Effect of Calcium Hydroxide as a Root Canal Dressing Material on Dentin Fracture Strength In Primary Teeth–*In Vitro* Study

Fadi Said */Moti Moskovitz **

Objectives: *The aim of the present study was to assess the effect of calcium hydroxide as a root canal dressing material on dentin microtensile fracture strength in human primary teeth in vitro.* ***Study design****: Thirty primary anterior teeth with root canals packed with calcium hydroxide were divided into groups of ten and immersed in saline at room temperature for 7, 30 and 90 days. Ten teeth with root canals filled with sterile saline were the control group. Microtensile fracture strength was measured in Mechanical tester Lloyd testing machine.* ***Results****: There was a significant difference (P < 0.05) between the fracture strength of the calcium hydroxide-filled teeth after 90 days (19.1 MPa) compared with the control (35.8 MPa). Dentin microtensile fracture strength of the calcium hydroxide-filled teeth decreased at an average of 0.142 MPa per day.* ***Conclusion****: Calcium hydroxide placed in root canals for an extended time had a significantly negative effect on root strength. Long-term success of root canal treatment in primary anterior teeth is estimated as 65% with most of the failures result from trauma recurrence.*

Clinical Relevance: *Our results stress the need to evaluate the pros and cons of root canal treatment compared to extractions of non-vital primary incisors.*

Key words: calcium hydroxide, root canal treatment, dentin fracture strength, primary teeth

INTRODUCTION

Root canal treatment in primary teeth is indicated when the radicular pulp exhibits clinical signs of irreversible pulpitis or pulp necrosis while the roots show minimal or no resorption [1]. The most commonly used root filling materials for primary teeth are zinc oxide–eugenol (ZOE), iodoform- based pastes and calcium hydroxide [2,3].

While in the United States the use of ZOE without setting accelerators has been previously recommended [4], its limited antibacterial action [5-7], irritantancy to the periapical tissues [8,9] and a resorption rate different from that of primary teeth [5,9], made it less attractive to use than iodoform/calcium hydroxide fillers [10]. Iodoform pastes have good resorbability and disinfectant properties but commonly produce a dark-brown discoloration of the tooth crowns compromising the aesthetics [5,7,11]. In order to overcome this shortcoming, the use of calcium hydroxide paste was suggested for primary anterior teeth. Calcium hydroxide provides the high pH (>10) environment that, along with iodoform, has a high bacteriostatic effect [12].

The antimicrobial action of calcium hydroxide is associated with its ionic dissociation into calcium and hydroxyl ions which diffuse through the dentinal tubules [13,14]. The aqueous, viscous, or oily vehicle used in the formulation of the root canal filling paste impacts the speed of ionic dissociation. As aqueous vehicles favor a high degree of solubility they will cause a depletion of the paste from the root canals *before* the time of physiological root resorption [15]. Viscous vehicles promote a lower solubility of the paste and oily vehicles have the lowest solubility and diffusion of calcium hydroxide pastes showing better results [7,16]. The high pH and antimicrobial properties [17] combined with the permeability of dentin [18,19] may account for its effectiveness as an intra-canal inter-appointment medicament, an inhibitor of inflammatory root resorption, and an inducer of apical closure in nonvital immature permanent teeth. However, when used in root canal for apexification the treatment may last from months to years [20,21] and immature permanent teeth treated with calcium hydroxide have been shown to have a high failure rate due to an unusual great number of root fractures. According to Stormer et al. 60% of all endodontically treated permanent teeth with immature root formation have had cervical fractures due to minor impacts [22] and even spontaneous fractures have been reported [23]. It has been proposed that root canal filling with calcium hydroxide will lead to weakening of endodontically-treated teeth [24].

From the Department of Pediatric Dentistry, Hebrew University, Hadassah School of Dental Medicine, Jerusalem, Israel.
Fadi Said DMD.
Moti Moskovitz DMD, PhD

Send all correspondence to:
Dr. Moti Moskovitz, Department of Pediatric Dentistry, Hebrew University Hadassah School of Dental Medicine, P.O.Box 12272, Jerusalem 9112102, Israel.
Phone: 972-2-6778496,
E-mail: motim@md.huji.ac.il

Calcium hydroxide dressing in the root canal for an extended time period weakens the root structure [24-26]. Using it as a dressing material in human permanent teeth *in vitro* for more than one month decreased tooth fracture resistance [27]. The effect of calcium hydroxide as a root canal dressing material in primary teeth has not yet been studied.

The aim of the present study was to assess the effect of calcium hydroxide as a root canal dressing material on the dentin microtensile fracture strength in human primary teeth *in vitro*.

