

The effects of short-term calcium hydroxide application on the strength of dentine

Safoora Sahebi¹, Fariborz Moazami¹, Paul Abbott²

¹Department of Endodontics, School of Dentistry, Shiraz University of Medical Sciences, Shiraz, Iran; ²School of Dentistry, University of Western Australia, Perth, WA, Australia

Correspondence to: Fariborz Moazami, Department of Endodontics, School of Dentistry, Shiraz University of Medical Sciences, Shiraz, Iran
Tel.: +98 711 6354860
Fax: +98 711 6354861
e-mail: fmoazami@sums.ac.ir

Accepted 19 August, 2009

Abstract – Background: Studies have suggested that the long-term exposure of dentin from immature teeth to calcium hydroxide may weaken the dentin but the effects of short-term exposure of dentin from mature teeth have not been reported. The aim of this study was to evaluate the effects of a short term application of calcium hydroxide on the strength of dentine from mature human permanent teeth. **Materials and methods:** 50 human extracted single rooted disease-free permanent mandibular premolars were chosen. The root canals were prepared with rotary instruments and randomly assigned to two groups. In one group, the root canals were filled with a calcium hydroxide paste. Canals of teeth in the control group were left empty. All teeth were stored in normal saline for 30 days and then coronal third root dentin cylinders were created by removing the crown and apical portions of the teeth. An Instron machine was used to measure the compressive forces needed to break the dentin cylinders and data were analysed using the Student's *t*-test. **Results:** The mean compressive force in the calcium hydroxide-filled teeth was significantly lower than that in the control teeth ($210.6 \pm 32.3 \text{ kg cm}^{-1}$ vs $246.2 \pm 29.0 \text{ kg cm}^{-1}$ respectively, $P < 0.001$). **Conclusion:** Teeth subjected to 30 days application of calcium hydroxide required less compressive force to break root dentin cylinders. Further studies are necessary to determine whether similar effects would result if impact tests were performed.

Calcium hydroxide is the most commonly used endodontic intracanal dressing material and pulp capping agent (1) because of its high pH and favourable effects such as antibacterial and hard tissue stimulation (2). It is widely used as both short-term and long-term intracanal dressings and has been included in some root canal sealers (3). Its broad spectrum antibacterial activity is another major factor for its widespread use and therapeutic success (4, 5). This action is directly proportional to the ability of the hydroxide ions to be released from the calcium hydroxide compound and then diffuse through the dentin (5).

The long-term filling of root canals with calcium hydroxide is widely accepted, especially when treating young, immature traumatized teeth or teeth with large periapical radiolucent areas. In these cases, the calcium hydroxide may be used for a variety of time periods ranging from 2 to 3 months up to 2 or 3 years. The longer periods are typically used for immature teeth in order to encourage the formation of an apical hard tissue barrier prior to completing the root canal filling. This process is commonly known as apexification. However, it has been reported that long-term treatment with calcium hydroxide may weaken tooth roots and contribute to the fracture of immature teeth (6, 7). There are a few reports in the literature about changes in dentin fracture strength in response to endodontic materials. This hypothesis has been tested in animal experiments using immature incisors from sheep (8), sheep dentin (7) and bovine

dentin (9). Rosenberg et al. (10) 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%. White et al. (9) reported a 32% mean decrease in dentin strength of bovine teeth when exposed to calcium hydroxide, a 33% decrease in strength when exposed to mineral trioxide aggregate, and a 59% decrease due to sodium hypochlorite exposure.

A common protocol for the management of infected mature teeth with apical periodontitis is to place calcium hydroxide in the root canal system for short periods of time ranging from 1 to 4 weeks. Therefore, it is important to assess whether there are any effects on dentin as a result of shorter term use of calcium hydroxide in mature teeth. Hence, the aim of the present study was to evaluate the effects of short-term calcium hydroxide application on the strength of human permanent dentin against the compressive forces.

Materials and methods

Fifty extracted mature human mandibular single rooted permanent premolars that had no signs of decay or restorations were chosen for this study. An endodontic access cavity was prepared in each tooth using a No. 4 round bur and a high speed hand piece and the working length was established by measuring the length at which the tip of a file could be visualized to be just protruding

beyond the apical foramen and subtracting 0.5 mm from this measurement.

The root canals were mechanically prepared with the ProTaper (Dentsply, Maillefer, Switzerland) rotary file system used according to the manufacturer's instructions. During preparation, the canals were irrigated with normal saline. The teeth were then randomly assigned to two groups – a control group and the experimental group – with 25 teeth in each group. Teeth in the control group had the canals left open and empty. The canals of the teeth in the experimental group were dried with absorbent paper points and then filled with a calcium hydroxide paste, which was made by mixing $\text{Ca}(\text{OH})_2$ powder (Merck, Darmstadt, Germany) with normal saline. The access cavities were sealed with Cavisol (IRIE, Golchai, Iran) to mimic the typical *in vivo* endodontic procedures. The paste was placed by using a Lentulo spiral (Dentsply, Maillefer, Switzerland) in a low speed handpiece. A radiograph was taken to ensure complete filling of the canals with the $\text{Ca}(\text{OH})_2$ paste.

