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Short Term Effect of Intracanal Calcium Hydroxide on the Compressive Strength of Root Dentin of Mature Human Permanent Teeth

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Abstract:
Context:
Calcium hydroxide is commonly used as an intracanal medicament in endodontic treatment of teeth with periapical infections. Although it is generally accepted as a highly biocompatible material, it may cause significant change in fracture resistance of root dentin of a tooth.
Aims: *The study aims at evaluating the effect of short term application of intracanal calcium hydroxide on resistance of root dentin of mature human permanent teeth against compressive forces with an objective to understand the interaction of the material with root dentin.*
Settings and Design: *Sixty human extracted permanent teeth were divided into two groups – a control group and an experimental group. Universal testing machine (Instron) was used to apply vertical compressive forces on the teeth under study.*
Methods and Material: *Endodontic access was achieved in all the teeth and the teeth in experimental group were filled with intracanal calcium hydroxide for 30 days while those in the control group were left empty, following which, they were sectioned at the level of cementoenamel junction and tested for the compressive force required to fracture the root by using Instron.*
Statistical analysis used:
- *Mean of compressive forces*
- *Independent t-test*

Results: *Teeth in the experimental group had mean value of compressive strength (211.85 MPa) which is lesser than that of control group (246.69 MPa). The short term use of intracanal calcium hydroxide reduces the strength of dentin of mature human teeth by 14.13% after 30 days.*
Conclusion: *Use of calcium hydroxide as an intracanal medicament decreases the compressive strength of root dentin making it more susceptible to fracture. Thus, use of calcium hydroxide in endodontics should be revisited.*
Key-words: *Calcium hydroxide, compressive strength, fracture resistance,intracanal medicament,root dentin.*

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I. Introduction

Calcium hydroxide is most commonly used in endodontics as an intracanal medicament and pulp capping agent because of its high pH, and antibacterial effect and hard tissue stimulation. Its broad spectrum antibacterial activity is one of the major factors for its widespread use and therapeutic success[1]. This action is directly proportional to the ability of the hydroxyl ions to be released from the calcium hydroxide compound and then diffuse through the dentin[2].

The high pH and antimicrobial properties of calcium hydroxide combined with the permeability of dentin may account for its effectiveness as an intracanal inter-appointment medicament, an inhibitor of inflammatory root resorption, and an inducer of apical closure in nonvital immature teeth[3]. However, when calcium hydroxide is used in these applications, therapy may extend from months to years before the desired effects are achieved[4].It has been observed that calcium hydroxide 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 calcium hydroxide medicament may be responsible[5].

It has been reported that long-term treatment with calcium hydroxide may weaken tooth roots and contribute to the fracture of immature teeth[6]. There are few reports in the literature about changes in dentin fracture strength in the response to endodontic materials. White et al.(2002)[7] reported a 32% mean decrease in strength of dentin in bovine teeth when exposed to a calcium hydroxide. Rosenberg et al (2007)[8] measured the effect of calcium hydroxide on the microtensile fracture strength of extracted human permanent maxillary incisors and they reported a weakening of the dentin by 23 – 43.9%.

Many current endodontic procedures involve the use of calcium hydroxide although its effects on permanent mature teeth have not been studied extensively. Therefore, the present study was undertaken to test the hypothesis that calcium hydroxide as intracanal medicament shows no significant difference on the compressive strength of root dentin.

II. Subjects and Methods

Sixty human extracted single rooted, non-carious permanent teeth were selected for the study. There were no signs of decay or restoration in these selected teeth. Collection, disinfection, storage and handling of extracted teeth were done according to guidelines and recommendation by occupational safety and health administration (OSHA) and center of disease control (CDC).

Guidelines and recommendations by *Occupational Safety and Health Administration (OSHA) and Centre of Disease Control (CDC)* for use of extracted teeth in dental educational settings were followed. The extracted teeth were cleaned by scrubbing with detergent water and using an ultrasonic scaler. Teeth were immersed in fresh solution of sodium hypochlorite. Access cavity preparations of all the teeth were done using the endo access bur *(TR-15, Mani)* and a straight line access was achieved. The orifices were located and widened with Gates Glidden Drill #3, #2, #1(*Mani)* using a Crown Down technique and irrigated with normal saline intermittently.

After coronal access preparation, the working length was determined by passing a # 10 k-type file into the canal until the tip was just visible at the apical foramen and then subtracting 1 mm from this length. The canals were cleaned and shaped up to the # 25 k-files, following which, the mechanical preparation of root canals of selected teeth were done by sequential use of S_1, S_2, F_1, F_2 and F_3ProTaperfiles*(Dentsply, Maillefer, Switzerland)* with rotary handpiece*(Anthogyr, Dentsply)*.

During the cleaning and shaping, the canals were irrigated with normal saline solution only. After the biomechanical preparation of the root canals of all selected teeth, the teeth were randomly divided into two groups – a control group and the experimental group with 30 teeth in each group.

1. Control group: In this group, canals of all the 30 teeth were left opened and empty. The access cavities of all the teeth were sealed with Cavit.
2. Experimental group**:** In this group, canals of all the 30 teeth were dried with absorbent paper points and then filled with a calcium hydroxide paste.

