An in vitro evaluation of environmental pH changes after root canal therapy with three different types of calcium hydroxide

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ABSTRACT
Objective: This study determined environmental pH changes after root canal dressing using 3 types of commercial calcium hydroxide pastes.

Methods: Thirty-two extracted single-rooted human premolars with 1 straight root canal were selected. Standard cavities were prepared on root surfaces. All root surfaces, excluding the cavities, were covered with nail polish. Root canals were prepared using the Easy RaCe rotary system. The teeth were randomly divided into 3 experimental groups filled with calcium hydroxide pastes: (Group 1) Sure-Paste, (Group 2) Meta-Paste, and (Group 3) Multi-Cal. The control group had 2 samples. Teeth were then placed in 10 mL of normal saline. Environmental pH values were measured at 1 h, 24 h, 48 h, and 1 week. Statistical evaluations of the results were performed via the ANOVA and Tukey tests.

Results: Results demonstrated that groups 3 and 1 showed a significant statistical difference (P<.001) with the pH being greater in group 3. There was no significant difference between groups 2 and 3 (P>.05). Intracanal placement of Multi-Cal compared with that of Sure-Paste and Meta-Paste resulted in a higher pH in simulated root resorption defects.

Conclusion: In cases, like apexification, that need longer pH changes and higher disinfecting qualities, it might be better to use Multi-Cal, and for short-time use as disinfectant medicament Multi-Cal and Meta-Paste are equally effective. [Eur J Dent 2013;7:69-73]

Key words: Calcium hydroxide; pH; intracanal dressings; root surface defects

INTRODUCTION
Calcium hydroxide, introduced by Herman in 1930, is considered the most common intracanal medicament because of its ability to promote hard tissue formation, antibacterial action,¹ dissolution of organic tissue,² an alkalizing effect, and control of inflammation and root resorption.³ Its long-term efficacy is due to 2 properties: the destruction of bacterial cytoplasm membranes by the liberation of hydroxyl ions, and the activation of tissue en-

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zymes like alkaline phosphatase. The Ca(OH)2 antibacterial action is due partly to the fact that it produces a pH of over 11. Necrotic teeth had a pH of 6.0-7.4 in the pulp dentin and periodontal ligament; however, after calcium hydroxide intracanal placement, the teeth showed a pH range in the peripheral dentin of 7.4-9.6. The therapeutic effectiveness of calcium hydroxide dressing materials is based on the release of hydroxyl ions causing an increase in pH. Calcium hydroxide exerts antibacterial effects in the root canal as long as it retains a very high pH. As the contents of commercial pastes differ, they may release hydroxyl ions in varying degrees that affect the pH of calcium hydroxide. Thus, this study aimed to evaluate environmental pH changes after root canal dressing with 3 types of commercial calcium hydroxide pastes and to determine whether the pH of these pastes changes with time. The null hypothesis tested was that there is no difference between the 3 kinds of materials.

**MATERIALS AND METHODS**

This in vitro study was conducted using 32 freshly extracted human adult premolars with single roots, 14-16 mm in length. These teeth had no fractures, cracks, or resorption. They were disinfected by immersion in 5.25% sodium hypochlorite (NaOCl) for 1 h and stored in normal saline (NaCl 0.9%) until use. Access cavities were created using a diamond bur with an air turbine hand-piece. A =10 K-file (Dentsply Maillefer, Ballaigues, Switzerland) was placed in the canal until it was just visible at the apex to determine patency and 1 mm was subtracted to establish working length.

The instrumentation sequence consisted of the Gates-Glidden burs (Dentsply Maillefer, Ballaigues, Switzerland) in sizes 3 and 4 for the coronal portion, and preparation followed using the Easy RaCe crown-down kit (FKG Dentaire, La-Chaux-de-Fonds, Switzerland) according to the manufacturer’s guidelines. An Endo IT control electric motor (VDW, Munich, Germany) was used. Prep-Rite RC (Pulpdent, USA), a viscous gel containing 17% EDTA, was used as a lubricant, and canals were irrigated with 5.25% NaOCl (Pakshoma, Tehran, Iran) throughout the instrumentation sequence. Following the cleaning and shaping procedure, each canal was finally flushed with 10 mL of distilled water.

