The effect of two different calcium hydroxide combinations on root dentine microhardness

O. Yoldaş[1], C. Doğan[2] & G. Seydaoğlu[3]

[1]Department of Conservative Dentistry and Endodontics; [2]Department of Pediatric Dentistry, Faculty of Dentistry; and [3]Department of Biostatistics, Faculty of Medicine, University of Cukurova, Adana, Turkey

Abstract

Yoldaş O, Doğan C, Seydaoğlu G. The effect of two different calcium hydroxide combinations on root dentine microhardness. *International Endodontic Journal*, **37**, 828–831, 2004.

Aim To evaluate the effect of a calcium hydroxide and glycerine mix and a calcium hydroxide and water mix on the microhardness of human root dentine.

Methodology Eleven freshly extracted maxillary canine and central incisor teeth were used. The teeth were sectioned transversally to produce a total of 22 dentine discs from the middle-third of the root. The specimens were divided into two groups of 11 discs each. Dentine samples were treated with either a $Ca(OH)_2$–glycerine combination or a $Ca(OH)_2$–distilled water combination for 1, 3 and 7 days. Dentine microhardness was measured with a Knoop indenter with a load of 100 g for 15 s before and during the experimental period. Each root disc received a series of three indentations around the pulp space, 1 mm from canal wall.

Results Statistical analysis showed that both combinations significantly decreased dentine microhardness after 3 and 7 days ($P < 0.01$). The reduction in dentine microhardness following the use of a $Ca(OH)_2$–glycerine combination was significantly greater than that after a $Ca(OH)_2$–distilled water combination after 3 and 7 days ($P < 0.01$).

Conclusion The use of $Ca(OH)_2$ combinations for intracanal dressing softens dentine.

Keywords: calcium hydroxide, dentine, glycerine, Knoop, microhardness.

Received 7 April 2003; accepted 19 August 2004

Introduction

During root canal treatment, it is necessary to remove as many bacteria as possible from the root canal (Sundqvist *et al.* 1998). The use of a root canal medicament has been considered one of the steps necessary to reduce further the microbial population prior to root filling (Chong & Pitt Ford 1992, Wadachi *et al.* 1998). Calcium hydroxide [$Ca(OH)_2$] pastes have been used as medicaments, because of new antibacterial action (Sjögren *et al.* 1991, Siqueira & Lopes 1999) and tissue dissolution ability (Türkün & Cengiz 1997, Wadachi *et al.* 1998).

Correspondence: Oğuz Yoldaş, Çukurova Universitesi, Diş Hekimliği Fakültesi, 01330 Balcal Adana, Turkey (Tel.: +90 322 3386354; fax: +90 322 3387331 e-mail: oguzyoldas@cu.edu.tr).

Calcium hydroxide powder has been mixed with various vehicles for canal medication, such as distilled water, saline, local anaesthetic solution, Ringer's solution camphorated monochlorophenol, cresatin and glycerine (Foreman & Barnes 1990, Rivera & Williams 1994, Alaçam *et al.* 1998, Öztan *et al.* 2002). When a medicament is placed the dentine of the canal wall is exposed to the action of the material and these different combinations of $Ca(OH)_2$ materials may cause various surface alterations on root dentine.

As microhardness is dependent on composition and surface structure (Moon & Davenport 1976, Panighi & G'Sell 1992), attention has focused on the relationship between dentine microhardness and the structural changes associated with pulpectomy and the application of materials within root canals (Craig *et al.* 1959, Fusayama & Maeda 1969, Cox *et al.* 1980, Lewinstein

& Grajower 1981, Rotstein *et al.* 1999, Saleh & Ettman 1999, Cruz-Filho *et al.* 2001).

A reduction in hardness of treated tooth tissue indicates dissolution and degradation (Craig *et al.* 1959, Saleh & Ettman 1999). It would be reasonable to assume that the dissolution effect of $Ca(OH)_2$ would effect dentine. As softened dentine is structurally nonsupportive, it is imperative that the microhardness of this tissue be retained or enhanced.

The aim of this study was to evaluate the effect of a $Ca(OH)_2$–glycerine combination and $Ca(OH)_2$–distilled water combination on the microhardness of human root dentine after contact for different time intervals.

Materials and methods

Eleven extracted human maxillary incisor teeth that were clinically intact and had patent root canals on radiograph were used. The teeth were stored in distilled water for up to 4 weeks before use.