Teeth in both groups were immersed in normal saline solution for 30 days at room temperature. Then the crowns of all teeth were cut off at the level of the cemento-enamel junction by a stone disc. The apical sections of the teeth were also removed with the stone discs at a level that was 5 mm below where the coronal section was made. The result was a dentine cylinder that was 5 mm long with two smooth surfaces which were polished with smooth sand paper to produce smooth flat ends to prevent any interference with the jaws of test machine (Fig. 1). The dentine cylinders were subsequently preserved in normal saline to prevent them drying out during the remainder of the experiment.

Each dentine cylinder was then tested for the compressive force required to fracture it by using a universal testing machine (Instron Model TT-OM-L; Instron Ltd, High Wycombe, Bucks, UK) at a cross-head speed of 2 mm min^{-1} . The samples were placed between the jaws of testing machine and forces were applied from the coronal end of the cylinder and in a vertical direction with the point of application being centred in the root canal until the cylinder fractured (Fig. 2).

Data were expressed as the mean \pm SD for each group. The results were analysed with the Student's *t*-test. Statistical calculations were performed using SPSS



Fig. 1. Examples of dentine cylinders before applying the compressive forces.

software (SPSS Inc., Chicago, IL, USA, version 12.0). Differences were considered significant at $P < 0.05$.

Results

Table 1 summarizes the results for each group. The mean compressive force required to break the samples in the experimental group that were treated with calcium hydroxide was $210.6 \pm 32.3 \text{ kg cm}^{-1}$. This was significant lower than the mean force required in the control group ($246.2 \pm 29.0 \text{ kg cm}^{-1}$). The decrease of 14.4% in dentin strength was statistically significant ($P < 0.001$).

Discussion

The results of this study have shown that short-term root canal filling with calcium hydroxide reduced the strength of dentin of mature human teeth by almost 15% after 30 days. This is consistent with the report by Rosenberg et al. (10) on human dentin and other reports of animal experiments (7–9). Andreasen et al. (8) described an equation that they used to calculate the rate of decrease in strength of dentin. This was based on the strength reaching its lowest level at infinity. The level reached in their study represented about 45% of the original strength and they calculated that the strength had reduced to 50% within a year. The results of the present study showed a significant reduction in the root strength within 30 days of application of calcium hydroxide. However, it should be noted that the 15% reduction in dentin strength was observed after only 30 days application. In the absence of longer-term testing of the teeth, it is unclear how the dentin strength



Fig. 2. Examples of dentin cylinders after they had fractured by being subjected to compressive forces.

Table 1. The mean and the range of compressive forces required to break the samples

Group	No. in group	Mean compressive force required (kg cm^{-1})	Range of compressive forces required (kg cm^{-1})	SD
$\text{Ca}(\text{OH})_2$	25	210.6	123–270	32.065
Control	25	246.2	187.5–294	28.341

will change if calcium hydroxide is used for up to 1 year or more.

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 (11, 12). Dentinal strength is determined by the link between hydroxyapatite and collagenous fibrils and disruption of this link occurs because of the strong alkalinity of calcium hydroxide. This may denature the carboxylate and phosphate groups which leads to collapse of the dentin structure. The disruption could take place due to neutralization, dissolution or denaturing of the acid proteins and proteoglycans which serve as bonding agents between the collagen network and the hydroxylapatite crystals in dentin (8).

A dissolving effect has been reported when calcium hydroxide contacts pulp tissue for just 1 week (13, 14). This action takes place by denaturation and hydrolysis of the pulp tissue. A possible relationship may exist between this phenomenon and the pH-changes in dentin observed after calcium hydroxide treatment (15, 16). If so, an extensive alteration of dentin by calcium hydroxide could be expected. This may reduce the organic support of the dentin structure, which may influence the mechanical properties of the dentin.

Irrigation of root canals by sodium hypochlorite has been reported to reduce the modulus of elasticity and flexural strength of dentin (17), and this was attributed to the loss of organic substance from the dentin (18). Hence, only saline was used in this study to irrigate the root canals during the canal preparation phase of the experiment. However, in clinical settings sodium hypochlorite is commonly used as an irrigant so it is possible that it may contribute to any weakening of the dentin that occurs.

Grigoratos et al. (19) reported a reduction in flexural strength of dentin specimens that had been exposed to calcium hydroxide. That study assessed forces applied in a different manner and a different direction. Hence, direct comparisons cannot be made with the current study but all of these studies highlight that further research is required and that re-evaluation of the use of calcium hydroxide should be considered. Ideally endodontic materials which will not weaken the tooth structure should be used rather than those that may affect the dentin.