After canal preparation, teeth were mounted in a wax model dental arch to improve device accuracy. In this study, we used the Promax 3D CBCT X-ray unit (Planmeca, USA). CT scan sections were obtained from the middle one-third, so dentin and cementum thickness were evaluated in this section.

One 2 X 2 mm cavity was then prepared on the buccal root surface in the middle one-third of the root. Cavities ended 1 mm from the inner canal wall based on an assessment of dentin thickness from the preoperative CT scans. The smear layer in the cavities was removed by irrigating with 17% EDTA for 3 min and subsequently with 5.25% NaOCl. The teeth were rinsed with distilled water, and then, the canals were completely dried with paper points (Orca, China).

All the teeth surfaces except for the cavities on the roots were sealed with 2 coats of nail polish. The 32 teeth were then randomly divided into 3 groups of 10 and a control group of 2:

- **Group 1**: Sure-Paste calcium hydroxide (Suredent corp, Seongnam-si, Korea).
- **Group 2**: Meta-Paste calcium hydroxide plus barium sulfate (Meta Biomed Co., Ltd., Korea).
- **Group 3**: Multi-Cal calcium hydroxide (Pulpdent, Watertown, USA).

All of these 3 pastes were water-soluble pastes. In all groups, calcium hydroxide paste was introduced directly via a syringe needle just 1 mm shorter than the working length, followed by backfilling. After calcium hydroxide placement in each group, a radiograph was taken to ensure that the entire canal was filled consistently with Ca(OH)2 up to the working length.

For the control group nothing was applied to the root canals.

The access cavities were sealed with a glass ionomer (Fuji II GC Corporation, Tokyo, Japan). The teeth were placed in individual vials containing 10 mL NaCl 0.9% (9g NaCl/1000 mL sterile water) and stored at 37°C. The pH was measured at baseline after 1 h, 24 h, 48 h, and 1 week using a pH meter (Metrohm 620, Switzerland) for each sample. The pH meter was calibrated with known standard pH solutions of 4, 7, and 10 and carefully rinsed with distilled water between the teeth.
Statistical Analysis

A repeated measurement test was used to compare pH values for each type of calcium hydroxide at different times. One-way analysis of variance (ANOVA) was used to compare the pH values for different types of calcium hydroxide in different periods, and the Tukey test was used to determine whether there was a significant relationship between different materials or between different intervals.

RESULTS

The mean pH values recorded for the 3 experimental groups at different times are presented in Table 1. The Multi-Cal calcium hydroxide group showed the highest baseline pH, followed by the Meta-Paste group. The lowest was recorded for Sure-Paste (P<.001, P<.05).

Table 1 show that the mean pH values in the Sure-Paste group had a constantly increasing trend. In the Multi-Cal experimental group, the mean pH values had a decreasing trend. There was a statistically significant difference among the pH values for these 2 types of calcium hydroxide in all periods (P<.001).

However, no statistically significant differences were found in pH values between the Sure-Paste and Meta-Paste groups or the Meta-Paste and Multi-Cal groups in any of the periods (P>.05).

Group 1 showed significant differences between 1 h and 24 h, and 1 h and 48 h. Group 2 showed significant difference between 48 h and 1 week; and group 3, between 1 h and 1 week.

DISCUSSION

The therapeutic effects of calcium hydroxide depend on the dissociation of calcium and hydroxyl ions and the availability of hydroxyl ions. When the number of hydroxyl ions is greater, the pH is higher. As the contents of commercial pastes are different, they may release hydroxyl ions in varying degrees, which affects the pH of calcium hydroxide. Components which are mixed with Ca(OH)₂ include various vehicles, such as glycerin, propylen glycol, olive oil, methylcellulose, distilled water, saline, and anesthetic solutions. Hansen et al. in their study, showed that in various root levels, pH values differed, and this may be related to the orientation and number of dental tubules in each level. According to Pérez et al., dentinal pH depends on the type of calcium hydroxide used, where it is placed, and the timing. Therefore, in the current study, cavities were prepared on the buccal root surfaces at the middle one-third to eliminate one of these intervening factors, thus making the dentinal tubules similar in size and direction.

