To Evaluate and Compare Effect of Calcium Hydroxide with Different Vehicles on the Mineral Content of Root Dentin: An EDAX Analysis

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ABSTRACT

Introduction: The aim of this study is to evaluate and compare effect of calcium hydroxide with different vehicles on the mineral content of root dentin—an EDAX analysis, after 1, 2 and 3 weeks.

Materials and methods: Seventy-five freshly extracted single rooted teeth were selected for study and randomly divided into 5 groups. An access to the root canal of all teeth was prepared using a round and cylindrical bur (Mani Inc.). Canals were instrumented with stainless steel K file (Dentsply Maillefer, Johnson City, TN) so that the file extended beyond the apical foramen by 1 mm. And then canals were prepared to a size F2 with hand proTaper (Dentsply Maillefer, Johnson City, TN). Copious irrigation with sterile saline was done. Sample of group 1—were sealed apically with bonded composite resin and coronally with cotton pellet and bonded composite resin. Samples of group 2—were filled with thick slurry made with calcium hydroxide and saline using lentulo spiral (Henry Schein). To ensure intimate contact with the canal walls, excess calcium hydroxide was intentionally extruded past the apex. Root canals were sealed apically and coronally in the same manner as in previous group. Samples of group 3—CalciGel (water based calcium hydroxide, Prevest Denpro Ltd), group 4—Metapex (oil based calcium hydroxide, Meta BioMed) and group 5—Calcium hydroxide and propylene glycol, were prepared in the same manner as previous group. The samples were maintained at room temperature and 100% humidity in incubator. After 7 days, 5 samples from each group were removed from incubator and the roots were vertically sectioned into 1 mm thick specimen with water cooled diamond disk. Each section of sample was then evaluated under EDAX. After 14th and 21st day 5 samples of each group were removed and tested in same manner as mentioned previously.

Keywords: CalciGel, Metapex, Propylene glycol, EDAX analysis.

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INTRODUCTION

Calcium hydroxide was introduced in endodontics by Hermann in 1920.¹ Use of calcium hydroxide in dentistry is well established and wide spread. It has been used extensively in multiple endodontic applications. Ca(OH)₂ is widely accepted as an interappointment intracanal medicament.² Calcium hydroxide application have been well documented in the scientific literature,³⁻⁶ including its use for root canal disinfection, the induction of calcification response, and the promotion of apexification. When placed within the root canal system, Ca(OH)₂ disassociates into calcium and hydroxyl ions,⁷ and the hydroxyl ions diffuse through the dentinal tubules.^{8,9} The high pH and antimicrobial properties of Ca(OH)₂,¹⁰ combined with the permeability of dentin,^{11,12} may account for its effectiveness as an intracanal inter-appointment medicament. However, when Ca(OH)₂ is used in these applications, therapy may extend from months to years before the desired effects are achieved.^{13,14} Furthermore, it has been observed that Ca(OH)₂ treated immature teeth show a high failure rate because of an unusual preponderance of root fracture and it has been suggested that changes in the physical properties of dentin by the Ca(OH)₂ medicament may be responsible.^{15,16}

Exposure of root dentin to the bioactive effects of Ca(OH)₂ may affect its physical characteristics and could have important clinical implications for the treatment of traumatized teeth and immature teeth with nonvital pulps. The purpose of the present study was to determine if intracanal exposure to Ca(OH)₂ for 30 and 180 days alters the fracture resistance of human root dentin.

MATERIALS AND METHODS

Seventy-five freshly extracted single rooted single canal human teeth were chosen for study. Before preparation teeth were stored in sodium hypochloride for 24 hours to dissolve any tissue on the root surface. The teeth were then scaled with an ultrasonic scaler (EMS, Mectron) to remove any deposits, concretions, calculus if present on root surface.

An access to the root canal of all teeth was prepared using a round and cylindrical bur (Mani Inc.). Canals were instrumented to a size 8 with stainless steel K file (Dentsply Maillefer, Johnson City, TN) so that the file extended beyond

the apical foramen by 1 mm. The canals were instrumented with stainless steel 10 number K-file (Dentsply Maillefer, Johnson City, TN). And then prepared to size F2 with hand proTaper (Dentsply Maillefer, Johnson City, TN). All files were extended 1 mm beyond the apical foramen and copious irrigation with sterile saline was completed between file systems. Canals were then thoroughly rinsed with saline solution. All teeth having identical preparation were assigned to one of the five groups, so that each group was comprised of 15 samples.