Calcium hydroxide paste was made by mixing calcium hydroxide [$Ca(OH)_2$] powder*(RC Cal, Prime Dental)* with distilled water solution. The canals of all 30 teeth were filled with calcium hydroxide paste. The paste was placed into the canal by using a Lentulospiral*(Dentsply, Maillefer, Switzerland)* in a low speed micromotor hand piece. The paste was placed in the canal until it filled the canal and came out through the apex. The access cavities were sealed with Cavit temporary filling material so as to mimic the typical in vivo endodontic procedures. Teeth in both groups were immersed in normal saline solution for 30 days at room temperature.

Crowns of all the 60 teeth were sectioned at the level of the cementoenamel junction by a diamond stone disc, thirty days following the sealing of canal with calcium hydroxide. The apical sections of the teeth were also removed with the stone disc at a level that was 5 millimeter(mm) below where the coronal section was made resulting in a dentin cylinder that was 5 mm long with two smooth surfaces. All the dentin cylinders were polished with smooth sand paper to produce smooth flat ends. The dentin cylinders were subsequently preserved in normal saline to prevent drying out during remainder of the study.

All the sixty dentin cylinders were ready for the compressive testing (Figure 1). Each dentin cylinder was then tested for the compressive force required to fracture it by using a universal testing (Instron) machine at a cross-head speed of 2 mm/minute. Each specimen of dentin cylinder was placed between the jaws of Instron testing machine. Forces were applied from the coronal end of the cylinder, in a vertical direction with the point of application being centered in the root canal until the dentin cylinder fractured. (Figure 2)

III. Results

The maximum compressive force values in (MPa) required to break the samples (dentin cylinders) for control and experimental group obtained are depicted in Graph 1:

Results of this study have shown the mean values of the compressive strength of the experimental group, 211.845 MPa, is lesser than the control group having 246.689 MPa .The mean values obtained by testing for maximum compressive force in the Instron machines are depicted in **Table 1**.

Independent t-test was applied for comparison between the means of control group and the experimental group to test the significance of difference. The results of the t-test are as below in **Table 2**:

Level of significance: 5%

Interpretations: Since one tailed p-value for the t-test is 0.000 which is less than that of 0.05 ($P < 0.05$), the results of the study are significant. The mean compressive strength of the experimental group is 14.125% lesser than that of control group.

IV. Discussion

Pure calcium hydroxide paste has a high pH and its actions are achieved through the ionic dissolution of Ca^{2+} and OH^{-} ions with their effect on vital tissues, the induction of hard-tissue deposition[9] and the antibacterial properties[10]. Esberard et al.[11]confirmed the observation that hydroxyl ion of calcium hydroxide paste diffuse through the dentinal tubules which was faster in the cervical and middle regions than in apical region. The diameter and the number of the dentinal tubules in the cervical and middle regions is larger than that of apical region permitting more rapid diffusion[12].

Extracted human teeth were selected in our study because the effects of short term application of calcium hydroxide on human dentin have been less studied previously. However, 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. It was assumed that if any of the tested materials affected the structural integrity of human dentin, a change in the compressive forces required to fracture a dentin disk would likely show a commensurate change in the shear forces required to cause a horizontal root fracture in vivo[13].Thus, only single rooted permanent mature extracted teeth were selected for this study.

Irrigation of root canals by sodium hypochlorite has been reported to reduce the modulus of elasticity and flexural strength of dentin[14], and this is attributed to the loss of organic substance from dentin[15].Hence, only saline was used in this study to irrigate the root canals during the canal preparation phase of the study.

The strength of root dentin has been evaluated either by the use of shear forces[16], compressive forces [17] and flexural forces[18]or combined tests[7] to examine the dentin samples. Fracture resistance of human root dentin to compressive strength after intracanal exposure to calcium hydroxide was evaluated in our present study.

Our results are in accordance with findings of Sahebi et al[19]reporting a 15% reduction in compressive strength of dentin of mature human teeth when exposed to intracanal calcium hydroxide for 30 days. Rosenberg et al[8]reported the reduction in microtensile fracture strength (MTFS) of human root dentin when exposed calcium hydroxide by 43.9% between 7 to 84 days. Treatment with calcium hydroxide could thus potentially enhance crack initiation and propagation on the surface of dentin rendering it more prone to fracture[20].

The result of the present study showed a 14% reduction in the root dentinal strength which was observed only after 30 days of application of calcium hydroxide. The decrease in fracture strength to compressive forces that was noted after the root canals were filled with calcium hydroxide may be explained by the reaction of calcium hydroxide with dentin and the changes that take place in the organic matrix that follow first order kinetics[21].

The weakening of root dentin caused by short term use of calcium hydroxide could mainly because of the breakdown of the protein structure caused by the alkalinity of the calcium hydroxide[21]. Previous studies[6-8,14,22]assessed forces applied to root dentin specimens in different manner and in different directions and have reported that alkaline materials can cause conformational change of protein structure, and it seems feasible that this phenomenon could be causing the reduction in strength of root dentin and weakening observed in this experiment by short term use of calcium hydroxide for one month.

This study suggests adaptation of a minimal time of treatment when using calcium hydroxide in the canal to minimize the weakening of treated teeth. Development of effective materials with more neutral pH may be desirable. Use of restorative materials that strengthen the tooth should be considered and further research and studies should be taken into consideration for more viable options.

V. Conclusion

Use of calcium hydroxide as an intracanal medicament decreases the compressive strength of root dentin rendering it more susceptible to fracture. Thus, use of calcium hydroxide in endodontics should be revisited and endodontic materials which would not weaken the tooth structure should be sought for as a viable replacement.

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