from any remnants of cementum and dentin particles with a short blast of air. The internal surfaces of the sections (root canal walls) were observed with an operating microscope (Protégé plus; Global Surgical Inc) under magnification of 19.2×.

In group IV, the root canals of this group were immediately obturated as described below without any previous placement of intracanal medicament.

All root canals were obturated with gutta-percha and AH26 root canal sealer (Dentsply DeTrey GmbH, Konstanz, Germany) by using the cold lateral compaction technique. AH26 sealer was prepared according to the manufacturer’s instructions. Sealer was applied with a size 40-K file used in a counterclockwise motion. An ISO size 40 master gutta-percha cone was inserted into the root canal to the working length until tug-back was obtained. The master gutta-percha cone was then coated with AH26 sealer and was placed into the root canal to the working length. After placing the master cone, a size No. 30 nickel-titanium spreader was inserted into the canal to a level approximately 2 mm short of the working length. Lateral compaction with accessory gutta-percha cones No. 25 was performed until the root canal was filled. Excess gutta-percha was removed with a System B condenser at the level of coronal surface and vertical force was applied with a vertical compactor to compact the remaining mass.

In group V, the roots of this group were filled with laterally compacted gutta-percha without sealer and served as positive controls.

In group VI, the roots of this group were sealed with gutta-percha and AH26 sealer, covered entirely with 2 coats of nail varnish, and served as negative controls.

After the obturation, radiographs were taken to ensure that the obturation material was placed completely throughout the canal length and width. Obturated roots were then stored in gauze and placed in an incubator for 48 hours at 37°C and 100% humidity to allow the sealer to set.

Leakage Assessment

After 48 hours, teeth were transferred to the laboratory. Leakage along all root canal fillings was measured by using fluid transport model. With a headspace pressure of 60 KPa (0.6 atm), distilled water was forced through a plastic tube attached to the coronal end of the root specimen. The apical end of each root was tied to another plastic tube connected to a 20-µL glass capillary tube 170 mm long (Haak, Waller-Graf & Co, Wertheim, Germany). An air bubble about 3 mm long was introduced through the open end of the capillary. All connections were closed tightly by twisting pieces of stainless steel wire. Fluid conduction through the root filling was performed by applying pressure for 3 hours after an interval period of 24 hours necessary for air bubble stabilization. The transport fluid results (F, Flow) were expressed in µL/h and divided into 5 categories: (1) F = 0 (no leakage, NL), (2) 0 < F < 20 (slight leakage, SL), (3) F > 20 (gross leakage, GL).

After the initial leakage measurement at 3 hours, the specimens of each group were detached from the measuring apparatus. Leakage was measured again 6 months after the initial assessment. Between the measurements, the roots were kept at 37°C in pieces of moist sponge.
TABLE 1. Transport Fluid Results (F in μL/h) at 3 Hours and 6 Months

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<tr>
<th>Group</th>
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<td>F = 0 μL/h</td>
<td>0 &lt; F &lt; 20 μL/h</td>
<td>F &gt; 20 μL/h</td>
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<td>Group I</td>
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6 months:
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GL, gross leakage; NL, no leakage; SL, slight leakage.

**Statistical Analysis**

Chi-square statistical analysis was used to investigate differences in terms of leakage frequencies among the 4 study groups for the 2 periods tested. All tests were 2-sided, and the level of statistical significance was set at 95% (P < .05).

**Results**

Gross leakage was recorded in the positive control group (L > 20 μL/h), whereas in the negative control group no leakage was observed (L = 0 μL/h). The transport fluid results at 3 hours for the 4 experimental groups are illustrated in Table 1. No statistically significant differences were found at 3 hours among the experimental groups (P = .989).

At 6 months, χ² test showed no statistically significant differences among the groups (P = .837). The transport fluid results at 6 months for the 4 experimental groups are illustrated in Table 1.

Examination of the root canal wall surfaces of the 6 pilot specimens revealed various amounts of residual medicaments regardless of the material used in each case. In the calcium hydroxide group, remnants were observed at the apical third as well as at the cervical level of root canals (Fig. 1A, B). In the calcium hydroxide plus chlorhexidine gel 2%, remnants of the paste were observed again at the apical and cervical thirds of the canals (Fig. 1C, D). However, in the chlorhexidine gel 2% group, large amounts of gel remnants were associated not only with apical and cervical levels but also with the middle third of the canals (Fig. 1E, F).