Root canals of teeth in group I were sealed apically with bonded composite resin (Tetric Ceram) and coronally with a cotton pellet and bonded composite resin. Root canal of teeth in group II were filled with Ca(OH)_2 mixed to thick slurry with sterile saline. To insure intimate contact with the canal walls and a dense fill of canal space and excess Ca(OH)_2 was intentionally extruded past the apex using lentulospiral (Dentsply). The root canals in group III were filled with Calcigel, group IV were filled with metapex, group V were filled with calcium hydroxide and propylene glycol. As with group I the teeth in groups II, III, IV and V were sealed apically with bonded composite and coronally with a cotton pellet and bonded composite. Samples were stored in saline 0.9% saline solution at room temperature in plastic container. After 7, 14, 21 days 5 samples from each group were removed from saline storage container and roots were vertically sectioned into two parts with water cooled diamond saw. Samples were then subjected to EDAX analysis.

EDAX Analysis

Energy dispersive X-ray spectroscopy is an analytical technique used for the elemental analysis or chemical characterization of a sample. It is one of the variants of X-ray fluorescence spectroscopy which relies on the investigation of a sample through interactions between electromagnetic radiation and matter, analyzing X-rays emitted by the matter in response to being hit with charged particles.

Its characterization capabilities are due in large part to the fundamental principle that each element has a unique atomic structure allowing X-rays that are characteristic of an element's atomic structure to be identified uniquely from one another. EDAX analysis was carried out for calculating percentage of mineral before and after preparation and Ca(OH)_2 treatment.

RESULTS

At Day 7

From the Tables 1 and 2 and Graphs 1A and B it can be seen that:

- The average calcium is significantly higher in saline group compared to control, Calcigel, metapex and propylene groups ($p < 0.01$ for all).
- The average calcium is significantly higher in control group compared to Calcigel and propylene groups ($p < 0.01$ for all).
- The average calcium is significantly higher in metapex group compared to Calcigel and propylene groups ($p < 0.01$ for all).
- The average phosphorus is significantly higher in control, saline and metapex groups compared to Calcigel and propylene groups ($p < 0.01$ for all).

At Day 14

- The average calcium is significantly higher in Saline group compared to control, Calcigel, metapex and propylene groups ($p < 0.01$ for all).
- The average calcium is significantly higher in control group compared to Calcigel and propylene groups ($p < 0.01$ for all).
- The average calcium is significantly higher in metapex group compared to Calcigel and propylene groups ($p < 0.01$ for all).
- The average phosphorus is significantly higher in control, saline and metapex groups compared to Calcigel and propylene groups ($p < 0.01$ for all).

Table 1: The distribution of calcium and phosphorus levels across five study groups at each stage
(The intergroup distributions)

	Control	Saline	Calcigel	Metapex	Propylene glycol
<i>Day 7</i>					
Calcium (%)	28.9 ± 0.93	30.8 ± 0.33	26.2 ± 0.22	28.6 ± 0.30	25.5 ± 0.25
Phosphorus (%)	13.2 ± 0.20	13.2 ± 0.27	12.1 ± 0.17	13.2 ± 0.26	11.9 ± 0.29
<i>Day 14</i>					
Calcium (%)	28.8 ± 0.83	30.5 ± 0.97	25.9 ± 0.84	28.3 ± 0.53	25.3 ± 0.67
Phosphorus (%)	13.1 ± 0.44	12.9 ± 0.54	11.9 ± 0.47	12.9 ± 0.30	11.8 ± 0.44
<i>Day 21</i>					
Calcium (%)	28.7 ± 0.79	30.2 ± 0.63	25.6 ± 0.94	27.9 ± 0.66	25.1 ± 0.66
Phosphorus (%)	13.0 ± 0.44	12.7 ± 0.44	11.5 ± 0.44	12.7 ± 0.34	11.6 ± 0.38

Values are mean ± standard deviation

Table 2: The statistical comparison of calcium and phosphorus levels across five study groups at each stage (The intergroup comparisons)

	Control vs saline	Control vs calcigel	Control vs metapex	Control vs propylene glycol	Saline vs calcigel	Saline vs metapex	Saline vs propylene glycol	Calcigel vs metapex	Calcigel vs propylene glycol	Metapex vs propylene glycol
Day 7										
Calcium	0.001 (S)	0.001 (S)	0.663 (NS)	0.001 (S)	0.001 (S)	0.001 (S)	0.001 (S)	0.001 (S)	0.044 (S)	0.001 (S)
Phosphorus	0.962 (NS)	0.001 (S)	0.986 (NS)	0.001 (S)	0.001 (S)	0.999 (NS)	0.001 (S)	0.001 (S)	0.779 (NS)	0.001 (S)
Day 14										
Calcium	0.001 (S)	0.001 (S)	0.718 (NS)	0.001 (S)	0.001 (S)	0.001 (S)	0.001 (S)	0.001 (S)	0.479 (NS)	0.001 (S)
Phosphorus	0.888 (NS)	0.001 (S)	0.987 (NS)	0.001 (S)	0.001 (S)	0.993 (NS)	0.001 (S)	0.001 (S)	0.993 (NS)	0.001 (S)
Day 21										
Calcium	0.004 (S)	0.001 (S)	0.237 (NS)	0.001 (S)	0.001 (S)	0.001 (S)	0.001 (S)	0.001 (S)	0.654 (NS)	0.001 (S)
Phosphorus	0.420 (NS)	0.001 (S)	0.644 (NS)	0.001 (S)	0.001 (S)	0.996 (NS)	0.001 (S)	0.001 (S)	0.994 (NS)	0.001 (S)