MATERIALS AND METHOD

Forty human maxillary primary incisor and canine teeth without decay or fillings and without physiological or pathological root resorption that had been stored in diluted sodium azide 0.1 M solution were randomly assigned to four treatment groups. Teeth were matched for size and dentin thickness. The teeth were prepared according to the protocol of Rosenberg *et al* [25] for root canal filling with calcium hydroxide, an access cavity was prepared using a bur carbide FG 330 (SS White® New Jersey). The working length was established by visualizing a file protruding beyond the apical foramen and subtracting 0.5 mm from this measurement. All teeth were instrumented to an apical size of 35 using a k-file. Root canals were irrigated with a 2% solution of chlorhexidine after instrumentation. The teeth were dried using paper points. Teeth were divided into two experimental groups.

Study groups 1-3: Thirty teeth with root canals packed with pure calcium hydroxide (Kerr, Orange, CA, USA) mixed with saline were divided into groups of ten teeth. The paste was carried to the coronal part of the pulp cavity using a Lentulo spiral at slow speed. The calcium hydroxide was further condensed from the apical foramen and all the samples had a minimum of 2 mm Intermediate Restorative Material (IRM, DENTSPLY Caulk) placed in both orifices. The teeth were then immersed in saline at room temperature for 7, 30 and 90 days. The saline was changed with a fresh sterile solution once a week.

Control group (Group 4): Ten teeth with root canals filled with sterile saline and the orifices sealed with IRM. The teeth were stored in saline for a month at room temperature and the saline was exchanged with a fresh sterile solution once a week.

Specimens preparation

The tooth samples were prepared for testing by mounting them in acrylic resin blocks. The tooth specimens were orientated with the crown submerged in acrylic resin to the cemento-enamel junction, leaving the root protruding from the block. The acrylic resin block and tooth sample was reinforced to prevent non-root fracture. Microtensile fracture strength was measured in a universal testing machine. Mechanical tester Lloyd testing machine, Model LR 10K equipped with a load cell of 500N and a chisel-shaped rod (Bencor Multi-T testing device). The samples were loaded into a vice and the Lloyd testing machine had a customized cross-head spade (Figure 1) that struck the cervical surface of the tooth at 1 mm/min^{-1}. A force was applied with the spade at a speed of 1mm/min until fracture and the fracture strength (force/area) was calculated in MPa (Microtensile fracture strength units).

Statistical analyses

Mean and Standard deviation (SD) of dentin microtensile fracture strength were calculated for each group. Data were analyzed using SPSS software Chicago, Illinois, USA. ANOVA and Newman-Keuls' multiple-range tests were used to compare the results from all the groups and to identify sample means that are significantly different. The level of significance was set at $p<0.05$.

RESULTS

The mean dentin microtensile fracture strength of the control group was 35.8 MPa. The mean fracture strength of the calcium hydroxide-filled teeth was 30.9 MPa after 7 days, 26.7 MPa after 30 days, and 19.1 MPa after 90 days (Table 1). Figure 2 illustrates the mean fracture strength at the three measuring time points (7, 30, 90 days) and Figure 3 presents the curve of reduction in fracture strength with time.

There was a significant difference ($P < 0.05$) between the fracture strength of the calcium hydroxide-filled teeth after 90 days (19.1 MPa) compared with the control (35.8 Mpa). Although there was a decrease in fracture strength after 7 and 30 days, this decrease was not statistically significant ($p=0.710$ and $p=0.207$ respectively).

The intracanal placement of calcium hydroxide weakened the fracture strength of the dentin by 11.8 MPa per 83 days: an average of 0.142 MPa per day^{-1}. Between 0 days (control) and 90 days the fracture strength of the dentin was reduced by 47% and between 7 and 90 days, the fracture strength of the dentin was reduced by 38%.

Table 1. Test results

Days	N	Mean	Std. Deviation	Minimum	Maximum
control	10	35.8	12.12	23	56
7	10	30.9	7.88	22	45
30	10	26.7	10.30	16	49
90	10	19.1	5.55	13	28
Total	40	28.1	10.88		

Figure. 1. The samples were loaded into a vice and the Lloyd testing machine had a customized cross-head spade that struck the cervical surface of the tooth at 1 mm min^{-1}.