**Discussion**

The short-term and long-term sealing abilities are considered to be 2 very important properties for all root canal filling materials. Leakage studies are performed to evaluate these properties under several circumstances as described in the present study. Also, it is very important to obtain leakage data measurements repeatedly after filling and during a long period of time, because the long-term sealing ability is a prerequisite for each tested obturation technique and filling material (29).

The results of the present study showed that at the 48-hour measurement no significant differences were observed in terms of leakage between the 4 tested groups. Long-term leakage measurements also showed no statistical differences between tested groups. However, more leakage was detected at 6 months for all tested groups in relation to the short-term (48 hours) measurements. This increasing leakage along root fillings observed at the 6-month measurement might be attributed to the possible dissolution of the root canal sealer over time (30).

Despite its viscous consistency, the new paste made by mixing calcium hydroxide and chlorhexidine gel 2% was found not to influence the sealing ability of the tested obturation technique. On the basis of the observations of the root canal walls of the pilot specimens, it is possible that the removal of this paste can be done more easily in relation to the removal of chlorhexidine gel 2%. But this supposition should be confirmed by future studies regarding the removal efficacy of this medicament.

On the basis of the results of the present study, it seems that the sealing ability of cold lateral compaction technique with AH26 as a root canal sealer is not adversely affected by the placement of any previous intracanal medicament tested. This result was obtained despite the fact that residual medicaments were observed at the internal surfaces of pilot specimens. Under these conditions, all the materials tested including the new mixing paste (calcium hydroxide plus chlorhexidine gel 2%) could be proposed for use in clinical practice.

The above results are in agreement with those of previous similar studies conducted under experimentally controlled conditions (23, 26, 27). These studies have supported the view that medication with calcium hydroxide or 2% chlorhexidine gel for 2 weeks does not influence the sealing ability of root canal obturation when using various types of root canal sealers. It is noteworthy that all these studies have recorded similar results with reliable leakage models such as fluid transport and bacteria.

On the other hand, studies that used dyes for leakage measurement have reported conflicting results regarding the influence of intracanal medication on sealing ability of root canal obturation (21–25). Of the above studies, 3 observed less dye penetration in the groups that received previous intracanal medication (calcium hydroxide) (21–23). However, this might be explained by the presence of residual calcium hydroxide, which has been found to decolorize methylene blue, providing false-negative results (31). These results showed clearly the severe limitations of dye leakage tests regarding their previously reported low sensitivity and clinical relevance (32, 33).

The short-term and long-term results for group IV (without previous placement of medicament) are quite similar to those found in previous studies (23, 34) in which same leakage test was used, indicating the reproducibility of fluid transport model. Regarding the removal efficacy of medicaments tested in the present study, it seems that none of them were removed satisfactorily from the root canal walls. On the basis of these limited observations, it is possible for chlorhexidine gel 2% to be removed more difficultly compared with the other 2 medicaments.

Under the conditions of the present study, none of the medications used before the root canal obturation seemed to affect negatively either...
the short- or the long-term sealing ability of the tested obturation technique with AH26 as a root canal sealer. Further studies with reliable models are needed in the future (eg, bacteria leakage test) to confirm the above results and to assess a common view regarding the influence of the placement of any intracanal medicament before the root canal system obturation.

References


Figure 1. (A) Root canal walls (1st specimen) after removal of calcium hydroxide paste. Note remnants of the medicament at coronal third of the canal. (B) Root canal walls (1st specimen) after removal of calcium hydroxide paste. Note remnants of the medicament at apical third of the canal. (C) Root canal walls (1st specimen) after removal of calcium hydroxide/chlorhexidine gel paste. Note relative cleanliness of root canal walls. (D) Root canal walls (2nd specimen) after removal of calcium hydroxide/chlorhexidine gel paste. (E) Root canal walls (1st specimen) after removal of chlorhexidine gel paste. Note characteristic patterns of residual medicament at all levels of the canal. (F) Root canal walls (2nd specimen) after removal of chlorhexidine gel paste.