Debris and soft tissue remnants on the root surfaces were removed with scaler. The crowns of teeth were removed and pulp tissue extirpated. A step-back technique was used to enlarge canals up to size 50 at the end-point apically with K-files. During instrumentation, root canals were irrigated with distilled water. Upon completion of the root canal preparation, the roots were fixed in acrylic resin blocks and cut transversally in 2 mm sections using a band saw (Exakt 300 cl Apparatebau, Norderstedt, Germany). The specimens were polished with 2500 grit abrasive paper (Hermes, Hamburg, Germany) using a micro-grinding system (Exakt 400 cs Apparatebau, Norderstedt). Two sections were obtained from the middle-third of each root. The root discs were divided randomly into two groups of 11. Baseline microhardness testing was completed using a microhardness tester (Buehler MMT-3 digital microhardness tester; Waukagen, Lake Bluff, IL, USA) with a Knoop diamond indenter. All indentations were made with 100 g loading for 15 s contact time according to ASTM standards (ASTM Designation E 384-99 2000). Each disc received a series of three indentations at points around the pulp space 1 mm from canal wall. Mean Knoop hardness numbers (KHN) were calculated for each specimen.

The sections were then placed into Petri dishes containing a 2 mm depth of $Ca(OH)_2$–glycerine combination (Merck, Darmstadt, Germany; one-seventh of the glycerine was distilled water) or $Ca(OH)_2$–distilled water combination for 7 days. The pH of both combinations was 12.6. The powder to liquid ratio was 1.2 g mL^{-1} for both combinations. To maintain the powder to liquid ratio constant over the experimental period, the Petri dishes were covered with stretch films (Linpac Plastics, Castleford, UK). Microhardness tests were repeated in the same manner after 24 h, 3 and 7 days. After each treatment period, the specimens were rinsed with distilled water and dried with soft absorbent paper before measuring microhardness.

Statistical analyses were performed with the statistical package SPSS v 12.0 (SPSS for windows; SPSS Inc., Chicago, IL, USA). The Student's *t*-test was used to compare independent groups. Time-dependent data within groups were analysed by repeated measure analysis. Paired *t*-tests were used to evaluate the differences within groups towards the baseline values ($P < 0.01$).

Results

Mean KHN values and standard deviations of root dentine before and after treating with $Ca(OH)_2$–glycerine and $Ca(OH)_2$–distilled water combinations are given in Table 1. Overall dentine microhardness values fell after treatment with different calcium hydroxide combinations.

No significant reduction in dentine microhardness occurred after 24 h of treatment with either combination ($P > 0.01$) compared with the pre-treatment control. Both combinations reduced dentine microhardness significantly after 3 and 7 days compared with the pre-treatment control ($P < 0.01$).

Table 1 Mean KHN values of root dentine before and after treatment with $Ca(OH)_2$–glycerine or $Ca(OH)_2$–distilled water combination

Group	Baseline value	Day 1	Day 3	Day 7	*P*-value (within groups)
$Ca(OH)_2$–glycerine	52.3 (2.4)	49.3 (2.5) NS	47.7 (2.3)*	44.4 (2.3)*	*$P = 0.000$
$Ca(OH)_2$–distilled water	52.2 (2.3)	51.4 (2.7) NS	50.5 (2.1)*	50.1 (2.0)*	*$P = 0.005$
P-value between groups	NS	NS	*$P = 0.005$	*$P = 0.000$	

Standard deviations are given in parentheses. NS, not significant, *$P < 0.01$.

Comparison of changes in dentine microhardness indicated that the reduction in hardness after $Ca(OH)_2$–glycerine combination treatment was significantly greater than that after the $Ca(OH)_2$–distilled water combination ($P < 0.01$).

Discussion

In this study, the ability of the Knoop microhardness test to detect surface changes of dentine after treatment with $Ca(OH)_2$–glycerine combination and $Ca(OH)_2$–distilled water combination was demonstrated.

When mixed with glycerine, $Ca(OH)_2$ has better handling characteristics and provides more complete canal fillings (Rivera & Williams 1994, Öztan *et al.* 2002). However, Safavi *et al.* (2000) concluded that the use of high concentrations of glycerine as a vehicle might decrease the effectiveness of $Ca(OH)_2$ as a root canal dressing, as the diffusion of calcium hydroxide in pure glycerine or propylene glycol was essentially zero.