The major limitation of this study and others reported in the literature is that the method used does not replicate the typical clinical scenario of forces being applied to teeth. The forces used in this study were compressive forces that were applied to a cylinder of dentine taken from the coronal third of the tooth root. The samples did not have any coronal tooth structure, including enamel which normally provides strength to teeth. The forces were applied in a vertical direction only and were centred within the root canal. They force was applied progressively at a constant rate until the dentine cylinder fractured. Clinically, this type of force cannot be applied to a tooth. Instead, any force that may lead to fracture of a tooth root is likely to be a sudden impact force rather than a continuously applied force. In

addition, it is likely to be applied at varying angles to the tooth structure rather than being vertical, with the actual angle depending on the direction of an accidental blow to the tooth, or the angle of forces resulting from functional and parafunctional habits. The amount of the one-off force will also be dependent on these same factors. Finally, some teeth may have coronal tooth structure that may provide increased resistance to fracture. Hence, the results of this study are not necessarily applicable to clinical situations.

Conclusions

Teeth subjected to 30 days application of calcium hydroxide required less compressive force to break root dentin cylinders. It means that the short-term application of calcium hydroxide can reduce the dentin strength significantly. Further studies are necessary to determine whether similar effects would result if the other tests such as impact tests were performed.

References

1. Yoshida K, Yoshida N, Iwaku M. Histological observations of hard tissue barrier formation in amputated dental pulp capped with alpha-tricalcium phosphate containing calcium hydroxide. *Endod Dent Traumatol* 1994;10:113–20.
2. Zmener O, Pameijer CH, Banegas G. An *in vitro* study of the pH of three calcium hydroxide dressing materials. *Dent Traumatol* 2007;23:21–5.
3. Holland R, de Souza V. Ability of a new calcium hydroxide root canal filling material to induce hard tissue formation. *J Endod* 1985;11:535–43.
4. Brännström M, Vojinovic O, Nordenvall KJ. Bacteria and pulpal reactions under silicate cement restorations. *J Prosthet Dent* 1979;41:290–5.
5. Fisher FJ, McCabe JF. Calcium hydroxide base materials. An investigation into the relationship between chemical structure and antibacterial properties. *Br Dent J* 1978;144:341–4.
6. Andreasen JO. Treatment of fractured and avulsed teeth. *ASDC J Dent Child* 1971;38:29–31.
7. Andreasen FM, Andreasen JO, Bayer T. Prognosis of root-fractured permanent incisors – prediction of healing modalities. *Endod Dent Traumatol* 1989;5:11–22.
8. Andreasen JO, Farik B, Munksgaard EC. Long-term calcium hydroxide as a root canal dressing may increase risk of root fracture. *Dent Traumatol* 2002;18:134–7.
9. White JD, Lacefield WR, Chavers LS, Eleazer PD. The effect of three commonly used endodontic materials on the strength and hardness of root dentin. *J Endod* 2002;28:828–30.
10. Rosenberg B, Murray PE, Namerow K. The effect of calcium hydroxide root filling on dentin fracture strength. *Dent Traumatol* 2007;23:26–9.
11. Sano H, Shono T, Sonoda H, Takatsu T, Ciucchi B, Carvalho R et al. Relationship between surface area for adhesion and tensile bond strength – evaluation of a micro-tensile bond test. *Dent Mater* 1994;10:236–40.
12. Pashley DH, Sano H, Ciucchi B, Yoshiyama M, Carvalho RM. Adhesion testing of dentin bonding agents: a review. *Dent Mater* 1995;11:117–25.
13. Andersson M, Lund A, Andreasen JO, Andreasen FM. *In vitro* solubility of human pulp tissue in calcium hydroxide and sodium hypochlorite. *Endod Dent Traumatol* 1992;8:104–8.
14. Hasselgren G, Olsson B, Cvek M. Effects of calcium hydroxide and sodium hypochlorite on the dissolution of necrotic porcine muscle tissue. *J Endod* 1988;14:125–7.

15. Nerwich A, Figdor D, Messer HH. pH changes in root dentin over a 4-week period following root canal dressing with calcium hydroxide. *J Endod* 1993;19:302–6.
16. Tronstad L, Andreasen JO, Hasselgren G, Kristerson L, Riis I. pH changes in dental tissues after root canal filling with calcium hydroxide. *J Endod* 1981;7:17–21.
17. Sim TP, Knowles JC, Ng YL, Shelton J, Gulabivala K. Effect of sodium hypochlorite on mechanical properties of dentine and tooth surface strain. *Int Endod J* 2001;34:120–32.
18. Driscoll CO, Dowker SE, Anderson P, Wilson RM, Gulabivala K. Effects of sodium hypochlorite solution on root dentine composition. *J Mater Sc Med* 2002;13:219–23.
19. Grigoratos D, Knowles J, Ng YL, Gulabivala K. Effect of exposing dentine to sodium hypochlorite and calcium hydroxide on its flexural strength and elastic modulus. *Int Endod J* 2001;34:113–9.

This document is a scanned copy of a printed document. No warranty is given about the accuracy of the copy. Users should refer to the original published version of the material.