It has been shown that reduction of dentin thickness has the potential to lessen buffering capacity. On the other hand, Tsesis et al. found that dentin thickness was a difficult variable to control. To obtain identical dentinal thickness in all samples, cone beam computed tomography (CBCT) was used in this study. The cavities ended 1 mm from the inner canal wall based on the CT assessment of dentin thickness. pH changes affected by smear layer removal from intracanal dentin and root surface defects, the smear layer was removed from instrumented canals but not from the cavities to simulate clinical condition. In previous studies, the teeth were immersed in saline or distilled water. In this study saline was chose as immersion media. Pacios et al., in their study, found that the pH of many Ca(OH)₂ pastes at different intervals remained constant, and Ca(OH)₂ with water as vehicle had a higher pH. In this study, all paste formulations were water soluble.
as manufacturers mentioned. Furthermore, it has been concluded that Ca(OH)₂ in a paste formulation remained in the root canal for a longer period, and delayed recontamination.¹⁹

Hansen measured pH changes in actual root surface cavities,¹² but the other studies checked it in immersion media. In this study, we chose to measure the immersion media pH and replaced the solution to facilitate diffusion in areas of defects to simulate in vivo situation. Sjogren et al²⁰ demonstrated that all bacteria in root canal were eliminated after 7-day Ca(OH)₂ dressing. The intervals in this study were designed as per Yucel et al, who concluded that Ca(OH)₂ mixture might be left in place for at least 7 days.

Several methods like fluorometry, flame photometry, and ultraviolet spectrophotometer have been used in order to measure pH changes.¹⁶,²² In this study, we used a Digital pH meter like Paicos et al¹⁸ because of its cost benefits and availability.

The difference between the present study and the previous one could be attributed to the experimental condition, measuring time, and composition of Ca(OH)₂ mixtures and immersion solutions.

According to the results in different periods, there was no constant reduction or increase in pH values for the 3 mixtures. It is in contrast with Tronstad et al²³ and Esberard,²⁴ who reported the maintaining of pH in long periods.

The results obtained with pH reduction after 1 h are in agreement with Calt et al,²⁵ who demonstrated a gradual but not statistically significant reduction of the pH values throughout the test period. This was explained by the dentin’s buffering ability and charge. OH⁻ may be absorbed into the hydrated layer of hydroxyapatite, thus decreasing its diffusion along the dentinal tubules. Rapid diffusion of Ca²⁺ and its increased concentration in the surrounding media may lead to a drop in pH values. The pH measurements obtained in the current study were all higher than those in Calt’s study, which may be attributed either to the usage of EDTA or the difference in chemical contents (the types of calcium hydroxide used). According to Ardesha et al,²⁶ the chelating agent may also affect pH dynamics. In this study, EDTA was used only to eliminate the smear layer; however, in their study, Calt et al²⁵ irrigated both root canals and external defects with EDTA resulting in an increase in the diffusion rate of Ca²⁺.

The pH values of Sure-Paste calcium hydroxide gradually increased during the experimental periods, concurring with the findings of Pérez et al.⁴ Poorni et al,² additionally, concluded that the different contents in calcium hydroxide pastes could affect ion diffusion into the dentinal tubules by affecting the surface tension of calcium hydroxide pastes. In contrast, Beltes et al,²⁷ found similar pH values despite the difference in the contents of the calcium hydroxide pastes used. In the present study, there were no significant differences in pH values between the Sure-Paste and Meta-Paste groups or the Meta-Paste and Multi-Cal groups, but there was a significant difference in the pH values obtained between the Sure-Paste and Multi-Cal groups in all periods. The null hypothesis was rejected. However, comparing the outcomes with such studies like that of Beltes et al²⁷ should be done with caution because in their study the most important factor (the tooth) was absent. Many studies are in accordance of peripheral pH reduction almost around 6-7.4,²³,²⁸ but in this study dropping of pH was almost around 9.

Previous studies have demonstrated enhancement of antimicrobial action of Ca(OH)₂ in combination with CHX.¹₂,²⁹ As E. faecalis can survive in alkaline environment (pH ≈ 11),³⁰,³¹ reinforcement of various Ca(OH)₂ pastes by addition of any other disinfectant material such as CHX could be designed in another study.

**CONCLUSION**

In cases like apexification that need longer pH changes and higher disinfecting qualities, it might be better to use Multi-Cal, and for short-time use Multi-Cal and Meta-Paste are equally effective.

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