Glycerine dissolves calcium hydroxide more effectively than water but cannot hydrolyse it into its active parts (Safavi *et al.* 2000). When dissolved in water, $Ca(OH)_2$ dissociates into hydroxide ions and calcium ions. The presence of hydroxide ions in a solution makes it alkaline and an antimicrobial effect occurs (Safavi *et al.* 2000). For this reason, distilled water was added to glycerine in a ratio of 1 : 7 as suggested by Alaçam *et al.* (1998).

Calcium hydroxide dissolves slightly in water but more readily in glycerine (Windholz *et al.* 1976). When a material dissolves in a vehicle, it should disperse homogeneously and the amount of material per unit volume should increase. If the material precipitated in the vehicle, diffusion would be difficult. Therefore, the glycerine fraction has the potential to penetrate dentinal tubules more than the distilled water fraction (Alaçam *et al.* 1998). The greater reduction in dentine hardness found after the $Ca(OH)_2$–glycerine combination could be explained by the different penetration ability of the two combinations into dentinal tubules. According to these findings, it could be suggested that intracanal dressing with $Ca(OH)_2$–glycerine may cause structural changes more readily than $Ca(OH)_2$–distilled water combinations as evidenced by the reduction of dentine microhardness. The degree of softening may have an influence on the physical and chemical properties of dentine structure.

Saleh & Ettman (1999) suggested that when considering the weakened status of root filled teeth, a reduction in dentine hardness is not a serious problem in terms of root fractures. This statement is true when compared with other weakening factors such as a reduction in water and fluid content following pulpectomy, extensive canal preparation and condensation force during obturation. However, Andreasen *et al.* (2002) theorized that the proteolytic action of $Ca(OH)_2$ could weaken a tooth up to 50%, and this weakness could lead to an increase in fracture. White *et al.* (2002) reported a 32% decrease in dentine strength after the use of $Ca(OH)_2$ and proposed this was caused by breakdown of the protein structure as a result of the alkalinity of calcium hydroxide. For some materials, hardness could be correlated with strength of materials. According to the present study, it could be speculated that $Ca(OH)_2$–glycerine combination may decrease the strength of tooth structures more than $Ca(OH)_2$–distilled water combinations.

The reduction in dentine microhardness after the $Ca(OH)_2$–glycerine combination treatment was significantly greater than after $Ca(OH)_2$–distilled water combination. One explanation of this might be the humectant property of glycerine in keeping substances moist due to its hygroscopicity (Osol & Hoover 1975).

Metzler & Montgomery (1989) found that intracanal $Ca(OH)_2$ left for 7 days with subsequent instrumentation cleaned the canal and isthmuses. Sjögren *et al.* (1991) also suggested that a 7-day dressing with $Ca(OH)_2$ efficiently eliminated the bacteria that survived biomechanical preparation. Because of these reports, the experimental period of the present study was between 1 and 7 days.

As microhardness of dentine may vary considerably within teeth (Seaman & Shannon 1979), comparison of dentine hardness values before and after treatment with $Ca(OH)_2$ combinations was made within the same root dentine sample. This was performed to minimize the effect of structural variations of different teeth, and to establish a reasonable baseline evaluation as suggested by Saleh & Ettman (1999). In addition, no other irrigant or disinfectant chemicals which may have affected hardness values were employed.

Deardorf *et al.* (1994) suggested that the complete removal of $Ca(OH)_2$ after intracanal dressing was difficult. An area of further study would be to test whether the addition of glycerine to $Ca(OH)_2$ would alter the adhesion of root canal sealers or restorative materials to dentine surfaces after root canal dressing.

Conclusion

The use of $Ca(OH)_2$ for intracanal dressing may soften the tooth tissue and may cause some surface alterations in root canals.

References

Alaçam T, Yoldaş O, Gülen O (1998) Dentin penetration of 2 calcium hydroxide combinations. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, Endodontics* **86**, 469–72.

Andreasen JO, Farik B, Munksgaard EC (2002) Long-term calcium hydroxide as a root canal dressing may increase for root fracture. *Dental Traumatology* **18**, 134–7.

ASTM Designation E 384-99 (2000) *Standard Test Method for Microindentation Hardness of Materials. Annual Book of ASTM Standards*. Philadelphia, PA: ASTM Designation, pp. 406–9.