Values are p-values, obtained by one-way analysis of variance (ANOVA) with Tukey's correction for multiple comparisons. p-value < 0.05 are considered to be statistically significant. S: Statistically significant, NS: Statistically nonsignificant

Graphs 1A and B: (A) The distribution of calcium levels across five study groups at each, (B) the distribution of phosphorus levels across five study groups at each stage (the intergroup distributions)

At Day 21

The average calcium is significantly higher in saline group compared to control, Calcigel, metapex and propylene groups ($p < 0.01$ for all).

The average calcium is significantly higher in control group compared to Calcigel and propylene groups ($p < 0.01$ for all).

The average calcium is significantly higher in metapex group compared to Calcigel and propylene groups ($p < 0.01$ for all).

The average phosphorus is significantly higher in control, saline and metapex groups compared to Calcigel and propylene groups ($p < 0.01$ for all).

DISCUSSION

The purpose of this research was to examine the possible deleterious effects of $\text{Ca}(\text{OH})_2$ on human root dentin. $\text{Ca}(\text{OH})_2$ is a material used in endodontic treatment, often over extended periods of time. Extracted teeth were selected because the

effects of long term $\text{Ca}(\text{OH})_2$ on human dentin has not been previously studied. The forces placed on human teeth *in vivo* are different than those placed on the dentin disks used in this study. However, it was felt that the current protocol would account for the variability of human dentin, not only between different teeth but also along the length of an individual root.

Addition of vehicles seems to prevent dentin phosphorus release. The vehicles may form a protective film on hydroxy-apatite crystals or combine with $\text{Ca}(\text{OH})_2$, thus reducing the attractive action on inorganic dentin components.

Propylene glycol is a clear and odorless liquid with a characteristic taste that resembles that of glycerin. Its wide application in endodontics as a vehicle for intracanal medicaments is attributable to its strong antibacterial action against microorganisms commonly found in infected root canals. Another advantage of this substance is its consistency, which improves the handling qualities of the paste. Simon et al¹⁷ recommend propylene glycol as the best vehicle in $\text{Ca}(\text{OH})_2$ preparation.

Metapex contains silicone oil as its vehicle. The superior properties of metapex may be due to the combination with iodoform and to the viscous and oily vehicle, which may prolong the action of the medicament.¹⁸

In a retrospective study, Cvek¹⁵ investigated 885 luxated nonvital incisors treated with $\text{Ca}(\text{OH})_2$ over a period ranging from 3 to 54 months with the mean value for immature teeth being 24 and 11 months for mature teeth. Of the 885 teeth, 168 suffered a cervical root fracture within the follow-up period, which ranged from 3.5 to 5 years.

The findings of this study may appear to support the contention that long term exposure to $\text{Ca}(\text{OH})_2$ alters the physical properties of dentin. This may be a result of a change in the organic matrix.¹⁹ Average calcium significantly dropped at day 21 compared to day 7 in saline and metapex group ($p < 0.005$ for both) and the average phosphorus significantly dropped at day 21 compared to day 7 in saline, CalciGel, metapex, propylene glycol group ($p < 0.05$ for all).

It has been shown that $\text{Ca}(\text{OH})_2$ dissolves pulp tissue,^{20,21} a process that may occur by denaturation and hydrolysis. In addition, the pH increase observed after exposure to $\text{Ca}(\text{OH})_2$ may also reduce the organic support of the dentin matrix.^{11,12} These processes may disrupt the interaction of the collagen fibrils and hydroxyapatite crystals that could negatively influence the mechanical properties of dentin.

CONCLUSION

Within the limitation of this *in vitro* study, oil based calcium hydroxide, saline based calcium hydroxide showed significant difference in calcium and phosphorus content as compared to CalciGel and propylene glycol on root dentin. Water based $\text{Ca}(\text{OH})_2$ was less derogative on root dentin surface. Further studies, e.g. *ex vivo/in vivo* would be helpful to reaffirm the above results.

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