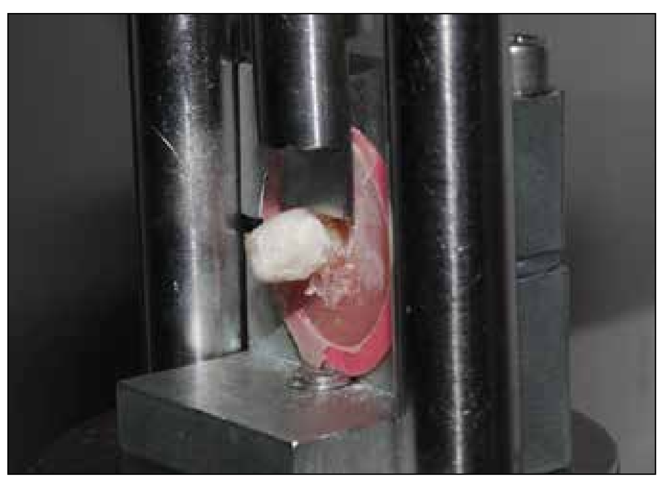
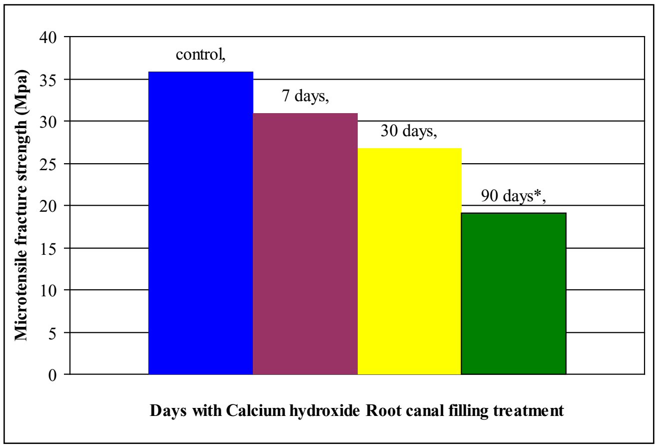
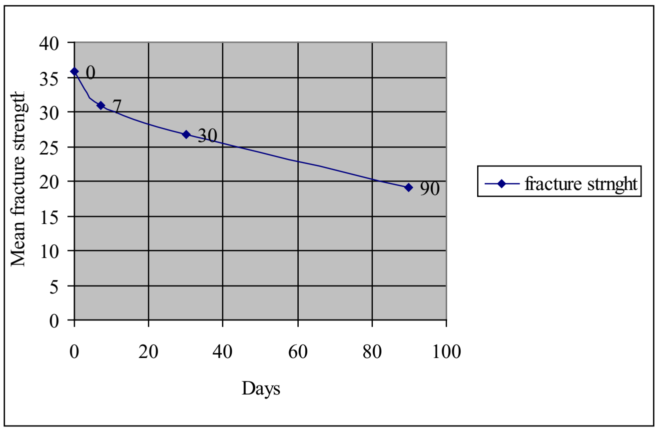


Figure 2 shows the mean fracture strength representing the various measurements.



*P=0.004

Figure. 3 curve of reduction in fracture strength with time.



DISCUSSION

A few longitudinal follow-up studies on root canal treated traumatized primary teeth aimed to determine whether it is beneficial to treat them [28]. Success of root canal treatment in primary anterior teeth was 65% and most of the failures occurred in the first year with trauma recurrence as the major cause for failure [28]. According to our knowledge the effects of long term calcium hydroxide as a root canal dressing material in primary teeth have not been previously studied. In the current study calcium hydroxide placed in root canals of primary incisors for an extended time had a significantly negative effect on the strength of the root. Weakening of root-filled teeth may predispose these teeth to fracture.

Similar to our results, Andreasen *et al* [24] and Rosenberg *et al* [25] found that the fracture strength of permanent teeth filled with calcium hydroxide will be reduced by almost 50% due to the root filling after a 360 and 84 days, respectively.

Contrary to our findings Hawkins et al. found insufficient evidence to support a decrease in fracture resistance of dentin within a 6-month period using Vitapex, Ultracal XS, or Pulpdent (three commercial calcium hydroxide formulations) in deciduous lamb incisors [29].

The decrease in fracture strength with time may be explained by the reaction of calcium hydroxide with dentin. Several studies have shown that the organic matrix changes due to long-term exposure to calcium hydroxide, and therefore the mechanical properties of dentin are modified. In addition, the pH increase observed after exposure to calcium hydroxide may also reduce the organic support of the dentin matrix. Dentinal strength is determined by the link between hydroxyapatite and collagenous fibrils. Calcium hydroxide alkalinity may denature the carboxylate and phosphate groups leading to a collapse in the dentin structure. These processes may disrupt the interaction of the collagen fibrils and hydroxyapatite crystals that could negatively influence the mechanical properties of dentin [26].

Microtensile fracture strength in the permanent dentition is about 30% higher than in the primary teeth [25]. According to our findings this is true also when the fracture strength decrease after long term exposure to calcium hydroxide as a root canal dressing material up to three months. Root canal treatments in non-vital primary anterior teeth that are performed using calcium hydroxide as a dressing material need to stay in the dental arch for years depending on the age of the treated child. Clinicians should take into account the fragility of those teeth with time especially with recurrent trauma being a predisposing factor in the long term success of the treatment.

CONCLUSIONS

1. This study is the first to investigate the long term effect of calcium hydroxide as a root canal sealer material in human primary teeth.
2. In the current study calcium hydroxide placed in root canals of primary incisors for an extended time had a significantly negative effect on the strength of the root.
3. Our results emphasize the need to evaluate the pros and cons of root canal treatment compared to extractions of non-vital primary incisors.

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