Chong BS, Pitt Ford TR (1992) The role of intracanal medication in root canal treatment. *International Endodontic Journal* **25**, 97–106.

Cox CF, Heys DR, Gibbons PK, Avery JK, Heys JR (1980) The effect of various restorative materials on microhardness of reparative dentine. *Journal of Dental Research* **59**, 109–15.

Craig RG, Gehring PE, Peyton FA (1959) Relation of structure to the microhardness of human dentin. *Journal of Dental Research* **38**, 624–30.

Cruz-Filho A, Sousa-Neto M, Saquy PC, Pecora JD (2001) Evaluation of the effect of EDTAC, CDTA and EGTA on radicular dentin microhardness. *Journal of Endodontics* **27**, 183–4.

Deardorf KA, Swartz ML, Newton CW, Brown CE Jr (1994) Effect of root canal treatments on dentin permeability. *Journal of Endodentics* **20**, 1–5.

Foreman PC, Barnes IE (1990) A review of calcium hydroxide. *International Endodontic Journal* **23**, 283–97.

Fusayama T, Maeda T (1969) Effect of pulpectomy on dentine hardness. *Journal of Dental Research* **48**, 452–60.

Lewinstein I, Grajower R (1981) Root dentin hardness of endodontically treated teeth. *Journal of Endodontics* **7**, 421–2.

Metzler RS, Montgomery S (1989) The effectiveness of ultrasonic and calcium hydroxide for the debridement of human mandibular molar. *Journal of Endodontics* **15**, 373–8.

Moon PC, Davenport WL (1976) Microhardness of acid-etched dentin. *Journal of Dental Research* **55**, 910.

Osol A, Hoover JE (1975) *Remington's Pharmaceutical Sciences*, 15th edn. Easton: Mack Publishing Co., pp. 243–255.

Öztan MD, Akman A, Dalat D (2002) Intracanal placement of calcium hydroxide: a comparison of two different mixtures and carriers. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, Endodontics* **94**, 93–7.

Panighi M, G'Sell C (1992) Influence of calcium concentration on the dentine wettability by an adhesive. *Journal of Biomedical Materials Research* **26**, 1081–9.

Rivera ME, Williams K (1994) Placement of calcium hydroxide in simulated canals: comparison of glycerin versus water. *Journal of Endodontics* **20**, 445–8.

Rotstein I, Cohenca N, Teperovich E, Moshonov J, Mor C, Roman I (1999) Effect of chloroform, xylene, and halothane, on enamel and dentin microhardness of teeth. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, Endodontics* **87**, 366–8.

Safavi K, Nakayama TA, Tomoko A (2000) Influence of mixing vehicle on dissociation of calcium hydroxide in solution. *Journal of Endodontics* **18**, 649–51.

Saleh AA, Ettman WM (1999) Effect of endodontic irrigation solutions on microhardness of root canal dentine. *Journal of Dentistry* **27**, 43–6.

Seaman F, Shannon IL (1979) Fluoride treatment and microhardness of dentin. *Journal of Prosthetic Dentistry* **41**, 528–30.

Siqueira JF, Lopes HP (1999) Mechanisms of antimicrobial activity of calcium hydroxide: a critical review. *International Endodontic Journal* **32**, 361–9.

Sjögren U, Figdor D, Spångberg L, Sundqvist G (1991) The antimicrobial effect of calcium hydroxide calcium hydroxide as a short-term intracanal dressing. *International Endodontic Journal* **24**, 119–25.

Sundqvist G, Figdor D, Persson S, Sjögren U (1998) Microbiologic analysis of teeth with failed endodontic treatment and the outcome of conservative re-treatment. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, Endodontics* **85**, 86–93.

Türkün M, Cengiz T (1997) The effects of sodium hypochlorite and calcium hydroxide on tissue dissolution and root canal cleanliness. *International Endodontic Journal* **30**, 335–42.

Wadachi R, Araki K, Suda H (1998) Effect of calcium hydroxide on the dissolution of soft tissue on the root canal wall. *Journal of Endodontics* **24**, 326–30.

White JD, Lacefield WR, Chavers LS, Eleazer PD (2002) The effect of three commonly used endodontic materials on the strength and hardness of root dentin. *Journal of Endodontics* **28**, 828–30.

Windholz M, Budavari S, Stroumtsos LY, Fretig MN (1976) *The Merck Index*, 9th edn. New Jersey: Merck KGaA, p. 212